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LONG-TERM TRENDS IN ARTHRITIC PAIN AND LOW BACK PAIN ACCORDING TO POPULATION-BASED SURVEYS IN THE USA

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A thesis submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy

Johannesburg, South Africa, September 2021



UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG



DECLARATION

I, Anne Elizabeth Ioannides, declare that this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy (Physiology) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree of examination at this or any other University



27th September 2021

To my Grandad, David Murphy: “When each wave sends you back to the shore, get back on your feet, stand fast in its wake, and watch for that open door”. *Biff, biff, bang*.

&

To my Παππού, Iakovos Ioannides: on the occasion of my final trip to ‘school’, 20 years from when we began the drive together. “Το αγριολούλουδο αντέχει”.

ABSTRACT

The prevalence of pain of multiple aetiologies in the global population is high, places a large burden on public health systems, and is costly to individuals and society. Yet, despite the wealth of data on pain, the research has some significant core limitations, namely: most studies are cross-sectional and geographically localised. There is, therefore, a dearth of long-term and geospatial research on pain in order to address the cost and burden thereof to society. Long-running, nationally representative, population-based surveys offer a potential source of such data on musculoskeletal pain. This thesis addresses the epidemiology of musculoskeletal pain in the United States from 1996 to 2018, using nationally representative health survey data. I evaluated temporal trajectories and geospatial trends, as well as associations between demographic- and lifestyle-related factors frequently associated with pain (namely, age, sex, socioeconomic status, BMI, and physical activity), over the full 23-year timeframe. Furthermore, population-based data are unavailable in South Africa over large timeframes, as they are in the US. Therefore, understanding US surveys, and corresponding musculoskeletal pain trends, will help to address the use of surveys in South Africa, and assist in planning allocation of resources.

Data were obtained from three long-running population-based surveys from the US: the Behavioural Risk Factor Surveillance System (BRFSS), the National Health Interview Survey (NHIS), and the National Health and Nutrition Examination Survey (NHANES) (Continuous). Between the three surveys, I was able to analyse long-running data on two types of common musculoskeletal pain: arthritic pain, and low back pain. After searching survey questionnaires for relevant questions, I downloaded and cleaned the corresponding data, and then created design objects to account for complex survey design. I made use of descriptive data to plot prevalence statistics across time, and US geo-space. I calculated annual growth rates for temporal prevalence data, and applied geospatial correlations to geospatial prevalence data. I assessed associations between musculoskeletal pain and demographic, and lifestyle factors, respectively, using Generalised Linear Models. All data cleaning, design object creation, and analyses were done in the R statistical environment, and the research is entirely reproducible and available on GitHub (https://github.com/AnneIoannides).

In addressing temporal trends of musculoskeletal pain (Chapter Three), I showed that the temporal prevalence trajectories of arthritic pain and low back pain in the US have remained

stable over the last 23 years. Approximately 25 to 30% of US residents have some kind of arthritic pain, while approximately 30% have low back pain. Although the prevalence may have remained constant, the absolute number of people with musculoskeletal pain increased by between 10 and 27.5 million people, depending on musculoskeletal pain type, by the end of the 23-year timeframe due to population growth and population aging. The temporal trajectories of both arthritic pain and low back pain were also constant within age groups, in males and females, and in employment groups; with the exception of a small increase in arthritic pain in the unemployed group. The temporal analysis also highlighted the consistency of both arthritic pain and low back pain prevalences in the respective demographic groups. Across the 23-year timeframe, females had more musculoskeletal pain than males, and unemployed people had more musculoskeletal pain than employed people. Furthermore, each group of increasing age had more arthritic pain than younger groups, consistently across time. Low back pain was slightly more prevalence in each increasing age group in young adults only, and was stable thereafter, consistently across time.

Geospatial heterogeneity existed in musculoskeletal pain, both by state and region (Chapter Four). I found a geospatial association between state residence and arthritic pain, where states closer together had similar arthritic pain prevalences. Furthermore, the same states appeared at the upper and lower limits of prevalence data across time. Appalachia and the Mississippi Valley were identified as arthritic pain hotspots, and states consistently at the upper prevalence limit included West Virginia, Kentucky, Alabama, Mississippi, Tennessee, Arkansas, and Michigan. Conversely, consistently at the lower prevalence limit were Hawaii, California, Arizona, Utah, Texas, Minnesota, and the District of Columbia. These spatial trends remained true across time, not only in the overall population, but also within various age groups, and in both males and females. US region-specific geospatial trends showed that the Midwest had significantly more reports of arthritic pain compared to the Northeast, South, and West, both nationally and within males and females. Age-specific analyses, however, were inconclusive. Likewise, regional analyses for low back pain were also inconclusive, and suggest that the geospatial trends for low back pain may be more randomly dispersed, or that regions are too large to yield a significant trend; however, a state-specific analysis to confirm this potential finding is recommended.

Demographic- and lifestyle-related factors and their potential relationship with musculoskeletal pain were addressed in Chapters Five, and Six, respectively. There was a significant, long-running association between arthritic pain and older age, where reports of arthritic pain increased progressively as age did. Arthritic pain increased from approximately 3% to 15% in 18- to 24-year olds, to approximately 47% to 60% in those aged 70 years and above, depending on arthritic pain type and survey. Low back pain, however, was already high in young adults (between 16% and 26%), increased only until adults were approximately in their thirties, and was then stable across middle- and older-adulthood (20% to 37%).

Female sex was associated with increased reports of all musculoskeletal pain types in the US across time. The prevalence of arthritic pain amongst females (23% to 38%), depending on arthritic pain type and survey) was always significantly higher than males (16% to 27%) ($P < 0.001$). I also evaluated the joint sites at which participants reported arthritic pain by age-sex divided demographic groups. All groups had high prevalences of pain, aching or stiffness in the knees. Young females reported more hip joint symptoms than age-matched males, young males reported more shoulder symptoms than age-matched females, and older people reported more joint symptoms in their hands and fingers than younger people. The prevalence of low back pain was also significantly higher in females (prevalence between 27% and 33%) than in males (prevalence between 23% and 30%) ($P < 0.001$).

Low socioeconomic status (by employment status, education level, and annual household income bracket) was significantly associated with arthritic pain throughout the study timeframe ($P < 0.05$ across years, with only a few minor exceptions due to smaller samples in module years or very small population demographic groups, demonstrated by wide confidence intervals). Low socioeconomic status (by employment status) was also significantly associated with low back pain over the whole study timeframe ($P < 0.001$). Lifestyle-related analyses indicated that increased BMI was significantly associated with musculoskeletal pain across time ($P < 0.001$ for painful arthropathies; $P < 0.001$ for low back pain). Physical inactivity was also statistically significantly associated with painful arthropathies ($P < 0.05$, except for four years, where the relationship was not significant) and low back pain ($P \leq 0.003$), consistently across time too.

My findings have shown, for the first time, the epidemiology of musculoskeletal pain on a national level, over a 23-year timeframe, using the same consistent measurement tools. I showed

the stable trajectory of musculoskeletal pain prevalence in the US population nationally, as well as within particular demographic groups. I have also shown the geospatial distribution and trends of musculoskeletal pain, and have shown (in the case of arthritic pain) that the geospatial distribution is consistent over time. Furthermore, my findings demonstrated that there is a long-running association between musculoskeletal pain with demographic- and lifestyle-related factors. This research, therefore, highlights areas where public health interventions for musculoskeletal pain may be aimed through targeting groups at greater risk for developing musculoskeletal pain by demographic group, lifestyle, or place of residence. It also offers clear trajectories that could be used to predict costs to public health systems. Finally, this thesis demonstrates a potential new methodology of studying pain in the population, through the use of population-based survey data.

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LIST OF ABBREVIATIONS

BMI – Body Mass Index

BRFSS – Behavioural Risk Factor Surveillance System

CAGR – Compound Annual Growth Rate

CDC – Centers for Disease Control and Prevention

DALYs – Disability-adjusted life years

GDP – Gross Domestic Product

NHANES – National Health and Nutrition Examination Survey

NHIS – National Health Interview Survey

YLDs – Years lived with disability

US – United States

AL – Alabama

AK – Alaska

AZ – Arizona

AR – Arkansas

CA – California

CO – Colorado

CT – Connecticut

DE – Delaware

DC – District of Columbia (Washington DC)

FL – Florida

GA – Georgia

HI – Hawaii

ID – Idaho

IL – Illinois

IN – Indiana

IA – Iowa

KS – Kansas

KY – Kentucky

LA – Louisiana

ME – Maine

MD – Maryland

MA – Massachusetts

MI – Michigan

MN – Minnesota

MS – Mississippi

MO – Missouri

MT – Montana

NE – Nebraska

NV – Nevada

NH – New Hampshire

NJ – New Jersey

NM – New Mexico

NY – New York

NC – North Carolina

ND – North Dakota

OH – Ohio

OK – Oklahoma

OR – Oregon

PA – Pennsylvania

RI – Rhode Island

SC – South Carolina

SD – South Dakota

TN – Tennessee

TX – Texas

UT – Utah

VT – Vermont

VA – Virginia

WA – Washington

WV – West Virginia

WI – Wisconsin

WY – Wyoming

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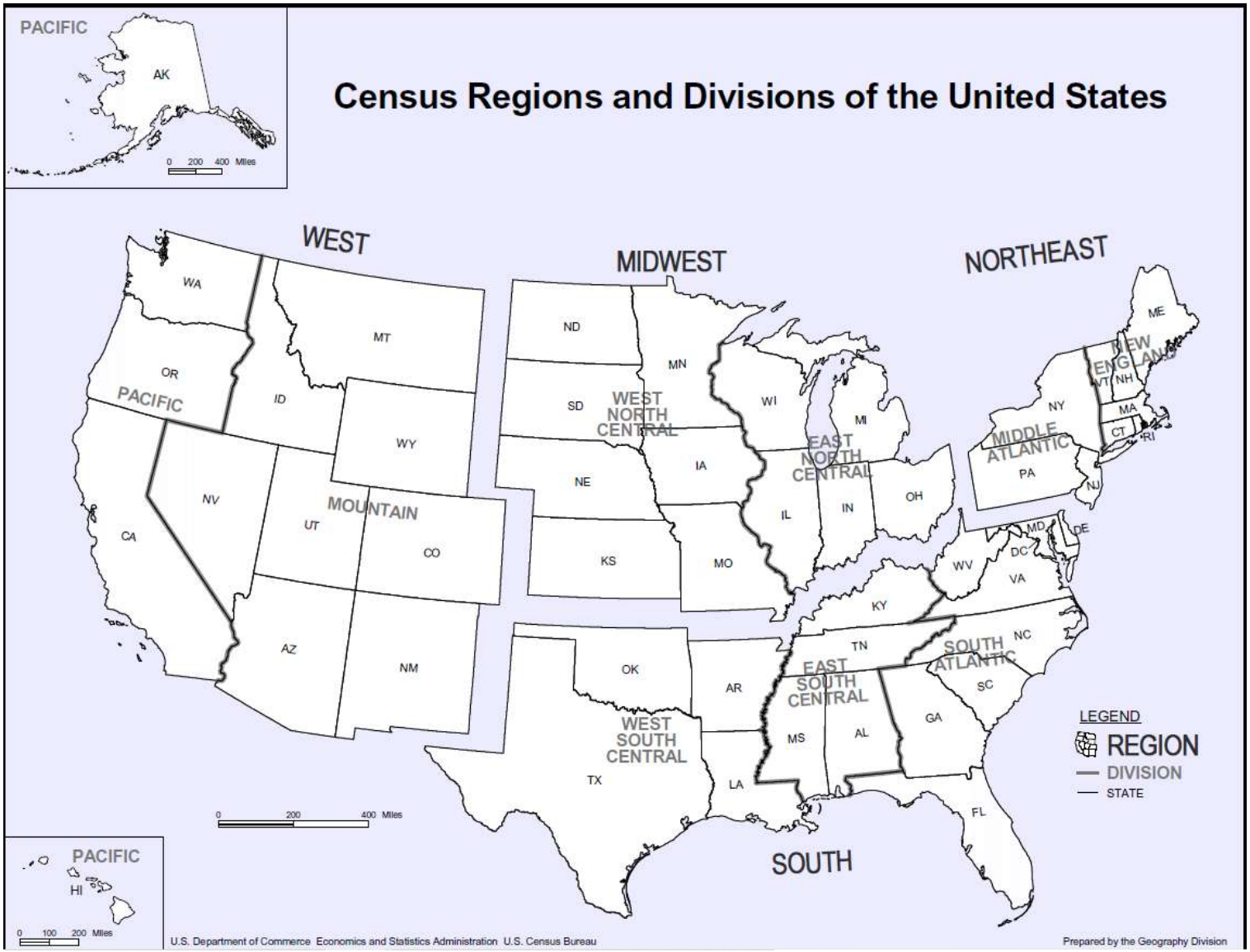


US Department of Commerce, Economics and Statistics Administration (2010)

CHAPTER ONE

Introduction

SECTION 1: AN INTRODUCTION TO THE EPIDEMIOLOGY OF MUSCULOSKELETAL PAIN

I spent the final year of my PhD scrutinising population data. I stared at temporal trends for hours, mentally dissected choropleth maps, and observed demographic and lifestyle-related risk factors. COVID-19, the global pandemic that took over our lives and screens in 2020, bombarded the world with the types of data that most people had perhaps never thought about. The virus was a testament to how important temporal, geospatial, and risk factor data are in having a robust understanding of the epidemiology of communicable diseases. I, however, had begun thinking about these very types of data two years prior to the start of 2020, although the context was somewhat different. Whilst perhaps not as fast-paced as COVID-19 and other communicable diseases, non-communicable diseases also pose a burden on those who have these conditions, as well as society. The financial burden of non-communicable diseases has been estimated at a loss of 2% in gross domestic product (GDP) in the European Union (Vandenberghe and Albrecht, 2020), and 1.4% of GDP in the United States (US) (Briggs *et al.*, 2018).

Musculoskeletal conditions are characterised by pain and a reduction in physical function, the most disabling of which include back and neck pain, osteoarthritis, and rheumatoid arthritis (Briggs *et al.*, 2018). An estimated one in three people live with chronic, painful musculoskeletal conditions worldwide (Briggs *et al.*, 2018), with the statistic increasing to one in two adults in the US (United States Bone and Joint Initiative, 2016). The burden of non-communicable diseases is also increasing. The disability-adjusted life years (DALYs) in 1990 as a result of non-communicable diseases was 43.9%, but accounted for 61.4% of DALYs by 2016 (GBD 2016 DALYs and HALE collaborators, 2017). Understanding the epidemiology of musculoskeletal diseases is thus critical in addressing musculoskeletal pain and its corresponding burden, both personal and societal, in the population.

The focus of this thesis is to address musculoskeletal pain in the population. The emphasis, therefore, is on the symptom of pain in various musculoskeletal conditions, rather than the diseases themselves. The two main divisions of musculoskeletal pain addressed in this thesis include arthritic pain (or referred to as painful arthropathies), and low back pain. “Arthropathy”

is a term that applies to any disease of the joints, and will be used throughout my thesis to refer to any painful condition or disease of the joints (including rheumatic disorders, joint symptoms, and arthritis), excluding the spine, as the spine is assessed separately as "low back pain". Each chapter of this work and its corresponding objectives, therefore, is divided into Section 1 (painful arthropathies) and Section 2 (low back pain). Throughout the thesis, "musculoskeletal pain" refers to painful arthropathies, and low back pain, collectively.

What is perhaps a standout feature of my work is that it makes use of data from the United States, despite my doing a PhD in Johannesburg, South Africa. Non-communicable diseases, and their corresponding burdens, are expected to rise in sub-Saharan Africa in the coming years, due to rapid changes in the population structure. The populations in sub-Saharan Africa are young by North American and European standards, but population distributions have shown strong trends for aging populations. There is a rapid increase in the prevalence of chronic conditions and harmful behaviours (such has alcohol intake, tobacco smoking, sedentary behaviours, and unhealthy diet consumption) in the sub-Saharan African population (Gyasi and Phillips, 2020). Whilst it would have been ideal to have South African data to work with, it is unfortunate that long-term, nationally-representative musculoskeletal pain data is unavailable in South Africa. A recent study in South Africa made use of the first assessment of pain at the level of the population, using a population-based survey. The researchers found that almost one in five South Africans has chronic pain (Kamerman *et al.*, 2020). This research – whilst the first of its kind in South Africa – was cross-sectional due to the lack of long-term survey data in South Africa, much like population-based research in Europe and North America. In the US, temporal survey data are available, although rarely or never utilised for long-term trends in musculoskeletal pain. By using these data, we can not only address the temporal trends of musculoskeletal pain in the US and factors that frequently associate with it, but also stream-line the process of developing such survey data for South Africa, by knowing which aspects of these surveys are most effective. The effectiveness of surveys could depend on numerous factors, such as making sure that all population groups are reached (especially in light of South Africa's diverse population), making sure that underlying reasons for pain are understood in South Africa's population, and making sure that the information obtained from surveys offers a potential workable solution for those affected by pain, by highlighting specific demographic- and lifestyle-related factors that can be addressed.

Furthermore, there is contradictory evidence on the prevalence of pain in Africa. A recent systematic review and meta-analysis suggested that the prevalence of low back pain is, in fact, much higher in Africa than in North America and Western Europe. The researchers' estimate of low back pain point prevalence in Africa was 39%, and annual prevalence was 57% (Morris *et al.*, 2018). Researchers did, however, highlight that there are some limitations on the availability of African data, as well as economic disparities resulting in a lack of research funding, and the poor methodological quality and heterogeneity in methods, samples, and in the studies included (Morris *et al.*, 2018). South Africa also tends to follow the US in other disease trajectories, such as cardiovascular diseases and diabetes (GBD, 2019a). As the structure of the population changes (such as the population becoming older, as well as an increase in lifestyle-related changes in diet and other harmful behaviours that result in an increase in chronic conditions (Gyasi and Phillips, 2020)), it is possible that the prevalence of musculoskeletal pain could follow trends seen in the US. The trends that I aim to establish in this work, therefore, are not only enabling for South Africa in terms of streamlining the process of collecting long-term survey data on musculoskeletal pain; but also assist in projecting the potential burden of musculoskeletal pain, and planning ahead for tackling this burden socially and economically.

1.1 Epidemiology of painful arthropathies

1.1.1. Prevalence trends

1.1.1.1. Temporal prevalence trends of painful arthropathies

The prevalence of painful arthropathies is high globally, the most common of which is arthritis. Indeed, the global prevalence of osteoarthritis alone (the most common form of arthritis) is comparable to cardiovascular disease, where the prevalence of osteoarthritis was over 528 million in 2019 (GBD, 2019b) and the prevalence of cardiovascular disease was 523 million in 2019 (Roth *et al.*, 2020). The US itself has a high prevalence of arthritis compared to the rest of the world (GBD, 2019b). US-based nationally-representative survey research has estimated that the average prevalence of doctor-diagnosed arthritis (all types) in the US, between 2013 and 2015, was 22.7% (54.4 million US residents) (Barbour *et al.*, 2017a). Joint pain, another painful arthropathy that is a defining feature of arthritis, can range from mild discomfort to severe pain. The prevalence of adults in the US with an arthritis diagnosis who cited severe joint pain was 26.5% in 2014, amounting to 14.6 million people (Barbour *et al.*, 2016a).

We know, therefore, that the prevalence of arthritis, and corresponding pain, affects as many as approximately one in four people. We do not, however, have a clear picture of whether the prevalence is actually increasing, or whether it is high but stable across time. Some research has looked at arthritis or joint pain over time by comparing prevalence statistics at two time points in a "before and after" fashion, such as that by Barbour *et al.* (2016)a. This research compared the prevalence of severe joint pain in US adults diagnosed with arthritis between 2002 and 2014, using nationally-representative survey data from the National Health Interview Survey (NHIS). The prevalence of people who had experienced severe joint pain within the 30 days prior to taking the survey did not increase significantly between time points (from 24.9% to 26.5%), but the absolute number of people increased significantly (from 10.5 million to 14.6 million). Whilst the growth is, thus, likely due to a growing and aging population, this research does not show what the trajectory over time looks like.

One study that has looked at the trajectory of the prevalence of arthritis over multiple points was done by Park, Mendy and Vieira (2018), using nationally-representative health survey data, also from the US. Using the National Health and Nutrition Examination Survey (NHANES)

(Continuous) from 2000 until 2014 (eight survey cycles, as the survey is administered over two years), they showed that the age-adjusted prevalence of arthritis diagnoses increased, but not statistically significantly, from approximately 20% to 24.7% over the 14-year period. The majority of the growth had occurred since 2012, and coincides with a statistically significant spike in US-based osteoarthritis specifically, increasing from 6.6% in 1999-2000 to 14.3% in 2013-2014 (Park, Mendy and Vieira, 2018). Rheumatoid arthritis and arthritis classed as "other" or "don't know" remained stable. Osteoarthritis is associated with aging, and thus the significant increase of osteoarthritis, as well as the increase (although not significant) in overall arthritis statistics could again be as a result of a growing and aging population. The "boomer" generation (the demographic group that we refer to when we speak about the growing and aging population) were born between 1946 and 1964. Therefore, the youngest boomers would have aged in years from 36- to 48-years-old; while the oldest boomers would have aged in years from 54- to 66-years-old. However, between 2012 and 2014, the same large generation has an age range of 48- to 68-years-old. Given the association between arthritis and older age, the increase in osteoarthritis established in Park, Mendy and Vieira (2018)'s research is explainable by the changed demography of the population.

The research that I have reported in the previous three paragraphs used data from population-based surveys, and has been able to demonstrate some type of temporal trend in painful arthropathies due to standardisation in population-based surveys. Firstly, these data are obtained using standardised questions that are identical when asked over different timeframes. Secondly, the data are also analysed according to complex survey analysis rules, accounting for complex survey sampling and design weights. These data are collected throughout the US, and minority groups are oversampled. While the initial sample sizes were between approximately 5 000 and 400 000 US residents (NHANES Continuous and BRFSS survey sample sizes, respectively), the data is then transformed to reflect the national US population. In doing so, the statistics presented show a real-time annual instance of the prevalence of various painful arthropathy diagnoses. The standardisation, therefore, reduces the potential bias introduced when samples are randomly obtained, as the demographic structure (for example, age or sex distribution) of the sample may differ.

Other temporal research on arthritis trajectories is available from the United Kingdom, and looked at temporal research on osteoarthritis (a defined case of osteoarthritis as having either at least one consultation with a recorded diagnosis of osteoarthritis), and "clinical osteoarthritis" (a patient was over the age of 45, with at least one consultation with a recorded peripheral joint pain symptom code affecting the knee, hip, and hand/wrist). Between 1992 and 2013, the age-sex standardised incidence rate of osteoarthritis (432 163 incident cases over the timeframe) increased from 29.2 to 40.5 per 1 000 person-years (Yu *et al.*, 2017). The study presented the annual incidence rate over the course of the entire timeframe, and found that, although diagnosed osteoarthritis increased slightly from 1992 until 2004, it decreased thereafter again. Clinical osteoarthritis (1 716 253 incident cases over the timeframe), similarly, increased until 2009, but dropped slightly thereafter (Yu *et al.*, 2017). This same trend-line was also seen in the age and sex strata. However, although there was a drop in osteoarthritis prevalence, there was instead a levelling off of clinical osteoarthritis prevalence (more reliant on pain reports). Although not explicitly stated, I would speculate that the decrease in osteoarthritis is more indicative of the proportion of people who do not report a painful joint to their practitioner, rather than a decrease in the prevalence of osteoarthritis. Clinical osteoarthritis incidence rates were consistently higher than osteoarthritis diagnoses across time, indicating that perhaps joint pain statistics are substantially higher than an official corresponding disease diagnosis statistics. The study also looked at the trends of clinical osteoarthritis and diagnosed arthritis by age, where incidence rates increased with increasing age, tapering after the age of approximately 65 years old. Furthermore, later birth cohorts had higher incidence rates of clinical osteoarthritis than the previous cohorts subsequent to people who were born in the mid-1950s (Yu *et al.*, 2017).

The data used in Yu *et al.* (2017) were, however, obtained from the Clinical Practice Research Datalink, which is reliant on patients presenting for clinical care for their ailments. The database also covers 7% of the UK population seeking primary healthcare, which has limitations for extrapolation to the overall population. Furthermore, researchers defined a case of osteoarthritis as having either at least one consultation with a recorded diagnosis of osteoarthritis. "Clinical osteoarthritis" was defined as a patient was over the age of 45, with at least one consultation with a recorded peripheral joint pain symptom code affecting the knee, hip, and hand/wrist. While the data from the study offer a trajectory, as well as information on temporal trends in different demographic groups, they do not represent the population at a national level, nor would they

capture people who may have osteoarthritis but do not present for clinical intervention. It is, therefore, unclear whether the incidence rate of osteoarthritis in fact increased, or whether the healthcare-seeking behaviour in people who have osteoarthritis has increased.

The research that I have discussed thus far has indicated that painful arthropathies may be constant in overall population prevalence, but may be rising in absolute numbers in the United States (Barbour *et* al., 2016a), or may in fact be increasing in the case of arthritis specifically (Park, Mendy and Vieira, 2018). While research by Park, Mendy and Vieira (2018) and by Yu *et al*. (2017) showed increases in arthritis by means of presenting a temporal trajectory, the latter paper did not make use of data that represented the overall population, but rather only a clinically-presenting sample. The findings on temporal trends in painful arthropathies, at the level of national populations, are thus available, but are somewhat inconclusive.

1.1.1.1.1 Demographic-specific temporal trends of painful arthropathies

In section 1.1.1.1, I highlighted research on temporal trends in painful arthropathies in overall populations or samples. Samples and populations, however, are heterogeneous. The corresponding temporal trajectories of specific demographic groups (such as various ages, sexes, or socioeconomic statuses) may, therefore, also be different compared to each other as well as the overall population statistics.

According to Park, Mendy and Vieira (2018), the nationally representative US study that showed temporal trajectory plots, the age-adjusted prevalence increase in osteoarthritis was significant in both males and females. A Canadian study looked specifically at the temporal trends of osteoarthritis in males and females separately between 1996-1997 and 2003-2004, using data on visits to health professionals and hospital admissions covered by the Medical Services Plan of British Columbia. Criteria for osteoarthritis included at least one visit or hospitalisation with a diagnostic code for osteoarthritis, as well as at least two visits or one hospitalisation with a code for osteoarthritis. Although fluctuations appeared in male data, overall, there was little to no growth in the prevalence of osteoarthritis in males (11.3 to 11.6 per 1 000 for definition one, and 6.1 to 6.0 per 1 000 for definition two). Age-standardised incidence of osteoarthritis in women, however, did increase during this time, particularly in older women (14.7 to 16.7 per 1 000 for

definition one, and 8.0 to 8.9 per 1 000 for definition two) (Kopec *et al.*, 2008). The study by Yu *et al*. (2017), which looked at osteoarthritis incidence rates in the United Kingdom, also looked at the incidence of osteoarthritis in men and women separately. They found that the age-standardised incidence rates were higher in women (46.2 per 1 000) than men (35.0 per 1 000) (Yu *et al.*, 2017) across time. Once again, however, the research in this paragraph (aside from Park, Mendy and Vieira (2018)) obtained data from databases that rely on people presenting for healthcare for their painful arthropathy. Although the results may be age-sex standardised, they would not necessarily represent the trends amongst the sexes nationally. Some people may not present for clinical care because they do not feel their arthropathy symptoms are not severe enough, or perhaps because of socioeconomic limitations.

Socioeconomic status itself may also result in different trajectories in painful arthropathies, although this research is very rare. Research has shown that people with different socioeconomic statuses have different temporal trajectories in painful arthropathies. Park, Mendy and Vieira (2018) found that the age-adjusted prevalence increase in osteoarthritis was significant in people with high socioeconomic status, and in people with a high school diploma or above, but not so in low socioeconomic status groups. The positive trend between socioeconomic status and painful arthropathies across time is an uncommon finding but suggests that the prevalence of osteoarthritis may be increasing in people with higher socioeconomic status in the US population. The definition of having osteoarthritis in the NHANES (Continuous) survey, which is the data that was used for this research, was dependent on the survey participant having received a diagnosis from a healthcare practitioner. It is thus unclear whether the number of diagnoses are increasing in those who have the socioeconomic means to seek healthcare and a corresponding diagnosis, but not in groups who potentially cannot afford to seek care. This paper, however, was the only one I found that looked at painful arthropathies over time, within the context of socioeconomic status. Given the association between painful arthropathies and socioeconomic status (discussed in a later section of this literature review), we cannot eliminate a potential difference in temporal trends between different socioeconomic groups. Perhaps the most critical socioeconomic status indicator for temporal trends, in my opinion, is that of various employment statuses. If the prevalence of arthritis is increasing in those of high socioeconomic status (such as those employed, as opposed to the unemployed), there may be a high and growing prevalence of painful arthropathies in the workforce. A high painful arthropathy prevalence in

the workforce would result in lost productivity, and thus be costly to employers and governments. If it emerges, however, that the prevalence of painful arthropathies is high and increasing in people who are unemployed, this in turn would also be costly to governments and socioeconomic support establishments.

1.1.1.1.2 Joint-site specific temporal trends of painful arthropathies

The specific joint sites at which painful arthropathies present has also been shown to change over time, with the trajectories thereof looking different in shape. UK-based research using National Health Service (NHS) hospital episode statistics between 2000-2001 and 2017-2018 looked at temporal trends of joint site citations in osteoarthritis, by age and by sex. The knee was the site most diagnosed with osteoarthritis, followed by the hip, first metatarsophalangeal joint (the big toe), and then the first carpometacarpal (the thumb) (Morgan *et al.*, 2019). The prevalence of osteoarthritis increased in the first carpometacarpal, first metatarsophalangeal, and the hip from 2000-2001 until 2016-2017, but has been temporally stable in the knee since 2008-2009 (Morgan *et al.*, 2019). We, therefore, see that the sites of painful arthropathies reported may be changing over time, and may be doing so differently by age and sex. These data are limited, however, in that they only include people who have sought healthcare.

1.1.1.1.3 In summary: on the temporal research of painful arthropathies

We have a very limited idea of what painful arthropathies (including arthritis as well as other joint symptoms) might be doing over time in the overall population (Kopec *et al.*, 2008; Culliford *et al.*, 2010; Ibrahim *et al.*, 2010; Barbour *et al.*, 2016a; Yu *et al.*, 2017; Park, Mendy and Vieira, 2018; Morgan *et al.*, 2019), but these data are not always able to give a complete picture. Some data offer before-and-after snapshots, while others are from healthcare-seeking-based archives. Furthermore, they do not include much information on various demographic groups. Thus, the research lacks a plotted trajectory of painful arthropathies in nationally-representative, nationwide populations, as well as plotted trajectories of the various demographic groups (different ages, sexes, and socioeconomic statuses). This type of epidemiological study would be particularly useful within the context of the US, as the US has the highest burden of

painful arthropathies worldwide (Safiri *et al.*, 2019; 2020). Furthermore, the US does have a number of population-based health surveys frequently administered to the population, which offer standardised questions asked frequently over time, therefore offering the instruments to assess painful arthropathies across time, at a national level.

When researchers have previously used US-based nationally representative surveys to research musculoskeletal pain, they have, at times, combined multiple years of survey data, such as research conducted by Mili, Helmick and Moriarty (2003); CDC (2008), CDC (2011a); Barbour *et al.* (2013); Barbour *et al.* (2017)a; Gamble *et al.* (2017); and Guglielmo *et al.* (2018). If, however, the prevalence of painful arthropathies (including arthritis, as I have discussed above) is increasing over time by substantial amounts, clustering these survey data together over a few years is not appropriate. Combining these data would not only disguise the temporal trends in the population that would otherwise be useful to know, but would also be clustering together data with different baseline painful arthropathy estimates. Temporal research is also required, therefore, in order to validate these kinds of studies.

Aside from the trajectory of painful arthropathies prevalences, the *burden* of painful arthropathies is definitely increasing. Between 1990 and 2010, the years lived with disability (YLDs) increased from 10.5 million (at 0.42% of disability-adjusted life years (DALYs)) to 17.1 million YLDs (0.69% of all DALYs) worldwide for hip and knee osteoarthritis alone (Cross *et al.*, 2014). Painful arthropathies are associated with decreases in overall health status. As a result of health status declining, the overall quality of life of individuals with painful arthropathies is greatly reduced. Compounding the matter is the fact that pain often affects multiple areas of life and health simultaneously, and navigating the entangled factors is often challenging. Some specific examples of the association between musculoskeletal pain and reduced health and quality of life include frequent co-occurring disability and reduced sleep quality (Koleck *et al*., 2006; Gerrits *et al*., 2012; Shmagel, Foley and Ibrahim, 2016), physical inactivity (Guglielmo *et al*., 2019), and increased BMI (Vennu *et al*., 2020). Furthermore, the financial lifetime cost of osteoarthritis alone is reported to be $19 600 per person (Lo, Chan and Flynn, 2020).

Aside from the level of the individual, communities are also affected. As the individual's quality of life is impeded, so too will their work performance and socioeconomic status be impeded (Cimas *et al*., 2018; Park, Mendy and Vieira, 2018). The cost of painful arthropathies therefore

does not end with the community, as socioeconomic impediments are extensive: one study estimated that, between 2013 and 2015, 180.9 million work days were lost due to arthritis (Lo, Chan and Flynn, 2020). Earnings losses are estimated at $6 783 annually, and those losses accumulate to an indirect cost of $373.2 billion for the state (Lo, Chan and Flynn, 2020).

Treatment of painful arthropathies, particularly when they have progressed over time in patients, is a complicated matter. One treatment option is surgical intervention, which has also increased over time, thus supporting the fact that the burden of pain is increasing over time. The incidence of total knee replacements (Culliford *et al.*, 2010; Ibrahim *et al.*, 2010) and total hip replacements (Culliford *et al.*, 2010) increased between 1991 and 2004. For example, age standardised primary total knee replacements, in 100 000 person years, increased from 42.5 to 138.7 in women, and from 28.7 to 99.4 for men between 1991 and 2006. Age-standardised total hip replacements, in 100 000 person years, increased from 60.3 to 144.6 in women, and from 35.8 to 88.6 in men, in the same timeframe. (Culliford *et al*., 2010). The total number of joint replacements were also significantly higher in females (Culliford *et al.*, 2010; Ibrahim *et al.*, 2010), and also increase with age in both sexes (Ibrahim *et al.*, 2010).

Given the associated costs and declines in quality of life with painful arthropathies, it follows that the burden on the individual and healthcare system is increasing. If the rate at which affected people require clinical interventions continues to increase faster than the rate of clinical care given, the increasing burden will never be attenuated. If, however, extensive clinical interventions (such as surgeries) decrease the rate at which the burden of painful arthropathies is increasing, then these interventions may well be a weapon against the painful arthropathy trajectory. Without understanding temporal trends of arthropathies over time, we cannot hope to attenuate their consequential growing burden.

1.1.1.2 Geospatial prevalence trends of painful arthropathies

Indeed, the prevalence of painful arthropathies is not equal across all geographical areas. Research has shown that the prevalence of arthritis is different in different continents and countries. For example, the Global Burden of Disease study of 2017 found that the prevalence of rheumatoid arthritis was in fact highest in North America (377.6 per 100 000 people), followed

by Western Europe (346.8 per 100 000), and the Caribbean (338.9 per 100 000). Countries with the lowest prevalence of rheumatoid arthritis included Southeast Asia (100.9 per 100 000), Oceania (135.3 per 100 000), and Western sub-Saharan Africa (135.7 per 100 000) (Safiri *et al.*, 2019). In the case of osteoarthritis, the highest regional age-standardised prevalence of osteoarthritis is North America (5 923.9 per 100 000), North Africa (4 609.8 per 100 000), the Middle East (4 609.8 per 100 000) and Australasia (4 594.8 per 100 000). The regions with the lowest prevalences of osteoarthritis include Eastern sub-Saharan Africa (2 567.9 per 100 000), Central sub-Saharan Africa (2 632.5 per 100 000), and Western sub-Saharan Africa (2 2678.3 per 100 000) (Safiri *et al.*, 2020).

European data showed that the prevalence of chronic joint and/or back pain also differed by country in adults aged 50 and above. Switzerland had the lowest prevalence of chronic musculoskeletal pain (18.6%), followed by the Netherlands (19.6%), Denmark (23.2%), Sweden (26.1%), Belgium (29.0%), Austria (29.1%), Germany (31.2%), Czech Republic (35.1%), Luxembourg (35.8%), Spain (36.6%), Estonia (38.5%), Slovenia (41.4%), Italy (42.2%), and the highest prevalence in France (45.6%) (Cimas *et al.*, 2018). Even data from regions that are geographically closer together, and part of the same regional geopolitical group, show differences in their painful arthropathy statistics.

North America clearly ranks amongst the regions with the highest prevalence of painful arthropathies (Safiri *et al.*, 2019; 2020). The prevalence of painful arthropathies has also been shown to be heterogeneous within the US. Reports from the Behavioural Risk Factor Surveillance System (BRFSS) national survey established, in a cross-sectional study on data from 2014, that the prevalence of arthritis ranged from 18.8% to 35.5% between US states, and from 15.8% to 38.6% between US counties (Barbour *et al*., 2016b). The states with the five highest unadjusted (not statistically adjusted to account for age – hence, a raw population prevalence statistic) prevalences included West Virginia (prevalence 40%), Alabama (34%), Kentucky (33.9%), Tennessee (32.6%) and Michigan (31.9%). Conversely, states with the lowest prevalences included Texas (19.4%), Utah (20.1%), California (20.3%), Hawaii (20.7%) and Minnesota (21.8%). US territories Puerto Rico and the District of Columbia also have low prevalences, at 15.7% and 19.2%, respectively (Barbour *et al*., 2016b). These data provide insight into the inter-state heterogeneity of arthritis trends, however, they are only for one time-

point in 2014. We do not know from these data whether these trends are historically consistent, or just circumstantial for 2014, specifically.

1.1.1.2.1 In summary: on the geospatial research of painful arthropathies

In order to understand other geospatial health-related trends in poor health outcomes that frequently associate with painful arthropathies, we must first understand the geospatial trends of painful arthropathies themselves. For example, a troubling geospatial trend from 2015 US state-specific research was that states with higher arthritis prevalences also had more negative health-related behaviours and characteristics compared to states with lower arthritis prevalences (Barbour *et al.*, 2018). These characteristics include arthritis-attributable activity limitations, arthritis-attributable severe joint pain, arthritis-attributable social participation restriction, 14 or more days out of 30 regarded as unhealthy, 14 or more days out of 30 regarded as mentally unhealthy, obesity, leisure-time physical inactivity, and the least leisure-time walking (Barbour *et al.*, 2018). State-specific data are critical to know for public health intervention and funding allocation, as it is at the state level that funding allocation as well as intervention programmes are often decided.

1.1.2 Demographic trends

1.1.2.1 Painful arthropathies and age

The positive association between age and painful arthropathies is well-known, and has been shown in different regions across the world (Van Saase *et al.*, 1989; Jordan *et al.*, 2014; Thomas, Peat and Croft, 2014; Allen and Golightlya, 2015; Blyth and Noguchi, 2017; Hunter *et al.*, 2017; Cimas *et al.*, 2018; Vina and Kwoh, 2018). The burden of painful arthropathies within the context of aging is very costly to society (Murphy *et al.*, 2018; Schofield *et al.*, 2018), as well as to elderly people who experience them (Chen *et al.*, 2020). Addressing the association between age and painful arthropathies is critical in the face of a growing aging population (Bloom *et al.*, 2011).

The prevalence of arthritis amongst different age groups is heterogeneous, but follows a consistent trend: the older the age group, the higher the prevalence of painful arthropathies. Between 2013 and 2015, the prevalence of arthritis in young adults between 18- and 44-years-old in the US was estimated at 7.1% (8.0 million), was 29.3% (24.2 million) middle-aged adults between the ages of 45 and 64, and 49.6% (22.2 million) of older adults, aged 65 and above (Barbour *et al.*, 2017a). Rheumatoid arthritis also increases with age. Research that used algorithms in health insurance claims databases found that the prevalence of rheumatoid arthritis was stable in younger groups of both sexes, but increased slightly in females in groups after the age of 44 years, and in males (although a more gradual growth) after the age of 54 years old (Hunter *et al.*, 2014). The 2014 prevalence of rheumatoid arthritis was 0.1% in females between 18 and 35, and increased progressively to reach just over 1.4% in females aged 65 years or above. In males (2014), the prevalence of rheumatoid arthritis ranged from less than 0.05 in those aged 18 to 35 years, and also increased progressively to reach approximately 0.75 in those aged 65 years and above (Hunter *et al.*, 2017). According to research on 2014 NHIS data, severe joint pain in young adults (age 18- to 44-years-old) was 24.9%, was the highest prevalence in middle-aged adults (age 45- to 64-years-old), at 30.7%, and was 24.3% in older adults (age 65-years-old and above) (Barbour *et al.*, 2016a). Although older adults cited the least severe pain, this could be due to different coping mechanisms, as the elderly have been shown to accept that their pain is part of their life as an old person (Chen *et al.*, 2020). Another potential reason could be different socioeconomic demands on different age groups. Older adults are most often retired,

and may not have work-related pressures to deal with, while middle-aged adults would potentially have work-related pressures and socioeconomic responsibilities (Hartvigsen *et al.*, 2018).

Joint symptom sites have also been shown to have an age-related trend. Not all joints are affected equally, and not all joints are affected equally during the same age phase of life. Knee and hip osteoarthritis rates have both been seen to increase with age, and females were particularly more at risk between the ages of 70 and 75 years old. However, hand osteoarthritis peaked in females aged 60 to 64 years, while the male-to-female risk ratio was highest between ages 50 and 55, suggesting a hypothesis for a link to menopause (Prieto-Alhambra *et al.*, 2014). We do not know, however, how joint sites have changed in various age groups over time within the context of the US.

Age is one of the strongest predictors of osteoarthritis, and is thought to be due to a combination of factors, including cellular senescence, reduced biomechanical adaptability, age-related sarcopenia, and increased bone turnover (Johnson and Hunter, 2014), as well as oxidative damage, thinning cartilage, and muscle weakening (Litwic *et al.*, 2013). The research on the association between aging and painful arthropathies has been cross-sectional in nature, and geographically localised. Given the strong association between aging and painful arthropathies, addressing the temporal trajectories and spatial distribution of painful arthropathies in various age groups is necessary, particularly at the level of the population. Assessing whether painful arthropathies associates with age consistently over time in the overall population is also critical in understanding how painful arthropathies have historically behaved in the aging population, and whether the burden thereof may increase as the population distribution changes as the population ages.

1.1.2.2 Painful arthropathies and sex

Chronic pain, in general, tends to be more common in females compared to males (Andrews, Steultjens and Riskowski, 2018). Research on chronic musculoskeletal pain across 14 European countries showed that, irrespective of international differences in chronic musculoskeletal pain prevalences, the prevalence of chronic musculoskeletal pain was consistently higher in females

compared to males across all countries (Cimas *et al.*, 2018). Painful arthropathies, specifically, have also previously been extensively associated with sex, where females frequently report more painful arthropathies compared to men (Allen and Golightlya, 2015; Hunter *et al.*, 2017; Cimas *et al.*, 2018; O'Neill, McCabe and McBeth, 2018; Vina and Kwoh, 2018). Indeed, across all the literature that I read, the only time I was able to find a painful arthropathy that was more common in males than in females was a study on hospitalisations from Sweden between 1998 and 2015, where more males were hospitalised than females for gout (Kiadaliri and Englund, 2018). There are a few potential theories proposed as to why females report pain more frequently, for example, sex-related genetics, sex hormones, the microbiome (Krasselt and Baerwald, 2019), psychological factors (such as coping strategies) (LeResche, 2011; Fillingim, 2017) and increased likelihood of being overweight (Wijnhoven, de Vet and Picavet, 2006). Furthermore, female sex has been associated with increased risk of central sensitisation and, hence, greater overall pain sensitivity, including painful arthropathies such as osteoarthritis (Bartley *et al*., 2016).

Within the context of the US, the prevalence of arthritis diagnoses in females was 26.0%, but was only 19.1% in males, based on population-based cross-sectional research on data between 2013 and 2015 (Barbour *et al.*, 2017a). The prevalence of different types of arthritis was also higher in females. Rheumatoid arthritis, specifically is also greater in females compared to males. Research from US health claims databases found that the age-adjusted prevalence of rheumatoid arthritis in US adults, in 2014, was 0.31% in males, and was 0.78% in females (Hunter *et al.*, 2017). Osteoarthritis prevalence is also reported to be significantly higher in females compared to males (Johnson and Hunter, 2014; Park, Mendy and Vieira, 2018).

Females with painful arthropathies also report more severe pain compared to males (Johnson and Hunter, 2014; Park, Mendy and Vieira, 2018). According to the 2014 NHIS data, severe joint pain reports in people with arthritis diagnoses has been shown to be higher in women (29.3%) compared to men (24.1%) (Barbour *et al.*, 2016a). It is thus imperative to address the burden of painful arthropathies in females, as not only do they experience more prevalent pain, but also more severe pain.

The site of painful arthropathy has also been found to differ between the sexes, and even by age groups within the sexes. For example, in adults older than 55 years old, females have been

reported to have an increased risk of knee osteoarthritis compared to males (Srikanth *et al.*, 2005). The same trend was found in longitudinal research on US Armed Forces members, where knee and pelvic region osteoarthritis rates were higher in females compared to males. Conversely, shoulder and cervical spine osteoarthritis was greater in male US service active members compared to female US service active members (Williams, Clark and Oh, 2016). The distribution of pain may, therefore, also be different between the sexes.

1.1.2.3 Painful arthropathies and socioeconomic status

Socioeconomic status can be measured using a number of metrics. Three such examples often used in nationally representative research (Barbour *et al.*, 2016a; Barbour *et al*., 2017a; Cimas *et al*., 2018; Park, Mendy and Vieira, 2018) include employment status, education level, and income level. Each socioeconomic index will be discussed individually with its relationship with painful arthropathies, below.

1.1.2.3.1 Employment status

The prevalence of painful arthropathies is typically higher in lower socioeconomic statuses compared to higher socioeconomic statuses (Allen and Golightlya, 2015). Across 14 pooled EU nations, the prevalence of chronic musculoskeletal pain (either joint pain or back pain) increased with employment categories of lower socioeconomic status. The prevalence of chronic musculoskeletal pain in the employed was 31.8%, was 38.4% in the retired, 39.2% in the unemployed, and 50.2% in the permanently sick or disabled (Cimas *et al.*, 2018).

In the US, the 2013 to 2015 prevalence of arthritis also differed depending on employment status. The prevalence of arthritis was 17.7% in employed US residents, compared to 19.3% in the unemployed. However, after being adjusted for age, prevalence between the employed and unemployed US residents was almost identical, at 14.9% and 14.3%, respectively (Barbour *et al.*, 2017a). The effect of age on national arthritis prevalence speaks to the fact that painful arthropathies push older workers out of work earlier, which in turn is costly to society (Laires, Canhão and Gouveia, 2015). Pain severity in arthritis-diagnosed US adults also differs between

the employed and unemployed. Severe joint pain in arthritis-diagnosed US adults was higher in unemployed people (31.6%) compared to employed people (20.7%) (Barbour *et al.*, 2016a).

The highest statistic, much like European data, was in those categorised as unable to work, whose arthritis prevalence was approximately half of all people in the category (52.0%, and 43.9% after adjusting for age) (Barbour *et al.*, 2017a). Indeed, a potential driver of unemployment has been cited as high prevalence of arthritis-attributable activity limitations (Barbour *et al.*, 2017a). Of all employment groups, the "unable to work" group have the highest prevalence of severe joint pain as a result of arthritis, according to 2014 NHIS data, at 53.1% (Barbour *et al.*, 2016a).

Based on these data, the prevalence and severity of painful arthropathies play a role in the productivity of adults of working age, which in turn affects all of society. Despite this effect, we are largely unaware of whether the prevalence of arthritis has changed in various employment groups over time. Furthermore, we do not know whether the association between employment status and painful arthropathies is present in the US population across time, or whether the association has emerged in more recent years as the population has aged.

1.1.2.3.2 Education level

Education level is associated with painful arthropathies, where people with lower education level report more painful arthropathies in the form of rheumatic conditions (Cleveland *et al.*, 2013; Putrik *et al.*, 2019). In the US, the prevalence of doctor-diagnosed arthritis is typically lower in people with a higher level of education. The doctor-diagnosed arthritis prevalence in the US between 2013 and 2015 was 19.1% in people who had completed college or above. In comparison, the prevalence of doctor-diagnosed arthritis increases slightly with each descending education level. The prevalence of doctor-diagnosed arthritis in those who had at least some college education was 22.8%, was 25.3% in those with a high school diploma, and was 25.9% in those who had less than a high school diploma (Barbour *et al.*, 2017a).

European data has shown a similar trend, where the prevalence of chronic musculoskeletal pain increased with lower levels of education. In those with some type of tertiary education, the

prevalence of chronic joint or back pain was 26.1%, while it was 33.2% in those with secondary education, and 43.0% in those with primary or lower (Cimas *et al.*, 2018).

Pain severity has also been shown to differ depending on education status, according to 2014 NHIS data. In arthritis-diagnosed people with a college qualification or above, the prevalence of severe joint pain was 19.5%, was 28.8% in people with some college education, but was 27.8% in high school graduates or equivalent, and was 42.2% in people with less than a high school diploma (Barbour *et al.*, 2016a).

One nationally representative study, however, showed that the relationship between education level and painful arthropathies may in fact be changing. The research showed that the age-adjusted prevalence of osteoarthritis has increased over time in people with at least a high school diploma or above (Park, Mendy and Vieira, 2018). Typically, arthritis is associated with low socioeconomic status (such as low education status) in cross-sectional research, as I have reported in the preceding three paragraphs. However, Park, Mendy and Vieira (2018) demonstrated that the prevalence of painful arthropathies is different in its trajectory for people with different education levels. The trend highlighted in this research then potentially implies that, if the prevalence of some education groups is changing over time, their association directionality may too in fact have changed over time. It is important to establish, at a national level, how painful arthropathies associate with education status over time.

1.1.2.3.3 Income level

Annual household income has previously been associated with painful arthropathies, where those with lower annual household income have reported more painful arthropathies (Cleveland *et al.*, 2013). Annual household income is dependent on the functional status of the people within the household. People who are unhealthy often have compromised earnings as a result of their ill-health. Increased rates of work loss, and therefore earnings loss, has been attributed to rheumatic diseases (Callhoff *et al.*, 2017). Rheumatic conditions have even been shown to lead to a decrease of 11.8% of annual household income (Wolfe *et al.*, 2005).

Research also suggests that developing arthritis may be an overlooked driver of poverty, as developing arthritis increases the risk of decreased income and falling into income and multidimensional poverty (Callander and Schofield, 2016). The relationship between income and painful arthropathies is indeed bidirectional, which compounds the burden of painful arthropathies on individuals and society. We do not know, however, whether annual household income is associated with various types of painful arthropathies in the US population. We also do not know whether the potential association is consistent across time, or whether there are perhaps patterns in the potential associations that align with global financial events, such as the global financial crisis of 2008. It is, however, important to be able to establish how big events such as a global financial depression affect health outcomes (such as painful arthropathies) in the population.

1.1.3 Lifestyle risk factors

1.1.3.1 Painful arthropathies and BMI

Obesity is a common co-morbidity in people with pain (Okifuji and Hare, 2015), including those with painful arthropathies (Okifuji and Hare, 2015; Vennu *et al.*, 2020). In the US, the prevalence of doctor-diagnosed arthritis between 2013 and 2015 in US residents was 16.4% in underweight or normal weight people, 22.5% in overweight people, and 30.6% in obese people (which is almost double the prevalence in underweight/normal weight) (Barbour *et al.*, 2017a). These data are supported by European samples, where the prevalence of chronic musculoskeletal (joint or back) pain was higher in people in all unhealthy weight ranges compared to the normal weight range prevalence of 30.1%. Prevalence in those overweight was 36.1%, was 40.1% in those underweight, but was highest in the obese population, at 45.7% (Cimas *et al.*, 2018). Obesity is also a risk factor for osteoarthritis, which is the most common type of arthritis (Nevitt, 2012; Allen and Golightlya, 2015; O'Neill, McCabe and McBeth, 2018; Vina and Kwoh, 2018).

There is also evidence to suggest that increased BMI can increase pain severity in those who already have the disease. Severe joint pain in arthritis-diagnosed adults has been shown to increase with an increasing BMI, according to research from 2014 NHIS data. The prevalence of severe joint pain was 21.4% in those of normal weight or underweight, 23.6% in those overweight, and 34.1% in those obese (Barbour *et al.*, 2016a).

Obesity results in increased lower limb loading and has been cited as a risk factor for lower extremity joint symptoms and disability linked to knee and hip osteoarthritis (Nevitt, 2012). Longitudinal research found that a $5kg.m^{-2}$ increase in BMI was associated with increased odds (32%) of knee osteoarthritis in adults aged 70 and above (Fowler-Brown *et al.*, 2015). Compared to having a BMI within the normal weight range, overweight, obesity sub-class I, and obesity sub-class II increased the risk of arthritis by 2.0-, 3.1-, and 4.7-fold in the knee, as well as in the hip (Reyes *et al.*, 2016).

Increased risk of arthritis with the presence of obesity may not only be as a result of excessive joint loading. Compared to having a normal BMI, having a BMI in the obese category also increased the risk of arthritis in the hand (Reyes *et al.*, 2016), which would not experience weight loading. Longitudinal research, one on older adults and one on women only, found that

increased leptin levels were associated with knee osteoarthritis (Karvonen-Gutierrez *et al.*, 2014; Fowler-Brown *et al.*, 2015). The study on mid-life females (Karvonen-Gutierrez *et al.*, 2014) found that increased serum levels at baseline were associate with cartilage defects, bone marrow lesions, osteophytes, meniscal tears, synovitis, and effusion 10 years later. In the Fowler-Brown *et al*. (2015) study, an increase of 200-pM of serum leptin associated with 1.11 increased odds of knee osteoarthritis. These data support the hypothesis that the association between BMI and knee osteoarthritis may not only be as a result of increased joint loading, but also inflammatory adipokines, such as leptin. Addressing BMI, then, as a risk factor for obesity becomes even more important as there is not only a link to increased weight loading on joints, but also a link to metabolic inflammatory pathways in developing a painful arthropathy.

1.1.3.2 Painful arthropathies and physical activity

Physical inactivity has been associated with increased painful arthropathies (Boring *et al.*, 2017). US nationally representative research has measured the prevalence of arthritis diagnoses in people with various physical activity levels. People were classed as physically active (completing 150 or more active minutes per week, vigorous or moderate), physical activity below guidelines (between one and 149 active minutes per week, vigorous or moderate), or physically inactive. The prevalence of people with an arthritis diagnosis who met physical activity guidelines was 17.3% (18.1% age-adjusted prevalence), compared to 26.0% (23.1 age-adjusted prevalence) in those active but not meeting guidelines, and 29.2% (23.6% age-adjusted prevalence) in those inactive (Barbour *et al.*, 2017a).

Physical inactivity has also been associated with increased pain severity levels in people who have painful arthropathy diagnoses. In people who have been diagnosed with arthritis, physical inactivity is associated with increasing severity of arthritic pain (Guglielmo *et al.*, 2019). Other research, using data from the NHIS in 2014, supports the finding that physical inactivity could lead to more severe pain. The research showed that the prevalence of severe joint pain in adults with an arthritis diagnosis was higher in people with less leisure-time physical activity. The prevalence of severe joint pain in those classed as physically active was 18.7%, was 25.3% in those insufficiently active, and was 36.7% in those who were inactive (Barbour *et al.*, 2016a).

Physical activity has other benefits that could indirectly attenuate the prevalence and pain of arthritis. Firstly, physical activity is important for muscle strength. Low muscle strength has recently been shown to predate the onset of osteoarthritis, and is also a core aspect of slowing down disease progression (O'Neill, McCabe and McBeth, 2018). Physical activity, therefore, may have a direct role in attenuating arthritic effects by maintaining muscle strength prior to disease onset. The direction of the relationship between physical activity and painful arthropathies is also bi-directional. Arthritis, for example has also been cited as a barrier to physical activity in people with obesity, where adults with obesity and arthritis were 44% more likely to be physically inactive compared to people with obesity and no arthritis (CDC, 2011a). The physical inactivity in those with obesity stands to potentially perpetuate the obesity effect on the arthritis.

The statistics on leisure-time activity (defined as participation in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking; outside of the regular job, during the preceding month) in people with arthritis in the US are concerning. The prevalence of no leisure-time physical activity was significantly higher in adults with arthritis compared to adults without arthritis, across all US states. The prevalence of no leisure-time physical activity was a per-state median of approximately 53% higher in adults who had arthritis than without arthritis. Whilst these prevalence data are not age-standardised, they do offer a worrying picture on the sedentary behaviours of the population with arthritis (CDC, 2011b). If arthritis and physical inactivity perpetuate each other, the consequences could have implications for other health outcomes too, including increased obesity, cardiovascular comorbidities, and even perpetuation of chronic pain in the population.

It could be possible that there is a U-shaped relationship between physical activity and painful arthropathies. Although the research I have reported on thus far demonstrates that physical activity leads to positive health-related outcomes, there is research to suggest that excessive exercise may be detrimental. Heavy physical activity for more than four hours per day, such as that by manual workers, has been shown to increase odds for knee osteoarthritis (O'Neill, McCabe and McBeth, 2018). However, appropriate physical activity has in fact been shown to improve health outcomes, including less pain and increased physical function (Kelley *et al.*, 2011).

The data I have discussed in this section, much like in all sections I have referred to thus far, either do not address the relationship between physical activity and painful arthropathies either at a national population level, are cross-sectional, or are geographically localised. We, therefore, do not know how the association between physical activity and painful arthropathies behaves over time. Establishing the long-term trends in physical activity in people with painful arthropathies is critical to informing public health measures for the future, such as forecasting future spending and resources.

1.2 Epidemiology of low back pain

1.2.1 Prevalence trends

1.2.1.1 Temporal prevalence trends of low back pain

Musculoskeletal conditions are a main driver of the burden of non-communicable diseases (GBD 2016 DALYs and HALE collaborators, 2017), and low back pain is the leading cause of years lived with disabilities in most countries and territories (GBD and Injury Incidence and Prevalence collaborators, 2016). Despite the high personal and societal cost of the condition, a systematic review on low back pain prevalence (165 studies) found that the global point prevalence was 18.7%, while the one-month, one-year, and lifetime prevalences were 30.8%, 38.0%, and 38.9%, respectively (Hoy *et al.*, 2012).

In the US, the prevalence of low back pain has been estimated as being even higher than global prevalence estimates (Wu *et al*., 2020), and appears to be increasing over time. A financial review of the estimated costs of low back pain reported that the prevalence of low back pain in US residents was an average of 33.9% (Lo, Chan and Flynn, 2020). Nationally-representative research from 2015 using the NHIS indicated that the prevalence of low back pain in the US was 30% (Peng, Pérez and Gabriel, 2018). Another NHIS study, using slightly earlier data (2009 until 2012) showed that the prevalence of low back pain in the US was fractionally lower, at 28.6% (Yang and Haldeman, 2018). Based on these statistics, the prevalence of low back pain appears to be increasing in small amounts in the US over approximately the past decade. Whether this is true and what the trajectory is over a longer period of time, is unclear.

It is very difficult to ascertain whether the low back pain prevalence is changing over time, as the literature on low back pain can be difficult to navigate. When evaluating the prevalence of low back pain, there is heterogeneity in how systematic reviews classify low back pain. Various timeframes are used, including i) point prevalence (the prevalence of people with low back pain at the moment in time at which they are surveyed), ii) period prevalence (the prevalence of people who have had low back pain during a particular time frame, commonly one month, three months, and one year), and iii) lifetime prevalence (the prevalence of people who have experienced low back pain at some point in their life). The differing timeframes used, as well as other methodological limitations, such as sample sizes that are not demographically

representative, or only considering those seeking healthcare, make a consensus on low back pain trends difficult to come to (Dionne, Dunn and Croft, 2006; Jeffries, Milanese and Grimmer-Somers, 2007; Konstantinou and Dunn, 2008; Hoy *et al.*, 2010; Shmagel, Foley and Ibrahim, 2016; Wáng, Wáng and Káplár, 2016). Due to the heterogeneity of the research, I have tried to make use of many systematic reviews and meta-analyses on low back pain in this literature review. I also refer to many population-based studies as they are administered in a standardised manner over time, and the gap in temporal trends is an aspect of low back pain that I wish to address.

One study that has managed to address the temporal trends of low back pain was the Global Burden of Disease Study 2017, that plotted the global age-standardised point prevalence of low back pain between 1990 and 2017. According to the study, the global age-standardised point prevalence of low back pain was 8.2% in 1990, and was 7.5% in 2017 (Wu *et al.*, 2020). The researchers had plotted the prevalence of low back pain annually on a line graph, which showed that the prevalence line was virtually flat. They also plotted the raw number of people with low back pain from 1990 to 2017, however, and found that the number of people with low back pain had, in fact, increased steadily over the timeframe, from 377.5 million to 557.0 million people (Wu *et al.*, 2020). These data indicate that, although the prevalence, or proportion, of low back pain within the population has remained fairly stable, the actual number of people with low back pain has in fact increased, likely due to population growth.

A similar trend was found in research conducted on low back pain from China, and was conducted in the same manner as the global study. The age-standardised point prevalence of low back pain in China was plotted across time, from 1990 until 2016. The prevalence, or proportion, of people with low back pain did not really change (going from 5.6% to 4.2%). Conversely, when the raw numbers of people with low back pain were plotted, there was a clear upward trajectory across time. The number of people with low back pain in 1990 was 5.45×10^7, and increased steadily to reach 6.73×10^7 in 2016 (Wu *et al.*, 2019). The trend was the same, therefore, as the global trend, and was also attributed to population growth in China during the timeframe.

The value in the aforementioned studies is that annual data were plotted, such that the actual trajectory could be observed. Another type of research that has been undertaken on low back

pain data is a before-and-after approach. One such study was conducted in North Carolina, in the US, between 1992 (4 437 sampled households) and 2006 (5 357 sampled households). A state survey assessed the prevalence of chronic low back pain in North Carolina residents using a state population-representative sample, and compared the data at the two time points. The researchers defined chronic low back pain as, "i) pain and activity limitations nearly every day for the past three months, or ii) more than 24 episodes of pain that limited activity for 1 day or more in the past year". The researchers found that the prevalence of low back pain had actually increased significantly from 3.9% in 1992 to 10.2% in 2006 (Freburger *et al.*, 2009). The study was able to show, with the use of standardised low back pain criteria, that the prevalence of low back pain may be increasing, without incurring the limitation of an inconsistent timeframe for a low back pain episode. However, despite showing that the prevalence of low back pain in the US (or, at the very least, in North Carolina) has increased, they do not give a picture as to what the 14-year trajectory looks like, which in turn makes forecasting low back trends difficult. The study was, furthermore, geographically localised to the state of North Carolina.

The global study (Wu *et al.*, 2020), and the study on China (Wu *et al.*, 2019), have shown that plotting an annual trajectory for low back pain is critical in understanding, visually, the burden of the disease. We do not, however, have information on the trajectory of low back pain (using annual data) for the US.

1.2.1.1.1 Demographic-specific temporal trends of low back pain

Another aspect of temporal research that is shown in the global and Chinese research is that of temporal trends of particular demographic groups, such as in males and females. Wu *et al.* (2020) plotted the annual point prevalence of people with low back pain in each sex, and both trend lines were virtually flat. Female point prevalence in 1990 was 8.86%, and was 8.01% in 2017. In males, the point prevalence in 1990 was 7.47%, reaching 6.94% in 2017 (Wu *et al.*, 2020). When plotting the number of people with low back pain, however, both sexes had an upward trajectory, increasing by at least 100 million each. The temporal trend of a relationship between the prevalence of low back pain in males and females also emerged, where the prevalence of low back pain was consistently higher in females than that of males over time (Wu *et al.*, 2020). The temporal research from China showed a similar trend, where low back pain

went from 6.4% in 1990 to 4.8% in 2016 in females, and went from 4.9% to 4.4% in males. Despite the decrease in point prevalence, the number of people with low back pain increased slightly in both sexes, but more so in females (approximately 3.75×10^7 in females, and 2.5×10^7 in males). Once again, the prevalence was consistently higher in females compared to males across time, with an approximate difference of 7.5×10^6 between the sexes (Wu *et al.*, 2019). Although a trajectory was not available in the study conducted in North Carolina, the researchers did investigate whether low back pain had altered over time within each sex. In males, chronic low back pain prevalence went from 2.9% (1992) to 8.0% (2006), while in females it went from 4.8% to 12.2% (Freburger *et al.*, 2009).

Another demographic group investigated by Freburger *et al*. (2009) was that of age. They showed that the prevalence of chronic low back pain in North Carolina increased in all age groups between 1992 and 2006. In those between ages 21 to 34 years, the prevalence of chronic low back pain increased from 1.4% to 4.3%; in those aged 35 to 44 years, the prevalence increased from 4.8% to 9.2%; in those aged 45 to 54 years, the prevalence increased from 4.2% to 13.5%; in those aged 55 to 64 years, the prevalence increased from 6.3% to 15.4%; and finally in those aged 65 years and above, the prevalence increased from 5.9% to 12.3% (Freburger *et al.*, 2009).

1.2.1.1.2 In summary: on the temporal research of low back pain

From these temporal data, low back pain may be increasing in the US in the overall population, as well as within different age groups, and the sexes. We do not, however, know what the temporal trajectory looks like for the population, or any of its sub-groups. We, furthermore, do not know whether there is an increase in the prevalence of low back pain in various socioeconomic groups, in either a global or US-based context. Knowing what the low back trajectory looks like within the workforce, as well as in those out of work, could be pivotal in understanding and forecasting the corresponding burdens on health systems and work places.

1.2.1.2 Geospatial prevalence trends of low back pain

Whilst temporal trends on low back pain are difficult to address, so too are regional differences. Different countries have often measured low back pain differently. Low back pain prevalence has been calculated over periods that range from instantaneous (whether the study participant had low back pain in the instant at which they participated in the research), to the participant's lifetime (whether the participant had ever had low back pain in their life) (Hoy *et al.*, 2012). Pain prevalences are also sometimes inclusive of other back regions, for example "pain in the back or neck" (Demyttenaere *et al*., 2007), or unspecific "back pain" (Stubbs *et al*., 2016). Some studies also ask explicitly about "chronic" low back pain or back pain (Garcia *et al*., 2014), whereas other studies do not. Furthermore, studies that do not specify between chronic low back pain and other low back pain do not necessarily specify whether the low back pain they are asking about is acute, recurring or chronic; irrespective of whether they are asking for an instantaneous ("point") prevalence, one-month prevalence, three-month prevalence, one-year prevalence, or a lifetime prevalence. The Global Burden of Disease Study was able to offer standardised point prevalence low back pain data for various regions of the world. The global age-standardised point prevalence of low back pain was 7.50%. The highest age-standardised point prevalence of low back pain in 2017 was in Southern Latin America (13.47%), High-income Asia Pacific (13.16%), and Western Europe (13.12%). The lowest age-standardised prevalence of low back pain in 2017 was in East Asia (3.92%), followed by Central sub-Saharan Africa (8.40%), and the Caribbean (5.67%) (Wu *et al.*, 2020). Amongst world regions, North America ranked seventh highest in low back pain prevalence (10.71%) (Wu *et al.*, 2020). However, global regions are large and comprise various heterogeneous factors within themselves, such as differing age distributions or socioeconomic distributions within individual countries.

Figure 1.1 shows a choropleth of low back pain prevalence across the globe, using Global Burden of Disease data and the visualisation tool from the Institute for Health Metrics and Evaluation (IHME) (IHME, 2019). These data show that there is great regional heterogeneity in various countries, but that countries that are closer together tend to have similar low back pain prevalences. There is even a bold north-south divide, where southern countries of the world have far lower prevalences than northern countries of the world (IHME, 2019). The US, in particular,

has a high prevalence of low back pain, and, based on these data, there are also inter-state differences in low back pain prevalence (IHME, 2019).

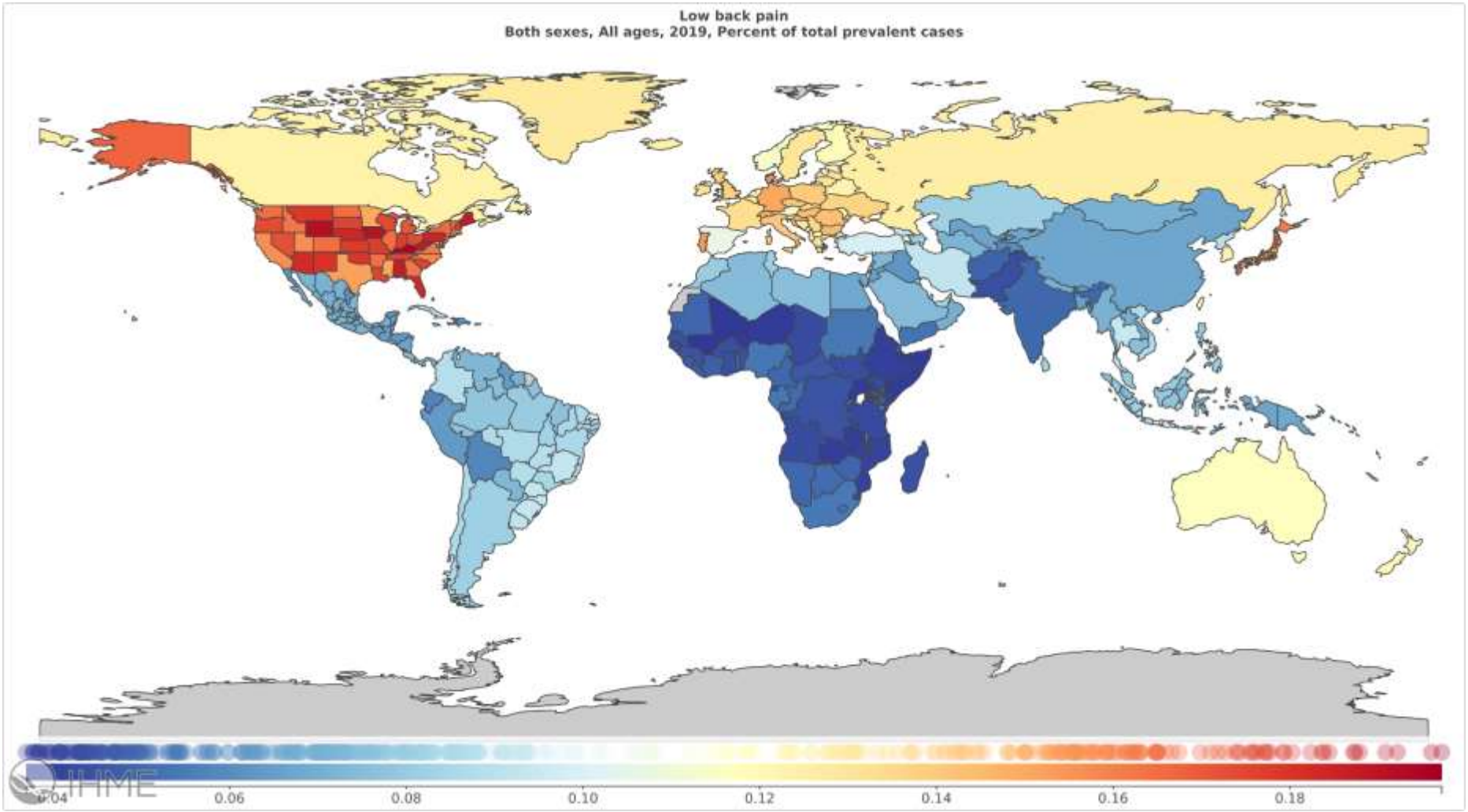


Figure 1.1: Prevalence (%) of low back pain across various regions across the world, using the Global Burden of Disease data and the Institute for Health Metrics and Evaluation (IHME) data visualisation tool*, for 2019, where the prevalence ranges from 4% (dark blue, left scale) to 20% (dark red, right scale)
*(GBD, 2019a)

Indeed, country-specific research has shown discrepancies in low back pain prevalences, both between countries and even within countries. A literature search on low back pain by country names yields many papers, collectively. Once again, however, it is very difficult to compare countries' low back pain prevalences when the definition for low back pain differs across research (including the timeframe over which low back pain is regarded as a positive response; whether the pain is localised to the lower back region or is less specific in the way it is asked; as well as whether the pain is chronic, acute, periodic or even unspecified). In some circumstances, where the same definition is used, the low back pain prevalence does show geospatial discrepancies between nations. To illustrate this, I have compiled a table (Table 1.1) including some available national statistics, whilst still considering the definitions of low back pain. I have only included literature reviews or population surveys. Table 1.1 illustrates three points: i) heterogeneous low back pain measurements make comparisons extremely difficult, both inter- and intra-nationally, ii) researchers have had much difficulty detecting temporal trajectories of low back pain due to different low back pain definitions and geospatial differences, and iii) geospatial prevalences do differ between countries in rare circumstances when definitions are standardised. I have not used the Global Burden of Disease data in Table 1.1 because Figure 1.1 makes use of these data, and thus illustrates the point that there are country-specific differences in low back pain.

Table 1.1: Weighted prevalence (%) of low back pain across multiple countries, according to population studies and literature reviews, on adult populations (aged 18 years and above)

Country	*Study*	*Study or data type*	*Point prevalence (%)*	*One month prevalence (%)*	*Three month prevalence (%)*	*One year prevalence (%)*	*Lifetime prevalence (%)*	*Another prevalence definition (%)*
North America								
United States	(Peng, Pérez and Gabriel, 2018)	2015 Population-based survey	-	-	30	-	-	-
	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	19.0[ε]
Canada	(Cassidy, Carroll and Côté, 1998)	Population-based study[η]	28.4	-	-	-	84.1	-
Europe								
Belgium	(Skovron *et al.*, 1994)	1991 Population-based study	33	-	-	-	-	-
	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	19.9[ε]
Bosnia Herzegovina	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	8.6[γ]
Croatia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	12.9[γ]
Czech Republic	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	13.3[γ]
Denmark	(Bredkjaer, 1991)	1986-87 Population-based study	12	-	-	-	-	-
Estonia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	8.6[γ]

Finland	(Heistaro *et al.*, 1998)	1972-1992 Population-based study	-	49.5	-	-	-	-
France	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	21.3[ε]
Germany	(Schmidt *et al.*, 2007)	2003 to 2006 Population-based study	37.1	-	-	76.0	84.6 to 86.3	-
	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	18.3[ε]
Greece	(Stranjalis *et al.*, 2004)	2000 Population-based study	-	31.7	-	-	-	-
Hungary	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	12.7[γ]
Italy	(Juniper, Le and Mladsi, 2009)	Literature Review	5.91	-	-	-	-	-
	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	29.6[ε]
Latvia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	11.0[γ]
Malta	(Cuschieri *et al*. 2020)	2015 Population-based study	6.3	-		-	-	-
The Netherlands	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	17.4[ε]
Russia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	6.7[γ]
Spain	(Alonso-García and Sarría-Santamera, 2020)	2017 Population-based study	-	-	-	-	-	20.9[ζ]

	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	14.7[ε]
Ukraine	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	42.2[ε]
	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	10.9[β]
United Kingdom	(Juniper, Le and Mladsi, 2009)	Literature Review	6.3 to 11.1	-		-	-	-
Central and South America								
Latin America[α]	(Garcia *et al.*, 2014)	Literature Review	-	-	-	-	-	10.5[δ]
Brazil	(Nascimento and Costa, 2015)	Literature Review	-	-	-	>50	-	4.2 to 14.7[γ]
	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	13.0[γ]
Columbia	(Demyttenaere *et al.*, 2007)	Population-based study[θ]	-	-	-	-	-	9.7[ε]
Dominican Republic	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.0[γ]
Ecuador	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	4.3[γ]
Mexico	(Demyttenaere *et al.*, 2007)	Population-based study[θ]	-	-	-	-	-	12.2[ε]
Paraguay	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	5.8[γ]

Uruguay	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.9[γ]
Asia (including the Middle East)								
Bangladesh	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	10.9[γ]
China	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	2.6[γ]
Georgia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.3[γ]
India	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	9.1[γ]
Israel	(Demyttenaere *et al.*, 2007)	Population-based study[ι]	-	-	-	-	-	17.9[ε]
Japan	(Fujii and Matsudaira, 2013)	2011 Population-based study	-	36	-	-	83	-
	(Demyttenaere *et al.*, 2007)	Population-based study[κ]	-	-	-	-	-	16.0[ε]
Kazakhstan	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	4.1[γ]
Korea (rural)	(Lee *et al.*, 2017)	Community-based survey[β] using clustered sampling[λ]	36.5	-	-	-	-	-
Laos	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	2.9[γ]

Lebanon	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	18.6[ε]
Malaysia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	1.8[γ]
Myanmar	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	0.6[γ]
Nepal	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	16.4[γ]
Pakistan	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	7.3[γ]
Philippines	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	1.8[γ]
Sri Lanka	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.2[γ]
Thailand	(Yiengprugsawan *et al.*, 2017)	2009 to 2013 National Survey[β]	-	13.0 (‘09) to 20.0 (‘13)	-	-	-	-
Turkey	(Oksuz, 2006)	Population-based study	19.7	-	-	34.0	44.1	-
Vietnam	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.0[γ]
Africa								
Africa (collectively)	(Morris *et al.*, 2018)	Meta-analysis and review	39	-		57	47	-
Burkina Faso	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	4.1[γ]
Chad	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	8.7[γ]

Comoros	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.2[γ]
Ethiopia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	4.1[γ]
Ghana	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	4.6[γ]
Ivory Coast	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	5.9[γ]
Kenya	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	5.1[γ]
Malawi	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.5[γ]
Mauritania	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	1.7[γ]
Mauritius	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	5.0[γ]
Morocco	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	16.5[γ]
Namibia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	4.3[γ]
Nigeria	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	16.3[ε]
Senegal	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.9[γ]
South Africa	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	26.3[ε]

	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	2.5[γ]
Tunisia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	5.9[γ]
Zambia	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	2.3[γ]
Zimbabwe	(Stubbs *et al.*, 2016)	2002-2004 Population (world)-based study	-	-	-	-	-	3.4[γ]
Australasia								
Australia	(Walker, Muller and Grant, 2004)	2001 Population-based study	25.6	-	-	67.6	79.2	-
New Zealand	(Demyttenaere *et al.*, 2007)	Population-based study	-	-	-	-	-	18.9[ε]
Global	(Hoy *et al.*, 2012)	Literature Review	18.3	30.8		38.0	38.9	

[α]Brazil, Colombia, Cuba, Ecuador, Mexico, Peru, Venezuela
[β]Not nationally representative
[γ]Chronic back pain
[δ]Chronic low back pain
[ε]One year back or neck pain prevalence
[ζ]Any back pain
[η]Canadian survey only on people aged 20 to 69
[θ]Colombian and Mexican survey only on people aged 18 to 65
[ι]Israeli survey only on people aged 21 and above
[κ]Japanese survey only on people aged 20 and above
[λ]Korean survey only on people aged 40 to 79

Demographic differences within countries are also relevant due to varying distributions of people within countries, which will in turn translate to different burdens on the societies. For example, age-related low back pain prevalence data may also differ by region due to different age distributions in different regions. Assessing the prevalence in various age groups, within different geospatial areas, is thus important for public health interventions. Geospatial differences in age groups have been seen internationally within countries. For example, the prevalence of low back pain in Spanish people, according to national survey data, was 8.7% in people below the age of 40, was 23.7% in people between 40 and 65 years old, and was 34.8% in people older than 65 years (Alonso-García and Sarría-Santamera, 2020). Another example is sex-specific differences within regions: the prevalence of limiting low back pain in Malta was higher in females (7.0%) than in males (5.6 %) (Cuschieri *et al*., 2020). In Spain, the one-year prevalence of low back pain was also higher in females (24.5%) compared to males (17.1%) (Alonso-García and Sarría-Santamera, 2020). The point prevalence of low back pain in Germany was also higher in females (38%) than in males (35.3%) (Schmidt *et al.*, 2007). Finally, the prevalence of low back pain was also higher in females (37.2%) than in males (25.8%) in Greece (Stranjalis *et al.*, 2004).

Large countries that cover a lot of land mass and consist of various regions that are quite different from each other (such as the terrain of the land, the climate, the regional socioeconomic opportunities, the population demographics [such as age- or race-specific distributions], as well as the cultural practices of the people and their corresponding lifestyles and habits) may also have differences in their low back pain prevalences. A study that looked at the prevalence of low back pain in China between 1990 and 2016 also found small (approximately 5%) regional differences in low back pain between provinces in the country (Wu *et al.*, 2019). A study conducted in Germany found that there were regional differences in disabling back pain within Germany itself. The odds of having disabling back pain were significantly higher in residents from Marburg (OR: 1.09), Bochum (1.17), and Lübeck (1.12) than those in Göttingen (0.86) (Schmidt *et al.*, 2007). The US is a very large country, comprising of regions and states that are quite different from each other. States and regions can be made of different demographic distributions (age, sex, and socioeconomic status), and they also have different geography. State-specific differences have been found in other musculoskeletal pain types (Barbour *et al.*, 2016b). Figure 1.1 highlights that there are indeed state-specific differences in low back pain trends

according to data from the Global Burden of Disease Study. US regions (the Midwest, Northeast, South, and West) have also been assessed for cross-sectional low back pain prevalence at three time points. In 1997, the prevalence of low back pain was 28.7% in the Midwest, was 27.1% in the Northeast, 27.5% in the South, and 30.0% in the West. In 2010, the prevalence of low back pain was 28.1% in the Midwest, was 28.0% in the Northeast, was 28.3% in the South, and was 29.3% in the West. Finally, in 2012, the prevalence of low back pain was 30.2% in the Midwest, was 25.7% in the Northeast, was 27.2% in the South, and was 29.1% in the West (CDC, 2013). From these CDC report data, it appears that the prevalence of low back pain was slightly different between regions in 1997 (within 3%), had virtually aligned by 2010 (within 1%), and were then slightly different again in 2012 (within 5%). In years where the low back pain did differ regionally (1997 and 2012), the prevalence of low back pain was slightly higher in the Midwest and West compared to the Northeast and South. It is, however, unclear whether these trends are consistent over time, or whether the geospatial trends of low back pain are in fact in flux.

Given that research on geospatial trends of low back pain are extremely limited (partially because the definitions of low back pain are often inconsistent, and partially because there are very few studies that examine these geospatial trends), it is difficult to use previous literature to propose potential drivers of low back pain-specific regional differences. One suggestion as to geospatial discrepancies of low back pain includes social advantages and disadvantages, including education quality (Schmidt *et al*., 2007). Indeed, as socioeconomic status is negatively associated with low back pain (Shmagel, Foley and Ibrahim, 2016) (which will be discussed later in this literature review), areas of lower socioeconomic status could indirectly drive regional discrepancies. One such example is Germany: regions where residents had lower education levels had higher odds of reporting low back pain (Schmidt *et al*., 2007). Furthermore, the CDC have conducted cross-sectional geospatial mapping of physical activity levels (CDC, 2020a) and BMI (CDC, 2019b) in the US, where they demonstrate clear trends of different lifestyles in people who resided in the Midwest and South compared to those who resided in the West and Northeast. Since increased BMI and physical inactivity are detrimental lifestyle choices that are frequently associated with increased reports of musculoskeletal pain, including low back pain (Peng, Pérez and Gabriel, 2018; Alzahrani *et al*., 2020), it is possible that a geospatial discrepancy could arise as a result of different lifestyle practices of different people in different

regions. Researchers who have investigated geospatial discrepancies of other types of pains (including unspecific chronic pain as well as other musculoskeletal pain types) have attributed potential geospatial trends to ethnic and cultural differences between people (Moreno-Montoya *et al*., 2015) and even environmental factors such as temperature extremes, altitude, and distance to the sea (İnanır et al., 2013), which could in turn affect the cultural practices and general wellbeing of the population.

1.2.1.2.1 In summary: on the geospatial research of low back pain

The literature I have reviewed on the geospatial trends of low back pain demonstrate how difficult it is to ascertain low back pain spatial trends due to heterogeneity of methods, but that it is necessary to know these trends. Furthermore, without knowing whether the prevalence of low back pain is changing over time, it is not possible to know whether low back pain prevalence data, when methodologically similar, are comparable. Within the context of the US, the geospatial trends in low back pain are largely unavailable, with the exception of a CDC report (CDC, 2013). Although the CDC report gives three temporal snapshots, it does not show whether the prevalence of low back is spatially dynamic, or whether geospatial trends are in fact consistent across time. Likewise, no information is available on the prevalence of low back pain within various demographic groups (such as age and sex) in the context of various geospatial areas in the US, or indeed in any country. Defining whether the population dynamics of a particular geospatial area behaves in a similar fashion to the overall population could be useful for forecasting the cost and social burden of low back pain.

1.2.2 Demographic trends

1.2.2.1 Low back pain and age

Age has previously been associated with low back pain, where increasing age is associated with greater low back pain reports (Shmagel, Foley and Ibrahim, 2016; Wu *et al.*, 2019; 2020). Indeed, the Global Burden of Disease Study 2017 found that, on a global level, the prevalence of low back pain increased incrementally from 7% in 20 to 24 year olds, to between 19% and 24% in 80 to 84 year olds, and then decreased fractionally in age groups aged 85 and above (Wu *et al.*, 2020). A study done in China also showed that the prevalence of low back pain increased stepwise incrementally from childhood until age 85 to 89, and then decreased slightly (Wu *et al.*, 2019).

There are, however, discrepancies in the age-related trends of low back pain. For example, *The Low Back Series* (paper 1), a working group of numerous leading low back pain epidemiology researchers producing coordinated papers in *The Lancet*, has suggested that low back pain is actually highest in the working population (Hartvigsen *et al.*, 2018). A systematic review of 165 studies from 54 countries examined global low back pain, and found that the peak prevalence of low back pain occurred between the ages of 40 and 69 years old (Hoy *et al.*, 2012), which would align well with the notion that the middle- and older-aged working populations have the highest prevalence of low back pain, as opposed to the elderly. I discussed in section 1.2.1.2 the heterogeneity of low back pain prevalence across different countries, and the aforementioned study comprised papers of 54 countries. The authors did indeed indicate that there was high heterogeneity in studies. Another systematic meta-synthesis of 56 epidemiological studies, although older than Hoy *et al.* (2012), has even suggested that low back pain lifetime prevalence is reached by 18 years of age (Jeffries, Milanese and Grimmer-Somers, 2007). Indeed, reports of low back pain in children are not uncommon. Children as young as seven years old have reported low back pain, albeit a small prevalence (between 1% and 6% in children between the ages of seven and ten years old). In adolescents between the ages of 14 and 16 years old, the prevalence of low back pain was estimated at 18% (Taimela *et al.*, 1997). More recent cross-sectional research has suggested that the point prevalence in children aged 10 to 17 was 8.6%, the one-year prevalence was 47%, and the lifetime prevalence was 65.1% (Minghelli, 2020).

Pain severity, too, has been associated with age. Older people have reported more severe low back pain compared to younger people (Dionne, Dunn and Croft, 2006; Wong, Karppinen and Samartzis, 2017). Age has also been associated with disability due to low back pain. Young adults with low back pain had significantly lower levels of disability compared to older adults with low back pain, including having greater low back pain-related problems with motion, sleeping, and socialising (Stanisławska *et al.*, 2019). Indeed, the risk of functional disability has been shown to be reduced only until the age of 30 (Mather *et al.*, 2019). If age is only protective of low back pain consequences until the age of 30, then knowing the prevalence of low back pain in various age groups is critical for planning ahead for the burden of low back pain.

Vlaeyen *et al*. (2018), in a disease primer review, proposed that the current data on low back pain and age may in fact be misleading. National surveys could potentially address the mismatch (Vlaeyen *et al.*, 2018). Norwegian population-based data (the HUNT studies) from the mid-1990's showed that low back pain increased with age in both males and females. The prevalence of low back pain in those aged 20- to 39-years-old was 14.2% in men, and 18.6% in females, in those aged 40 to 59 years was 24.8% in males and 30.6% in females, in those aged 60 to 79 years was 23.7% and 30.3% in females, and in those aged 80 years and above was 20.6% in males and 26.7% in females (Heuch *et al.*, 2010). These data also suggest that the peak prevalence of low back pain occurs between age 40- and age 79-years-old.

Cross-sectional research has, like the HUNT studies, been conducted on national health surveys from the US. Research using the NHANES (Continuous) survey found, in a cross-sectional study of the 2009-2010 data, that the prevalence of low back pain increased significantly in ascending age groups. Compared to 20- to 29-year-olds, the odds of having low back pain in 30- to 39-year-olds was 1.39, was 1.27 in 40- to 44-year-olds, was 2.03 in 50- to 54-year-olds, and was 2.07 in those between 60- and 69-years-old (the oldest group analysed) (Shmagel, Foley and Ibrahim, 2016). Whilst this research showed an age-related trend, the study did not analyse those who were older than 69-years-old, and the small decrease in low back pain is thus not available from these results. Other nationally representative data form the US between 2009 and 2012 (using the NHIS) showed that the prevalence of low back pain increased with age, and peaked at age 56 to 64 years old (33.9%). The prevalence of low back pain in 18- to 25-year-olds was 19.2%, increasing to 26.0% in 26- to 40-year-olds, was 31.4% in 41- to 55-year-olds, was 33.9%

in 56- to 64-year-olds, was 31.4% in 65- to 74-year-olds, and was 32.0% in those aged 75- to 85-years-old (Yang and Haldeman, 2018). More recent NHIS data (2015) showed that the prevalence of low back pain increased from 23.1% in 18- to 39-year-olds, to 33.4% in 40- to 59-year-olds, and only fractionally to 35.3% in adults aged 60-years-old and above (Peng, Pérez and Gabriel, 2018).

Research has suggested, at different cross-sectional points in time and on different samples, that there is an age effect on low back pain prevalence. What is not clear from the research, however, is at what age low back pain prevalence peaks. Clarification of the prevalence of low back pain is required in order to ascertain what the pattern of low back pain is over the course of the adult lifetime in those who are affected. It may also be that there are regional differences in the relationship between age and low back pain, or it may be that the relationship between age and low back pain is mediated by another factor (such as physical inactivity or BMI). However, due to the heterogeneity in low back pain definitions in the literature, the relationship between age and low back pain remains somewhat unclear. The starting point is to ascertain whether a similar prevalence pattern in various age groups is seen over time, in a standardised manner of assessment, may shed light on how low back pain looks in various age groups.

1.2.2.2 Low back pain and sex

Low back pain been associated with sex across much research, where females tend to report more low back pain compared to males, across time and geography (Stranjalis *et al.*, 2004; Schmidt *et al.*, 2007; Hoy *et al.*, 2012; Maher, Underwood and Buchbinder, 2017; Mather *et al.*, 2019; Wu *et al.*, 2020). The global prevalence of low back pain has been estimated at 29.4% in males, and 35.3% in females (Hoy *et al.*, 2012).

The disparity in low back pain prevalence is also present in all age groups, where females have higher prevalence of low back pain across the lifetime, irrespective of the low back pain definition or methodology used (Hoy *et al.*, 2012; Wáng, Wáng and Káplár, 2016; Wu *et al.*, 2020). Menopause has been cited as a potential factor for increased low back pain in females compared to males, as sex hormones may influence the extent to which spinal discs degenerate (Wang and Griffith, 2010). Whilst a menopause link may well exacerbate the sex differences

later in life, it could not be the sole reason for it, as females report more low back pain than males across all age groups (Yang and Haldeman, 2018; Wu *et al.*, 2019).

Other mediating factors have also been investigated, of which one example is obesity. Females have higher odds of having low back pain compared to males in all BMI-matched categories, (Peng, Pérez and Gabriel, 2018). Furthermore, one population-based study has shown that obesity is a significant risk factor for low back pain in women, but not so in men (Shiri *et al.*, 2019). As well as having higher odds of low back pain in each BMI category, females also have higher odds of low back pain compared to males in various physical activity categories. Irrespective of the amount of physical activity done, the odds for females to have low back pain was always higher than that of males in the physical activity category in question (Yang and Haldeman, 2018).

Socioeconomic status has also been investigated as a potential mediator for the low back pain difference between the sexes. The research conducted by Yang and Haldeman (2018) examined sex-specific trends within other demographic variables known to associate with low back pain. For example, the prevalence of low back pain in females was higher than that of males across all matched age groups, across all education statuses (ranging from less than high school to a Master's degree), as well as across all but one income category (annual household income of $35 000 to $64 999) (Yang and Haldeman, 2018).

In the US, cross-sectional research on low back pain using population-based surveys has also shown that the prevalence of low back pain is higher in females compared to males. From research on 2009-2010 NHANES (Continuous) research, the odds of low back pain in females was 1.28 times that of males, in the representative US population (Shmagel, Foley and Ibrahim, 2016). Grouped, cross-sectional analyses using 2009 to 2012 NHIS data showed that the prevalence of low back pain was higher in females (30.5%) compared to males (26.5%) (Yang and Haldeman, 2018). More recent NHIS data (2015) showed that the nationally representative prevalence of low back pain in males was 28.5%, compared to 31.3% in females (Peng, Pérez and Gabriel, 2018).

The research is conclusive on the association between low back pain and sex. What we do not know, however, is whether the association between low back pain and sex remains significant when applying the same criteria in assessing low back pain, within the context of the US.

1.2.2.3 Low back pain and socioeconomic status

Socioeconomic status can be measured using a number of metrics. Here, I discuss the relationship between low back pain and employment status, education level, and income level, individually.

1.2.2.3.1 Employment status

Low back pain has long been associated with socioeconomic status, where the trend shows that increasing socioeconomic status has been associated with reduced low back pain reports. A number of socioeconomic status indices have shown this trend, including employment status (Shmagel, Foley and Ibrahim, 2016; Ikeda *et al.*, 2019). In particular, within those who are employed, the type of work is also important. For example, more manual or physical working roles are associated with low back pain. Workers whose job involves regular heavy lifting have an increased risk of low back pain (Heuch *et al.*, 2017; Shiri *et al.*, 2019), possibly also exacerbated by waist circumference, which is also known to associate positively with low back pain (Shiri *et al.*, 2019). Sciatica (defined in the review in question as being an umbrella term for compression of the sciatic nerve accompanied by pain, due to heterogeneity in definitions across the research papers used for their review) has also been associated with type of employment, where being a manual labourer (more than two hours of manual labour per day), being a routine labourer (more than two hours per day), and working with the trunk flexed (more than two hours per day) resulted in higher odds of low back pain compared to desk work (Parreira *et al.*, 2018). Finally, low back pain has been significantly associated with work absenteeism on a global scale (Dagenais, Caro and Haldeman, 2008; Patrick, Emanski and Knaub, 2014). Furthermore, the most common reported cause of work disability in the US was in fact back or neck problems (Theis *et al.*, 2018). Having a good understanding of how low back pain associates with various employment statuses, and where the corresponding burdens to the workforce are, is critical. While it is useful to understand low back pain in various employment groups (such as manual labour versus desk work), it is also necessary to examine the whether there is a difference in low back pain trends between those who are employed and those who are unemployed.

One cross-sectional study using nationally representative research from the US did investigate employment (employed and unemployed) status and low back pain. According to 2009-2010 NHANES (Continuous) data, low back pain was significantly higher in people who were looking for work (odds ratio 1.17) and in those without work (odds ratio 1.79) compared to people who were working for pay (Shmagel, Foley and Ibrahim, 2016). The cross-sectional nature of these findings do not, however, give a direction of causality in the population. It is unclear whether the unemployed are more likely to get low back pain, or whether people develop low back pain and, in turn, end up leaving work.

Employment status was also significantly associated with people with low back pain that had sought healthcare ten or more times in the year prior to taking the survey. Compared to people who were employed, those who were looking for work were 1.82 times more likely to have sought care, while those who were not working were three times as likely to have sought care ten or more times that year (Shmagel, Foley and Ibrahim, 2016). It is interesting to note that healthcare-seeking behaviour is therefore greater in people with lower socioeconomic status, which begs the question of what the prevalence of low back pain is in the unemployed, and what kind of burden is resultant of that low back pain.

Other available research on employment and low back pain has investigated demographic trends, within the workforce, as it is possible that employment status may mediate the relationship between low back pain and demographics. According to these nationally representative US-based data, the prevalence of low back pain in all workers was 25.7%. The prevalence of low back pain was 24.5% in the male workforce, while it was 27.1% in female workers, aligning with the general sex trends. However, the prevalence of low back pain in younger workers was 23.8% and 27.7% in older workers, which is in fact more similar than age-based trends suggest, and so it is then possible that socioeconomic status and/or employment status may mediate the relationship between low back pain and age. The prevalence of low back pain even within workers did, however, increase incrementally with age, where the prevalence of low back pain in 18 to 25-year-old workers was 21.2%, was 25.0% in 26- to 40-year-olds, was 27.6% in 41- to 55-year-olds, and 28.0% in those aged 56- to 64- year-olds (Yang *et al.*, 2016). The demographic trends within the workforce align with overall population-based trends. The research does not, however, offer information on unemployment and low back pain.

What the literature does not show, therefore, is what the prevalence of low back pain is within different employment statuses is across time, using a standardised assessment of low back pain that is representative of the population. Whether there is an association between employment status (a direct comparison of people who are employed versus those who are unemployed) and having low back pain, at the level of the US population, over time is also unknown. Hence, we cannot say, with the available research, whether a potential association has existed at various points in time, or whether it occurs across time, irrespective of different generations within the workforce.

1.2.2.3.2 Education level

Low back pain has also been associated with education status in various regions across the world (Schmidt *et al.*, 2007; Fujii and Matsudaira, 2013; Shmagel, Foley and Ibrahim, 2016; Peng, Pérez and Gabriel, 2018; Shiri *et al.*, 2019; Alonso-García and Sarría-Santamera, 2020). As a stand-alone factor, education status has also been associated with low back pain. A cohort in Japan showed, after adjusting for age, that the odds ratio for having low back pain was 1.21 in those who had less than college education (Fujii and Matsudaira, 2013). Spanish national survey data from 2017 also showed that, with decreasing level of education, came increasing prevalences of low back pain. The prevalence of low back pain in people with a university qualification was 13.4%, however, was 17.9% in those who completed high school, was 29.0% in those who completed elementary school, and was 38.4% in those who had less than elementary school (Alonso-García and Sarría-Santamera, 2020).

Education level has also been found to mediate the relationship between low back pain and other factors known to associate with it, such as physical activity, and manual occupations. For example, one study found that, in low back patients who participated in a randomised controlled trial promoting physical activity, the odds of patients with an education of secondary school or above being physically active was more than five times that of patients who had an education level of below secondary school (Schaller *et al.*, 2017). Likewise, low education level has also been associated with higher work place activity (Schaller *et al.*, 2017), which is a risk factor for low back pain itself. Population-based research in France showed that the odds ratio for low back

pain in men was 1.75 for when they did not have a diploma. When the model was adjusted for physical workload, however, the odds ratio reduced to 1.02 (Leclerc *et al.*, 2009), The reduced odds ratio indicates that education level may mediate the relationship between employment status and low back pain, as education level may be dictating the type of work people do (manual or desk work, for example). Low education level has also predicted longer low back pain episode duration, and poorer health outcomes thereafter (Dionne *et al.*, 2001). Education level is thus a critical factor in the development in low back pain, and understanding the epidemiology thereof is necessary.

A few cross-sectional studies on low back pain and education status have also been done in the US. According to 2009-2010 cross-sectional data from the NHANES (Continuous) population-based survey, having an education below a high school education was associated with low back pain. Compared to people who had a college degree or higher, the odds of having low back pain increased in those with a GED (General Education Development) or AA (community college Associate's) degree (odds ratio 1.99), and were highest in those who had less than a high school completion (odds ratio 2.27) (Shmagel, Foley and Ibrahim, 2016). Research from the same time (2010) from the NHIS survey showed that the prevalence of low back pain in the workforce also differed by education level. The prevalence of low back pain in US workers who had an education level of less than high school was 29.2%, as well as in those who had some college, indicating that an incomplete education level may result in greater prevalences of low back pain. US workers with a minimum of a high school diploma had a low back prevalence of 25.7%, while those with a college education and those with a Master's degree or above had a low back prevalence of 21.6% and 21.1%, respectively (Yang *et al.*, 2016). Another study on aggregated NHIS data from 2009 until 2012 also showed that the prevalence of low back pain increased with decreasing education level. The prevalence of low back pain in people who had a Master's degree was 22.2%, was 22.9% in those who completed college, was 30.1% in those who did some college, was 29.5% in those who completed high school, and was 34.4% in those who had less than a high school completion (Yang and Haldeman, 2018). More recent (2015) cross-sectional NHIS research showed that the prevalence of low back pain in those who had an associate degree or higher was 27.1%, compared to the 33.7% of people who had less than an associate degree with low back pain (Peng, Pérez and Gabriel, 2018).

There is a fair amount of cross-sectional evidence for the association between low back pain and education level, in representative US samples. The research is, however, limited to a period between 2009 and 2015. It is not clear whether the education trend is a long-standing one in the US, using a standardised question and representative sample.

1.2.2.3.3 Income level

Low back pain prevalence also changes with changing income levels, where the prevalence of low back pain increases in people who fall into lower income categories. Low income has been associated with low back pain according to nationally representative survey data from the US in 2009-2010. The odds of having low back pain increased in each decreasing annual household income bracket. Compared to people with an annual household income of over $100 000, low back pain increased in those with an income of $65 000 to $99 000 (odds ratio 1.18), income $45 000 to $64 000 (odds ratio 1.36), income $20 000 to $44 000 (odds ratio 1.42), and income below $20 000 (odds ratio 2.29) (Shmagel, Foley and Ibrahim, 2016). Income source may also be important, where having disability grant income is also associated with low back pain (odds ratio 2.62, compared to those without disability income grants) (Shmagel, Foley and Ibrahim, 2016). It is, however, unclear whether disability grants have increased odds of low back pain because they are *disability* grants, or whether the trend simply aligns with the income effect.

Prevalence also increases in a step-wise manner with changing income levels. The prevalence of low back pain, in nationally representative US survey data from 2009 until 2012 (the NHIS) showed that people in the highest earning tier ($65 000 to $75 000 and above) had a low back prevalence of 23.5%, while people with earnings of $35 000 to $64 999, $15 000 to $34 999, and less than $15 000 had prevalences of 25.9%, 27.7%, and 28.3%, respectively (Yang and Haldeman, 2018). Likewise, NHIS prevalence data from 2010 only showed that prevalence of low back pain in the US workforce decreased with increased earnings. The prevalence of low back pain in US workers with an income of $65 000 or above was 24.8%, was 25.7% in those with an income of between $35 000 and $64 999, was 27.1% in those with an income of between $15 000 and $34 999, and was 28.8% in those with an income of less than $15 000 was 28.8% (Yang *et al.*, 2016).

Like education status, the trend between low back pain and income status has been shown in a nationally representative US sample. What could be added to the literature is repeated analyses with standardised low back pain measurements in order to establish whether the income-low back pain trend occurs over time, as the average annual household income has increased across the US, between the 1990s and the present day.

1.2.3 Lifestyle risk factors

1.2.3.1 Low back pain and BMI

Low back pain has been extensively associated with BMI, where increased BMI associates with more low back pain reports (Heuch *et al.*, 2010; Smuck *et al.*, 2014; Shmagel, Foley and Ibrahim, 2016; Parreira *et al.*, 2018; Peng, Pérez and Gabriel, 2018; Shiri *et al.*, 2019). Some research, using data from US healthcare databases, have even suggested that being obese increases the risk of low back pain six-fold compared to those who are not obese (Shemory, Pfefferle and Gradisar, 2016), and BMI is a risk factor for low back pain irrespective of demographic groups known to have different low back prevalences, such as sex (although it is possible for demographic-specific physiology to exacerbate the BMI effect) (Zhang *et al.*, 2018).

Cross-sectional population-based research has shown the relationship between increased BMI and low back pain, and has shown this trend across multiple time points. Norwegian population-based research from 1995 to 1997 investigated the relationship of BMI with low back pain, and found that the prevalence of low back pain increased incrementally with each increasing BMI category. The increase was shown in both sexes individually, although the low back pain prevalence in females was higher compared to males in each BMI category. Even after adjusting for sociodemographic factors (such as education, smoking, leisure-time physical activity, work status, and work activity), the odds of low back pain were increased by 1.08 in males and by 1.17 in females for every 5 $kg.m^{-2}$ increase in BMI (Heuch *et al.*, 2010). Finnish longitudinal population-based research also found a step-wise incremental increase in odds ratio with each increasing weight category, based on BMI. Another study found that the odds ratio of low back pain in the previous month was 1.30 times in overweight people, and was 1.62 times in obese participants, compared to people within a normal BMI range (Shiri *et al.*, 2010).

The prevalence of low back pain in Spain also increased with increasing BMI, according to nationally representative data from the 2017 National Health Survey. The prevalence of low back pain in people with a normal BMI was 15.5%, was 23.2% in overweight people, and was 29.6% in obese people (Alonso-García and Sarría-Santamera, 2020). What is noteworthy, however, is that overweight people outnumber normal weighted people in Spain. The number of overweight people in Spain is 3.17 million, while the number of obese people is 1.88 million, and those of

normal weight is 2.74 million (Alonso-García and Sarría-Santamera, 2020). The number of people with an unhealthy BMI is in fact almost double those of normal BMI, which could result in a significant low back pain burden on Spanish society. The US also has a high proportion of people with increased BMI, and the proportion is growing. Between 1999-2000 and 2017-2018, the age-adjusted obesity prevalence increased from 30.5% to 42.4% of the population. Severe obesity also increased in the same timeframe, from 4.7% to 9.2% (Hales *et al.*, 2020). Given the high and rising proportions of increased BMI, and the association between BMI and low back pain, low back pain temporal trends may also be affected, and need to be evaluated.

Sciatica has also been associated with increased BMI, according to an umbrella review that included 15 systematic reviews and 134 cohort studies (Parreira *et al.*, 2018). Finnish prospective cohort studies on sciatica hospitalisations (where sciatica was defined as pain radiating from the lower back to the back of the thigh and down the leg, and accompanied by clinical findings suggestive of compression and irritation of the lumbosacral nerve root) were analysed for risk factors. The study found that obesity increased sciatica hospitalisations by 36% when defined by BMI, and by 41% when defined by waist circumference (Shiri *et al.*, 2017).

The association between BMI and low back pain has also been shown in US-based research. Cross-sectional research using nationally representative 2009-2010 NHANES (Continuous) data found that increasing weight categories were significantly associated with low back pain. The odds of having low back pain increased to 1.14 in those who were overweight ($25 kg.m^{-2} \leq BMI \leq 30 kg.m^{-2}$), and to 1.46 in those who were obese ($BMI > 30 kg.m^{-2}$), compared to those with a BMI of below $25 kg.m^{-2}$ (Shmagel, Foley and Ibrahim, 2016). A NHIS study from the same timeframe (2010) indicated similar results, where the prevalence of low back pain in those with a normal or underweight BMI was 24.5%, while it was 27.7% in overweight people, and 34.9% in obese people. Indeed, the relationship was significant, where being overweight increased odds of low back pain by 1.14, and being obese increased the odds of low back pain by 1.42 (Yang and Haldeman, 2018). The prevalence of low back pain was also significantly higher in each successive BMI group within each sex separately. Research done using the NHIS database slightly more recently, in 2015, also showed that the prevalence of low back pain was higher in ascending BMI categories. The prevalence of low back pain in underweight people was 24.1%, was 25.0% in people of normal BMI ($18.5 kg.m^{-2} \leq BMI < 25 kg.m^{-2}$), was 29.6% in those who

were overweight ($25 kg.m^{-2} \leq BMI < 30 kg.m^{-2}$), and 36.4% in those who were obese ($BMI > 30\ kg.m^{-2}$) (Peng, Pérez and Gabriel, 2018).

The relationship between BMI and low back pain is, therefore, well-documented in the US and abroad. From the small timeframe available (2009 until 2015), the BMI-related trend continues to emerge from data. The prevalence of obesity in the US is high and rising, and is approximately 42.4% (Hales *et al.*, 2020), and obesity is common in people with chronic pain (Okifuji and Hare, 2015). Obtaining BMI-related trends is therefore critical within the context of the US. Long-term, repeated analyses on data that uses the same low back pain assessment methods are not available in the current literature, resulting in an inability to establish whether the BMI-related trends are a consistent problem within the context of the US.

1.2.3.2 Low back pain and physical activity

Leisure-time physical activity has been inversely associated with low back pain. Longitudinal population-based research from Finland compared people who perform high and moderate leisure-time physical activity to people who perform low leisure-time physical activity, and found that the odds of low back pain are reduced in those who perform moderate (0.86) and high (0.70) physical activity (Shiri *et al.*, 2019). Spanish national survey data also showed an increasing prevalence of low back pain with less physical activity. People who were physically inactive had a low back prevalence of 25.3%, which was higher than those who participated in physical activity occasionally (21.6%), and those who were regularly physically active (13.5%) (Alonso-García and Sarría-Santamera, 2020). Even walking or cycling to work has been shown to reduce hospitalisations for sciatica in prospective cohorts from Finnish national surveys, independent of body weight and leisure-time physical activity (Shiri *et al.*, 2017).

However, many barriers remain in getting people with low back pain to perform physical activity. Amongst low back patients who participated in a randomised controlled trial promoting physical activity, “being tired” (59%), “pain” (59%), and “stress” (50%) were the most frequent barriers to physical activity cited. The number of people who reported these barriers was also significantly higher in inactive compared to active study participants. Other barriers cited significantly more in people who were inactive compared to those who were active included “not

feeling like it", "wanting to stay home", being "depressed", and "forgetting to do sport" (Schaller *et al.*, 2017).

Another difficult aspect of the relationship between low back pain and physical activity is the interaction of BMI. Physical activity can, however, attenuate the effects of low back pain in people with unhealthy weights. Research has even proposed how each BMI group could benefit from exercise. For example, the amount of time spent sedentary was positively associated with low back pain in obese participants. In overweight participants, however, it was the number of minutes sustaining physical activity above 50 minutes in a session that showed an inverse effect with low back pain (Smuck *et al.*, 2014). Moreover, moderate physical activity has been inversely associated with low back pain in both the overweight and obese groups (Smuck *et al.*, 2014). Given the burden of obesity in the US (Hales *et al*., 2018), addressing physical activity is critical.

Within the context of the US, recent data using the NHIS (2015) showed that the prevalence of low back pain was more prevalent in less active groups. Compared to people who were physically active (meeting the guidelines of 150 minutes of activity per week) (prevalence of low back pain 25.4%), the prevalence of low back pain was higher in those were physically active, but did not meet physical activity guidelines (prevalence 31.8%), and those who were physically inactive (prevalence 36.2%) (Peng, Pérez and Gabriel, 2018). Earlier data from the US (aggregated NHIS data from 2009 until 2012) has also shown that low back pain increased significantly with decreasing physical activity level. Those who were regularly active had a low back prevalence of 22.2%, those who were insufficiently active had a low back pain prevalence of 26.7%, and those who were inactive had a low back prevalence of 31.3% (Yang and Haldeman, 2018). The prevalence of low back pain was also significantly lower in each successively more active group within each sex separately, with one exception where there was no difference in the low back reports of males who were inactive and those insufficiently active.

While the US-based literature has shown that the prevalence of low back pain differs in groups of varying levels of physical activity, there is no information on the association between low back pain and physical activity over time, despite the call to increase physical activity in the US population to address the burden of musculoskeletal pain. Establishing how the association between physical activity levels and low back pain looks over time is essential to knowing

whether the public health interventions are working, but that information is presently unavailable.

1.3 Conclusion: musculoskeletal pain epidemiology

I conducted a literature review to ascertain the current landscape of musculoskeletal pain, with particular reference to the United States. As well as using Google Scholar and PubMed, I also used the general Google search engine (to see whether there were any useful online dashboards put together by data scientists or data science students), the US Bureau of the Census, and websites of well-known US-specific population-based surveys administered by the CDC (namely, the Behavioural Risk Factor Surveillance System, National Health Interview Survey, and National Health and Nutrition Examination Survey Continuous). The types of literature I used included meta-analyses, systematic reviews, localised pain studies, national reports, and dashboards (such as those by the Global Burden of Disease collaborations together with the Institute for Health Metrics and Evaluation (IHME). I did not assign any time limits to my searches, although I always endeavoured to use the most up-to-date studies available, particularly when presenting prevalence data. The only time I opted to use older research was when demonstrating potential changes over time. My search terms included various combinations of the disease-states I investigated ("low back pain", "arthritis", "arthropathy", "musculoskeletal pain", and "chronic pain", where I searched for chronic pain in order to check whether any musculoskeletal pain variables were investigated within the chronic pain research). Other search terms on variables of interest included "age", "sex", "males and females", "income bracket", "education level", "employment status", "socioeconomic status", "BMI", "body mass index", "physical activity", and "exercise". I also tried to use nationally representative data when presenting data from various countries, and hence I used search terms, "nationally representative" and "population-based". Temporal and geospatial research is scarcely available, and I largely used online reports or dashboards (such as those published by the CDC). My search terms for temporal and geospatial research were initially specific (such as "temporal trends of painful arthropathies", or "geospatial trends of low back pain"), but then broadened to include terms such as "geography", "area-specific", "state-specific", and "over time". Finally, I also searched through papers published using data from population-based surveys in order to cross-

check for pain-related research, and hence I used search terms, “Behavioural Risk Factor Surveillance System”, “BRFSS”, “National Health Interview System”, “NHIS”, “National Health and Examination Nutrition Examination Survey”, “NHANES”, “Medical Expenditure Panel Survey”, “MEPS”.

I have demonstrated from the above literature review that musculoskeletal pain is highly prevalent in the US, particularly in the forms of painful arthropathies (approximately one in four US residents), and low back pain (between 18.7% and 38.9%, depending on how the low back pain was measured).

It is also clear that both painful arthropathies and low back pain vary when dissecting the population into various demographic groups. Cross-sectional research has shown that both painful arthropathies and low back pain have been associated with older age and female sex. The prevalence of painful arthropathies could be as high as 7% (8.0 million) in young adults (18- to 44-years-old), 29.3% (24.2 million) in middle aged adults (45- to 64-years-old), and 49.6% (22.2 million) in older adults (65-years-old and above) (Barbour *et al*., 2017a). The prevalence of generalised joint pain (as opposed to data that are obtained from people obtaining an official diagnosis) could be higher still. Low back pain, however, has been shown to increase incrementally from 7% in 20- to 24-year-olds, to between 19% and 24% in 80- to 84-year-olds (Wu *et al*., 2020). Prevalence reports in both painful arthropathies and low back pain have differed by sex. Painful arthropathy prevalence has been reported as higher in females (approximately 26%) than in males (19.1%), according to cross-sectional research (Barbour *et al*., 2017a). The prevalence of low back pain has been reported at approximately 29.4% in males, and 35.3% in females (Hoy *et al*., 2012).

Painful arthropathies and low back pain were also significantly with associated low socioeconomic status in the form of employment status, education level and income, in various cross-sectional studies. Likewise, cross-sectional research has also demonstrated the significant association between painful arthropathies and low back pain with lifestyle-related factors such as increased BMI and physical inactivity.

The above literature review also highlighted that there are some shortfalls in the available musculoskeletal pain research. The vast majority of chronic pain research (including painful arthropathies and low back pain) is cross-sectional, and geographically localised. Low back pain

research is also a challenge to compare temporally and geographically due to heterogeneity in study-specific definitions.

SECTION 2: THESIS RATIONALE, AIM, AND OBJECTIVES

Although much research has been done on pain, including various types of musculoskeletal pain, there is a dearth of analyses on long-term trends in pain. Even available longitudinal studies to date have been limited to only a few years, and are often geographically isolated. Based on these limitations, it is unclear what the prevalence of musculoskeletal pain looks like over time. In the limited available studies where a musculoskeletal pain trajectory is shown, such as that by Park, Mendy and Vieira, (2018) for arthritis, and that of Wu *et al.* (2020) for low back pain, the trajectories for multiple demographic profiles known to be affected by pain are limited or unavailable. Specifically, we do not know the prevalence trajectories of various musculoskeletal pain types within people of different ages, between the sexes, and in those of different socioeconomic statuses. Even the evidence for whether or not painful arthropathies (Barbour *et al.*, 2016a; Park, Mendy and Vieira, 2018) and low back pain (Freburger *et al.*, 2009; Wu *et al.*, 2020) are increasing or remaining steady is contradictory.

Furthermore, studies examining geospatial trends on musculoskeletal pain types themselves are also extremely limited. Even when such studies are available, they are often cross-sectional, and so we have no way of knowing whether geospatial trends of pain are in fact dynamic. Geospatial trends in particular demographic groups to date, to my knowledge, have not been established. In the case of low back pain, the prevalence of low back pain has been measured in such a heterogeneous manner that comparing regional prevalences is almost impossible.

Finally, whilst we know that there is an array of variables that have been associated with musculoskeletal pain (age, sex, socioeconomic status, BMI, and physical activity), we do not know whether these associations stand true over time at a national level.

In 2018, there was a call by the leading low back pain epidemiology researchers to standardise low back pain research methods. The aim of this standardisation was to address the difficulty in assimilating the available research on low back pain, as well as to improve low back pain population surveillance (Buchbinder *et al.*, 2018). Indeed, writing the literature review presented here on low back pain was challenging, as synthesising results from such different methods could often not be done.

Population-based surveys are a means of addressing these limitations to the current pain literature. Population-based surveys collect data from nationally representative samples, in the case of this thesis, from the US. The Behavioural Risk Factor Surveillance System (BRFSS), National Health Interview Survey (NHIS), National Health and Nutrition Examination Survey (NHANES) (Continuous) are three such US-based nationally representative surveys. The methodology used by these surveys will be expanded upon in Chapter Two of this thesis, however, they make use of complex survey designs and oversampling of minority groups, and provide design weights that, when analysed, provide data at a national level. These surveys also collect demographic information, including age, sex, socioeconomic indices (including employment status, annual household income, and education status). The surveys in question also collect data on lifestyle factors, including physical activity and BMI. Finally, and crucially for this work, these surveys collect data on musculoskeletal pain conditions. The BRFSS collects data on whether respondents have been diagnosed with a rheumatic disorder by a healthcare professional. The NHIS collects data on whether respondents have had joint symptoms, as well as whether they have had low back pain, within a specific timeframe prior to taking the survey. The NHANES (Continuous) collects data on whether participants have received an arthritis diagnosis from a healthcare professional.

Using national health surveillance data on musculoskeletal pain in order to explore the epidemiology of musculoskeletal pain could prove to be a powerful tool in understanding the epidemiology of various types of musculoskeletal pain within the context of time, space, demographics, and lifestyle – and all at a national level. These data, therefore, offer the chance to use statistically powerful methods to evaluate musculoskeletal pain on a large scale. Finally, the use and analysis of US-based population health survey data can assist to inform and streamline processes for the implementation of such long-term surveillance in South Africa.

This thesis, thus, addresses the epidemiology of musculoskeletal pain (including temporal trends, geospatial trends, and demographic- and lifestyle-related factors that associate with musculoskeletal pain) in the US nationally, from 1996 to 2018.

1.4 Aim and objectives

1.4.1 Aim

To establish temporal and spatial trends of musculoskeletal pain (in the form of painful arthropathies, and low back pain), as well as demographic and lifestyle-related factors frequently associated with musculoskeletal pain, in the United States of America, between 1996 and 2018.

1.4.2 Objectives

Using three long-running population-based survey data sources (BRFSS: 1996 to 2018; NHIS: 1997 to 2018; NHANES (Continuous): 1999 to 2018), I will address the following objectives related to musculoskeletal pain experienced by people in the US:

a) To establish temporal trends in the prevalence of painful arthropathies, and of low back pain
b) To establish spatial trends in the prevalence of painful arthropathies (by state and region), and of low back pain (by region)
c) To describe the association between demographic factors (age, sex, and socioeconomic status) with having a painful arthropathy, or low back pain
d) To describe the association between lifestyle-related factors (BMI, and physical activity) with having a painful arthropathy, or low back pain.

CHAPTER TWO

Methods

SECTION 1: POPULATION-BASED SURVEYS AS A DATA SOURCE

In order to address my thesis objectives at the level of a nationally representative population, and over time and space, I used population-based surveys administered in the US by the Centers for Disease Control and Prevention (CDC). This chapter describes the methods that I used in order to select relevant pain-related questions and corresponding data, set up appropriate design objects in order to account for complex survey designs, and ultimately conduct my data analysis. Data were obtained from three long-running population-based surveys from the US: the Behavioural Risk Factor Surveillance System (BRFSS), the National Health Interview Survey (NHIS), and the National Health and Nutrition Examination Survey (NHANES).

The surveys selected were surveys that, firstly, are well-established surveys that are administered to the US by the CDC. The surveys are, therefore, subject to scrutiny by the highest health authorities in the US. The surveys are also nationally representative, hence, the statistics obtained from them are applicable to the entire country and are not geographically isolated to one geographic location or health centre, hospital, university or the like. Furthermore, the national representation of the surveys mean that they are largely unbiased (such as, for example, research done at particular hospitals or health centres that only sample people who come to such places). The CDC has a number of ongoing surveillance systems in place. Of these, the largest and most general health-related surveys include the BRFSS, NHIS, and NHANES surveys. These surveys are large-scale, and assess numerous health-related outcomes in the population. The surveys that I selected are also long-running surveys, which means that questions asked to populations would be highly consistent, both in their wording as well as their administration. In turn, the consistency of the questions would result in more robust comparisons in outcome measurements over time. Finally, in order to be selected for this research, the survey in question had to contain questions related to pain (it became apparent during my searches through these three surveillance systems that the pain-related questions that were available were musculoskeletal in nature). Once I was certain that there were consistent long-running pain-related data available in each of the three surveys in question, I then looked for other variables of interest (such as age, sex, socioeconomic metrics, and lifestyle-related variables). The final test that I ran before I confirmed the selection of the surveys was to download one year's worth of data on each survey

and run an exploratory analysis on the data (including data cleaning, preparation, and analysis) in order to be certain that the data could address my objectives.

2.1 Behavioural Risk Factor Surveillance System (BRFSS)

As referred to in Chapter One of this thesis, the Behavioural Risk Factor Surveillance System (BRFSS) survey is a telephonic survey that collects health-related data on adult (aged 18 years or above) US residents. The BRFSS interviews over 400 000 non-institutionalised US residents per annum from all over the country, and is administered in English or Spanish. Data are collected by state and county, from all 50 US states, as well as the District of Columbia, and US territories (CDC, 2018). The BRFSS makes use of complex survey design, in the form of multistage sampling in clusters and strata, as well as the incorporation of design weights (Lumley, 2010). Surveys are conducted continuously over the course of the whole year. The structure of the questionnaires involves: i) a core section, asked to the entire sample, where questions are either asked every year (fixed core) or every other year (rotating core); ii) optional modules, decided at national level and asked to particular states; and iii) state-added questions, as defined by the state in question (CDC, 2018).

Potential BRFSS participants are sampled via their telephone numbers (landline only prior to 2011, and landline and cellular phone from 2011 onwards). The BRFSS assigns various deposition codes to different participants as part of a screening process. A large effort is made to reach respondents and assess eligibility, including up to 15 phone calls before assigning final deposition codes. Eligible people include adults living in private residence or college housing within the jurisdiction of the US, with an associated phone number. US residents in a holiday home for 30 days or more are also eligible. Eligibility is established by asking respondents whether they live in private residence, with definitions of private residence provided as needed. If a cellular phone that is used solely for business is sampled, the person associated with the number is not eligible. People living in group homes, military barracks, or other living arrangements are also not eligible for participation (CDC, 2019a).

The survey is constantly being updated in terms of sample size, methods, and questions. Keeping the BRFSS representative of the whole population is a priority. One of the largest

methodological improvements includes the incorporation of cellular phone sampling since 2011. Likewise, weighting methodology was also improved from 2011, where poststratification weighting methods were replaced with iterative proportional fitting, known as "raking". Raking is a more sophisticated weighting method in a number of ways. Firstly, raking allows for more demographic information to be incorporated into participant final weighting, and without requiring demographic information for small geographic areas. Secondly, as new demographic variables are included in the weighting information, so the final weight value adjusts to reach a final population-based weighting. Therefore, the BRFSS was able to incorporate not only age, sex, race, and geographic area into weighting methodology, but also demographic aspects such as education level, marital status, home ownership, and phone (landline or cellular) ownership (CDC, 2012). However, due to the amendments made to the BRFSS for data from 2011 onwards, prevalence measurements and analysis results pre- and post-2011 are inappropriate to compare, and the BRFSS panel has suggested that changes reflected in data analysis results were more likely better-estimated results, rather than a temporal change (CDC, 2012). I conducted analyses both before and after 2011, however I have clearly shown the breaks in my plots, as well as assessed growth rates pre- and post-2011 separately in my temporal analysis (Chapter Three).

In addressing my aim to evaluate musculoskeletal pain across time, space, demographic, and lifestyle-related variables, the questions I chose to use from the BRFSS were repeated across multiple years, as well as across different states. The BRFSS consists of a question on the diagnosis of painful rheumatic conditions in the population, which is repeated across surveys and is asked to people from various geographic areas. Therefore, I was able to use the BRFSS survey data to establish how time, space, demography (age, sex, and socioeconomic status), and lifestyle (BMI) interacted with musculoskeletal pain, in the form of painful rheumatic disorder diagnoses. Specific question selection is discussed later in this chapter. Full sampling details and response rates for each year of BRFSS data used are found in Appendix C.

2.2 *National Health Interview Survey (NHIS)*

The NHIS is a cross-sectional in-person household interview survey, also administered by the CDC as well as the National Center for Health Statistics (NCHS), that interviews civilian non-institutionalised US residents across 50 states and the District of Columbia. Group quarters (for

example homeless shelters, rooming houses, and group homes) are included. The NHIS also makes use of complex survey design, in the form of multistage sampling in clusters and strata, and inclusion of design weights (Lumley, 2010). Surveys are conducted continuously over the course of the whole year, and are nationally representative through oversampling minority groups. The interview consists of the NHIS Core, which is further divided into the Household Composition, Family Core, Sample Child Core, Sample Adult Core, and Re-contact information. Supplemental questionnaires may be added to the Core section, however these are often flexible and change annually (NCHS and CDC, 2018).

The NHIS exclusion criteria includes people who have no fixed address (excluding homeless shelters), people who live on military bases and active military personnel, people in long-term care institutions (old age homes, hospices, homes for the disabled, and wards for neglected and abused children), people in correctional facilities, and US nationals not currently residing in the US. The NHIS has been re-evaluated frequently and has also been updated every 15 to 20 years to cover more and more relevant health topics and refined weighting methodology. This thesis uses the survey with standardised design from 1997 until 2018 (NCHS and CDC, 2018).

Survey interviewers (field representatives) are trained and overseen by supervisors at the US Census Bureau Regional Offices, and can offer the interview in either English or Spanish. An "advance letter" is sent to sampled households explaining the survey, voluntary participation, and data protection information, in advance of the interview. Consent is obtained on arrival of the field representative. Computer-assisted technology for personal interviews is utilised by field representatives, and face-to-face interviews are conducted at sampled participants' homes. Participants may request a telephone interview, or telephone interview may be conducted if travel to the participant is not possible (for example, when road conditions make it difficult to schedule a personal visit) (NCHS and CDC, 2018). Field representatives are equipped with questionnaires, flashcards, as well as a manual and survey flowchart to facilitate and standardise the interview.

My thesis focuses on musculoskeletal pain, for which questions were available in the Sample Adult Questionnaire (asked to a randomly selected adult per household) of the NHIS survey. The Sample Adult Questionnaire consists of approximately 30 000 adult participants per year. Specifically, data on joint symptoms, as well as low back pain were used for this work, within

the context of temporal trends, geospatial trends (by US region), demography (age, sex, and socioeconomic status), and lifestyle factors (BMI and physical activity). Selection of specific questions is discussed later in this chapter. Sampling information and response rates for each year of analysis can be found in Appendix D.

Finally, a disclaimer, as requested by the NCHS: the data analyses in this work, the interpretations thereof, and the conclusions made are my own and/or in collaboration with my supervisors, and not those of the NCHS, which is only responsible for the initial data.

2.3 National Health and Nutrition Examination Survey (NHANES) (Continuous)

The National Health and Nutrition Examination Survey (NHANES) consists of various studies with the primary aim of assessing health and nutritional status of adults and children in the US. NHANES is administered by the National Center for Health Statistics (NCHS) and CDC, and consists of interviews and physical examinations. NHANES samples approximately 5 000 US residents per survey. NHANES survey data collection is nationally representative, and oversamples people aged 60 and above, African Americans, Hispanics, and low-income white people. NHANES sampling makes use of a multistage clustered sample design and design weights (Lumley, 2010), for which the details are available in Appendix E. From 1999, NHANES underwent revision and the NHANES Continuous began, where a dynamic structure was established such that the changing focuses on health status in the US could be met. Questions included in the survey cycles can therefore evolve according to national health objectives, or national health burdens. My research includes NHANES (Continuous) data (CDC and NCHS, 2020).

NHANES interviewers and field staff are selected on the basis of various academic requirements, skills, and knowledge, as well as their ability to speak both English and Spanish. Furthermore, field staff are extensively trained for the NHANES protocol, including interview and examination techniques and requirements. Informed consent is obtained before the interviews and examinations begin. Appointments are set up with respondents in advance, and interviews and examinations were approximately two weeks apart. The interview is conducted at

respondent's home residence, on individuals aged 12 and above (although only adults aged 18 and above were analysed for my own research) (CDC and NCHS, 2020).

The focus of this thesis is musculoskeletal pain. The NHANES (Continuous) contains a question about arthritis diagnoses amongst survey participants, asked over the full NHANES (Continuous) timeframe (survey cycle 1999-2000 until 2017-2018). Therefore, data obtained from the arthritis diagnosis question were analysed within the context of temporal trends, demography (age, sex, and socioeconomic status), and lifestyle factors (measured BMI). Specific question selection is shown later in this chapter. Sampling information and response rates for each year of analysis can be found in Appendix E.

2.4 Terminology and survey distinguishing

For ease of communication, I assigned the survey variables I used to various terminology. Figure 2.1 shows precisely what I am referring to when using this different terminology. "Painful arthropathies" is a term that applies to all the joint-related content of this thesis, namely rheumatic disorders (BRFSS), joint symptoms (NHIS), and arthritis (NHANES). Painful arthropathies and low back pain in turn were classified together as musculoskeletal pain. I have also colour-coded all survey results so graphs belonging to a particular survey are easily identifiable. BRFSS graphs are shown in blue, NHIS graphs (both for joint symptoms and low back pain, respectively) in purple, and NHANES graphs in green. Note however that choropleth maps are not colour-coded.

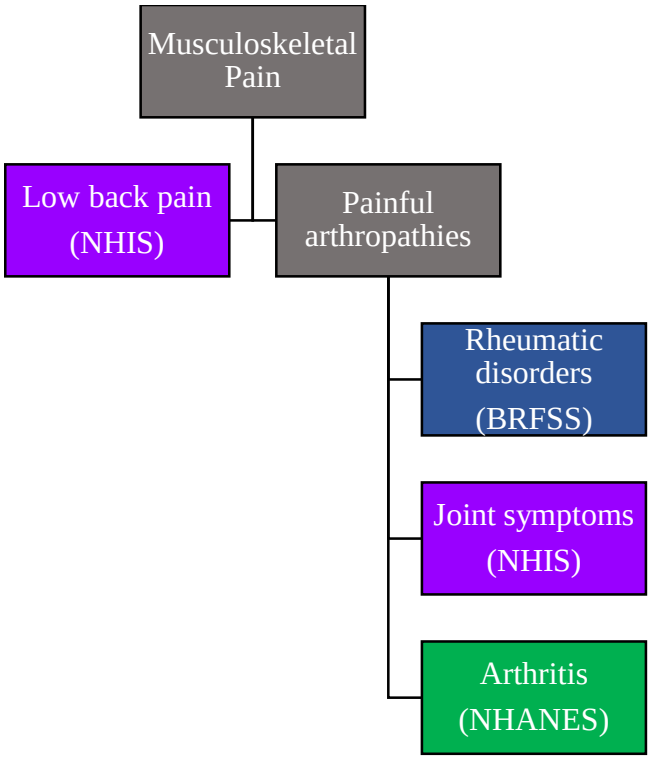


Figure 2.1: Schematic diagram showing a breakdown of terminology used, as well as colour-coding by survey

2.5 Ethical clearance

Data from all three surveys are made available to the public from open data sources, released under the ODC Open Database License (ODbl). All information is already de-identified in accordance with Health Insurance Portability and Accountability (HIPAA) guidelines of the US Department of Health and Human Services. Accordingly, an ethics waiver was granted from the University of the Witwatersrand Human Research Ethics Committee (Medical), reference number: W-CBP-180917-4 (Appendix B).

SECTION 2: QUESTION SELECTION

Survey questionnaires were electronically searched using the following search terms: “pain”, “arthritis”, “low back”, “age”, “sex”, “employ”, “education”, “income”, “physical activity”, and “BMI”. I also conducted a subsequent catchment manual search of survey questionnaires. The questions flagged with the aforementioned search terms were then assessed manually for relevance to my objectives, and the frequency and amount of time (number of survey cycles) they were asked over. Objective-based relevant questions with at least 10 years’ worth of data were retained for analysis. Tables 2.1, 2.2, and 2.3 consist of the final question selection.

Analyses on BRFSS questions (CDC, 1996 to 2018) were conducted from 1996 until 2018, with the exception of 2006 and 2008, where the question on rheumatic disorders was not included in the questionnaire. Although the rheumatic disorder diagnosis question was part of a module (not the BRFSS Core) in years 1996 to 2000, 2002, 2004, and 2010, and were therefore only asked in a few states and consequentially to fewer people, I included these years in my analysis. The NHIS analysis was done on questions from years 2002 to 2018 for joint symptoms, and from 1997 to 2018 for low back pain; except for 2004, where the stratum variable was missing from the data file (NCHS and CDC, 1997 to 2018). The NHANES data analysis was done on survey cycles 1999-2000 until 2017-2018 (CDC and NCHS, 1999-2000 to 2017-2018). The BMI variable for the NHANES (Continuous) surveys was obtained from the examination section of the survey, for all NHANES analyses.

Table 2.1: List of final question selection from the Behavioural Risk Factor Surveillance System (BRFSS), the survey codebook and data file variable name, and the years that the variable was used in my analysis

Research variable	Survey Question	Survey codebook variable name	Years for which question was included and analysed
Painful arthropathy/ arthritic pain	Have you ever been told by a doctor, nurse or other healthcare professional that you have some form of arthritis[α], rheumatoid arthritis, gout, lupus, or fibromyalgia?	HAVARTH3, HAVARTH2, HAVARTH	1996-2018 (except 2006, 2008)
Low back pain	-	-	-
Demographics: age and sex	What is your age?	_AGEG5YR, AGE	1996-2018 (except 2006, 2008)
	Indicate sex of respondent	SEX1, SEX	1996-2018 (except 2006, 2008)
Demographics: socioeconomic status	Are you currently: employed for wages, self-employed, out of work for 1 year or more, out of work for less than one year, a homemaker, a student, retired, unable to work	EMPLOY1, EMPLOY	1996-2018 (except 2006, 2008)
	Is your annual household income from all sources: less than $10 000, $10 000 to less than $15 000, $15 000 to less than $20 000, $20 000 to less than $25 000, $25 000 to less than $35 000, $35 000 to less than $50 000, $50 000 to less than $75 000, $75 000 or more	INCOME2	1996-2018 (except 2006, 2008)
	What is the highest grade or year of school you completed: Never attended school or only kindergarten, grades 1 through 8 (elementary), grades 9 through 11 (some high school), grade 12 or GED (high school graduate), college 1 year to 3 years (some college or technical school), college 4 years or more (college graduate)?	EDUCA	1996-2018 (except 2006, 2008)
Lifestyle: BMI	Calculated BMI variable from self-reported height and weight	_BMI5, _BMI4, _BMI3, _BMI2, _BMI	1996-2018 (except 2006, 2008)

Spatial data	State residence	_STATE	1996-2018 (except 2006, 2008)
Statistical variables for design object creation	Primary sampling unit	_PSU	1996-2018 (except 2006, 2008)
	Strata	_STSTR	1996-2018 (except 2006, 2008)
	Weighting	_LLCPWT, _FINALWT	1996-2018 (except 2006, 2008)

[α]Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

Table 2.2: List of final question selection from the National Health Interview Survey (NHIS), the survey codebook and data file variable name, and the years that the variable was used in my analysis

Research variable	**Survey Question**	**Survey codebook variable name**	**Years for which question was included and analysed**
Painful arthropathy	The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?	JNTSYMP	2002-2018 (except 2004)
	Which joints are affected? (Listed options to select: right shoulder, left shoulder, right elbow, left elbow, right hip, left hip, right wrist, left wrist, right knee, left knee, right ankle, left ankle, right toes, left toes, right finger/thumb, left finger/thumb, other joint not listed	JMTHP1-JMTHP17	2002-2018 (except 2004)
Low back pain	During the PAST THREE MONTHS, did you have low back pain?	PAINLB	1997-2018 (except 2004)
Demographics: age and sex	Age *(confirmed from Household Core section)*	AGE_P	1997-2018 (except 2004)
	Are you male or female?	SEX	1997-2018 (except 2004)
Demographics: socioeconomic status	Employment status last week: working for pay at a job or business; with a job or business but not at work; looking for work; working but not for pay at a family-owned job or business; not working at a job or business or not looking for work *(confirmed from DOINGLWP in Family Core section)*	DOINGLWA	2002-2018 (except 2004)
Lifestyle: BMI	Calculated BMI variable from self-reported height and weight	BMI	1997-2018 (except 2004)
Lifestyle: physical activity	How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?	VIGFREQW	1997-2018 (except 2004)
	About how long do you do these vigorous leisure-time physical activities each time?	VIGMIN	1997-2018 (except 2004)

	How often do you do LIGHT OR MODERATE leisure-time physical activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or a SLIGHT to MODERATE increase in breathing or heart rate?	MODFREQW	1997-2018 (except 2004)
	About how long do you do these light or moderate activities each time?	MODMIN	1997-2018 (except 2004)
Spatial data	Regional residence	REGION	1997-2018 (except 2004)
Statistical variables for design object creation	Primary sampling unit	PPSU, PSU_P, PSU	1997-2018 (except 2004)
	Strata	PSTRAT, STRAT_P, STRATUM	1997-2018 (except 2004)
	Weighting	WTFA_SA	1997-2018 (except 2004)

Table 2.3: List of final question selection from the National Health and Nutrition Examination Survey (NHANES) (Continuous), the survey codebook and data file variable name, and the years that the variable was used in my analysis

Research variable	Survey Question	Survey codebook variable name	Years for which question was included and analysed
Painful arthropathy	Has a doctor or other health professional ever told you that you had arthritis?	MCQ160A	1999-2000 to 2017-2018
Low back pain	-	-	-
Demographics: age and sex	Age in years at screening	RIDAGEYR	1999-2000 to 2017-2018
	Gender of the participant	RIAGENDR	1999-2000 to 2017-2018
Demographics: socioeconomic status	In this part of the survey, I will ask you questions about your work experience. Which of the following were you doing last week? Working at a job or business; with a job or business but not at work; looking for work; not working at a job or business	OCD150, OCQ150	1999-2000 to 2017-2018
	Total annual household income, reported as a range value in dollars: $0 to $4 999; $5 000 to $9 999; $10 000 to $14 999; $15 000 to $19 999; $20 000 to $24 999; $25 000 to $34 999; $35 000 to $44 999; $45 000 to $54 999; $55 000 to $64 999; $65 000 to $74 999; $75 000 to $99 999; $100 000 or over	INDHHIN2, INDHHINC	1999-2000 to 2017-2018
	What is the highest grade or level of school you have completed or the highest degree? Less than 9th grade; 9th – 11th grade (includes 12th grade with no diploma); High school graduate/GED or equivalent; Some college or AA degree; College graduate or above	DMDEDUC2	1999-2000 to 2017-2018
Lifestyle: BMI	Body mass index *Calculation from NHANES examiner-measured height and weight*	BMXBMI	1999-2000 to 2017-2018
Spatial data	-	-	-
Statistical variables for design object creation	Primary sampling unit	SDMVPSU	1999-2000 to 2017-2018
	Strata	SDMVSTRA	1999-2000 to 2017-2018
	Weighting	WTINT2YR	1999-2000 to 2017-2018

SECTION 3: SAMPLE SIZE

Table 2.4 shows a breakdown of the total unweighted sample size included in this thesis, as well as the total unweighted sample size for each form of musculoskeletal pain analysis, per year, and in total.

The total unweighted sample size across all surveys and all years of analysis included in this thesis was 6 884 452 participants. The total unweighted sample size for the rheumatic disorder study (BRFSS) across all years was 5 717 620. The total unweighted sample size for the arthritis diagnosis study (NHANES) across all survey cycles was 52 292. The total unweighted sample size for the joint symptoms study (NHIS) was 474 744. The total unweighted sample size for the low back pain study (NHIS) was 639 796. Although I have shown a breakdown of unweighted sample sizes, it is important to keep in mind throughout my results that through the use of complex survey designs (clusters, strata, and design weights), the samples are representative of the entire US adult population.

Table 2.4: Sample sizes (unweighted) for each musculoskeletal pain group, and corresponding survey, for each year of analysis. Included are the totals for each musculoskeletal pain group, by survey, as well as overall sample size

Year	BRFSS	nhanes	National Health Interview Survey		Total Study Participant Sample
	Rheumatic disorder diagnosis	*Arthritis diagnosis*	*Joint symptoms*	*Low back pain*	
1996	12 068*	--	--	--	
1997	10 021*	--	--	36 028	
1998	9 469*	--	--	32 393	
1999	21 758*	4 438	--	30 774	
2000	119 026*		--	32 331	
2001	207 774	5 023	--	33 257	
2002	130 068*		30 973	30 980	
2003	257 225	4 728	30 787	30 789	
2004	50 648*		--	--	
2005	347 643	4 763	31 384	31 375	
2006	--		24 225	24 226	
2007	418 448	5 698	23 364	23 366	
2008	--		21 773	21 767	
2009	414 021	6 043	27 706	27 713	
2010	35 094*		27 136	27 340	
2011	497 206	5 310	32 987	32 987	
2012	468 695		34 506	34 505	
2013	484 198	5 575	34 525	34 530	
2014	456 586		36 662	36 671	
2015	433 455	5 464	33 646	33 641	
2016	477 245		33 005	32 999	
2017	441 068	5 250	26 723	26 727	
2018	425 904		25 342	25 397	
ALL	5 717 620	52 292	474 744	639 796	6 884 452**

* Module year

**When joint symptoms and low back pain samples from the NHIS are considered as separate samples

SECTION 4: TECHNOLOGICAL METHODS

Raw data were imported into the R statistical environment (v3.6.2, R Core Team, 2019) from the respective survey websites, and saved as RDS[1] files. Data were then cleaned. Design objects were created for each dataset for each year separately, in order to incorporate complex survey designs and sample weights, using the *Survey* package in R (Lumley, 2004). Design objects were saved as RDS files to Dropbox.

All plots that I generated were done using the *ggplot2* package in R (Wickham, 2016), and the geofacet package (Hafen, 2019).

All code (data cleaning and analysis) is available on GitHub, and is reproducible. Each survey (BRFSS[2], NHIS[3], and NHANES [Continuous][4]) has a dedicated repository. Furthermore, all design objects for the BRFSS[5], NHIS[6], and NHANES (Continuous)[7] are available on DropBox.

[1] A compressed file type
[2] BRFSS: <https://github.com/AnneIoannides/BRFSS_Musculoskeletal-Pain>
[3] NHIS: <https://github.com/AnneIoannides/NHIS_Musculoskeletal-Pain>
[4] NHANES (Continuous): <https://github.com/AnneIoannides/NHANES_Musculoskeletal-Pain>
[5] BRFSS: < https://www.dropbox.com/sh/tocjag7syjh64t0/AABqPk-G3iTliynx5BDNyIB8a?dl=0>
[6] NHIS: < https://www.dropbox.com/sh/hazoszwugo2er2x/AACgupJlgL16aE_OE_yaw0FPa?dl=0>
[7] NHANES (Continuous):
<https://www.dropbox.com/sh/5xhdyvqhfgy3y8l/AABt19ENYDmvu7oROt5zoXxWa?dl=0>

SECTION 5: DATA ANALYSIS

2.6 Data cleaning

After downloading the data from each respective survey website, I cleaned the data by selecting the variables I intended analysing (shown in Tables 2.1 to 2.3), as well as the primary sampling unit, strata, and weighting data. Any participant without weighting, or stratum data was excluded. Furthermore, "unknown" data for painful rheumatic disorders (BRFSS), arthritis diagnoses (NHANES), joint symptoms (NHIS), and low back pain (NHIS) were excluded from analysis before the design objects were created. The exclusion of unknown joint symptom data, and unknown low back pain data was done separately, such that the participants with a full dataset for either one condition or the other were not lost. I also changed all "Not ascertained", "Unknown", and "Refused" data observations to unknown values (NA) for analysis.

In order to facilitate temporal and spatial prevalence analyses, I divided age into 11 age groups, namely (in years): 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above. Sex was divided into male and female categories. Socioeconomic status comprised of three variables for the BRFSS and NHANES, but only one variable for the NHIS. Employment status was common to all surveys. The BRFSS offered a more robust set of employment options, where the only cleaning I did involved collapsing options "out of work for one year or more" and "out of work for less than one year" into a joint unemployed variable. Employment options changed over time in the other surveys, where the only options that remained consistent across time were "working for pay at a job or business, and not working at a job or business and not looking for work". These were therefore the two options I used for consistency across time, and made other options unknown. I made annual household income and education status as comparable between the BRFSS and NHANES surveys as possible by dividing education statuses into school phases, and income brackets as similar to each other as possible, within the bounds of the categories in the original questions. BMI was left continuous for all three surveys. Finally, I used the NHIS to analyse musculoskeletal pain and physical activity. I used a combination of four questions (Table 2.2) to categorise people as physically active or not, based on the *Healthy People 2010* objective. The *Healthy People 2010* objective categorised someone as physically active if they did vigorous physical activity (causing large increases in breathing rate, heart rate, and sweating) three times per week or more for 20

minutes or more; or if someone did moderate or light physical activity (causing small or moderate increases in breathing rate and heart rate) five times a week or more for 30 minutes or more.

After cleaning the data, I created a survey design object for each year, in each survey. I assigned the primary sampling unit, strata and weighting to the data, and highlighted that the sample was clustered by assigning nesting as true within design objects (Lumley, 2010) using the *Survey* package (Lumley, 2004) in R and R Studio (v3.6.2, R Core Team, 2019). These steps make the sample representative of the US population.

2.7 A note on prevalence

I used prevalence (95% confidence interval) data to compare my data temporally and spatially. I calculated prevalence as the proportion of people who had a positive result for the variable in question. For the BRFSS, participants had to have answered "Yes" to the question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?". For the NHIS, participants had to have answered "Yes" to the question, "The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?"; and "Yes" to the question, "DURING THE PAST THREE MONTHS, did you have low back pain?". For the NHANES, participants had to have answered "Yes" to the question, "Has a doctor or other health professional ever told you that you had arthritis?". I calculated the prevalence of the musculoskeletal pain variable in question for every year of analysis in the overall population, per region or state, per age group, per sex, and per employment status.

Furthermore, the NHIS asked participants which joint sites they have had joint symptoms at. I calculated the proportion of mentions of a particular joint site in each age-sex divided demographic group.

It is the aforementioned prevalence analysis method that I refer to as "prevalence" within the following sections.

2.8 Temporal trends (Chapter Three)

Using the BRFSS, I calculated, and plotted on a line graph, the prevalence of painful rheumatic disorder diagnoses amongst the US population, for each year included (1996 until 2018, with the exception of 2006 and 2008 where the rheumatic disorder diagnosis question was not included in the survey questionnaire). I included data for which the question was included both as a core question (2001, 2003, 2005, 2007, 2009, 2011 to 2018), as well as a module question (1996 to 2000, 2002, 2004, and 2010). I plotted these prevalence data over time for the overall US population, for each age group, for either sex, and for each employment status group. Thereafter, I calculated the compound annual growth rate (CAGR) for these prevalence values. I calculated the CAGR of rheumatic disorder diagnoses for the overall population, for each age group, for either sex, and for employment status. The BRFSS however changed their weighting methodology between years 2010 and 2011. Therefore, I calculated three CAGR values per group: one from 2001 until 2009 (I specifically did not include a module year due to more variance in the estimates), a CAGR from 2011 until 2018; and an overall CAGR from 2001 to 2018. The CAGR for the whole timeframe (2001 to 2018) should, however, be interpreted with caution due to the changed weighting methodology resulting in less precision in estimates.

Using the NHIS, I calculated, and plotted on a line graph, the prevalence of joint symptoms amongst the US population, for each year included (namely, 2002 until 2018, except 2004 where stratum data was unavailable, rendering it not possible to create a design object). I plotted prevalence data over time for the overall population, by age group, by sex, and by employment status. Thereafter, I calculated the CAGR for these prevalence values, using 2002 for the start year and 2018 as the end year, thus 17 years. I calculated the CAGR of joint symptoms for the overall population, each age group, either sex, and by employment status.

Using the NHANES, I calculated, and plotted on a line graph, the prevalence of arthritis diagnoses amongst the US population for each survey cycle (every two years). I plotted these prevalence data over time (in survey cycles) for the overall population, by age group, for either sex, and by employment status. I then calculated the CAGR for the prevalence data from the earliest to latest year. Therefore, although the survey is administered over two years instead of one, I used a year count of 1999 until 2018 (20 years) and compounded the time value

appropriately. I calculated the CAGR of arthritis diagnoses for the overall population, by age group, for either sex, and by employment status.

Using the NHIS, I calculated, and plotted on a line graph, the prevalence of low back pain amongst the US population for each year included (namely, 1997 until 2018, except 2004 where stratum data were unavailable, rendering it not possible to create a design object). I plotted prevalence data over time for the overall population, by age group, by sex, and by employment status (where employment status data were from 2002 until 2018). Thereafter, I calculated the CAGR for the prevalence data from the start year to the end year (1997 to 2018, thus 22 years). I calculated the CAGR for the overall US population, by age group, for either sex, and for employment status (2002 to 2018, thus 17 years).

2.9 Spatial trends (Chapter Four)

2.9.1 Prevalence-based trends

Using the BRFSS, I calculated the prevalence of rheumatic disorder diagnoses by US state for each year of analysis that the rheumatic disorder diagnosis question was included in the core questionnaire and thus asked to people in all states (namely, 2001, 2003, 2005, 2007, 2009, and 2011 to 2018). I plotted these data on a choropleth of the political US state map. I calculated and plotted US state choropleth maps for the overall US population, by age group, and by sex.

Using the NHIS, I calculated the prevalence of joint symptoms by US region (Midwest, Northeast, South, and West) for each year of analysis (namely, 2002 until 2018, except 2004 where stratum data were unavailable, rendering it not possible to create a design object). I plotted these data on a choropleth of the political US regional map for the overall US population. In order to assess age- and sex-based prevalences, I calculated the prevalence of each age group, and each sex group, respectively, and plotted these prevalence data as regional geofacet plots.

I repeated the aforementioned NHIS analysis for low back pain by US region, from 1997 until 2018 (with the exception of 2004). I plotted the region-based prevalence of low back pain of the overall US population on choropleths of the political US regional map. I then created regional geofacet plots for low back pain by age, and sex, respectively.

I also calculated and mapped the annual proportion of each age group and sex living in each US state and region in order to assess for confounders in the state or region prevalence data.

2.9.2 Spatial correlation

I wanted to assess whether there was a spatial association in rheumatic disorder diagnoses (BRFSS) by state. It was not possible, however, to run a spatial correlation on a design object in R using the data points within the design object. Therefore, I assigned the calculated prevalences to a shapefile in R first, using the *sp* (Pebesma and Bivand, 2005; Bivand, Pebesma and Gomez-Rubio, 2013) and *sf* (Pebesma, 2018) packages. On the assumption that the prevalence data represents the amount of rheumatic disorder diagnosis reports within each state, I ran a Global Moran's I on the prevalence data by state, using the *spdep* package (Bivand and Wong, 2018).

Regional association analysis based on NHIS data (for joint symptoms, and low back pain, respectively) was done using logistic regression, to see whether living in a particular region was associated with having either joint symptoms, or low back pain.

2.10 Demographic factors (Chapter Five)

2.10.1 Prevalence-based trends

Using the BRFSS, I calculated the prevalence of rheumatic disorder diagnoses amongst US residents, by age group, and sex. I calculated the prevalence on all years, including module years (1996 to 2018, excluding 2006 and 2008).

Using the NHIS, I calculated the prevalence of reported joint symptoms amongst US residents, by age group, and sex; from 2002 until 2018, except 2004. I also used the NHIS to calculate the prevalence of US residents who reported low back pain, by age, and by sex; from 1997 until 2018, except 2004.

I used the NHANES to calculate the prevalence of arthritis diagnoses amongst US residents by age group, and sex; from the 1999-2000 survey until the 2017-2018 survey.

2.10.2 Association-based trends

Using the BRFSS, I conducted sex-adjusted logistic regressions, for each year (1996 to 2018, except 2006 and 2008), to assess whether age associated with rheumatic disorder diagnosis. I also conducted age-adjusted logistic regressions, for each year to assess whether sex associated with rheumatic disorder diagnosis. Finally, I conducted age- and sex-adjusted logistic regressions to assess whether socioeconomic status (in the form of employment status, annual household income, and education level) associated with rheumatic disorder diagnosis.

Using the NHIS, I conducted sex-adjusted logistic regressions, for each year (2002 until 2018, except 2004), to assess whether age associated with joint symptoms. I also conducted age-adjusted logistic regressions, for each year, to assess whether sex associated with joint symptoms. Finally, I conducted age- and sex-adjusted logistic regressions to assess whether socioeconomic status (in the form of employment status) associated with joint symptoms.

Furthermore, using the NHIS, I conducted sex-adjusted logistic regressions, for each year (1997 until 2018, except 2004), to assess whether age associated with low back pain. I also conducted sex-adjusted logistic regressions on all years to assess whether sex associated with low back pain. Finally, I used age- and sex-adjusted logistic regressions, for each year, to assess whether socioeconomic status (employment status) associated with low back pain.

Finally, using the NHANES (Continuous), I conducted sex-adjusted logistic regressions for each survey cycle (1999-2000 until 2017-2018) to assess whether age associated with arthritis diagnosis. I conducted age-adjusted logistic regressions on all survey cycles to assess whether sex associated with arthritis diagnosis. Thereafter, I conducted age- and sex-adjusted logistic regressions to assess whether socioeconomic status (in the form of employment status, annual household income, and education level) associated with arthritis diagnosis.

For each age analysis across all surveys, my reference group was set as the youngest age group (age 18 to 24 years). The reference group for sex was males. The reference group amongst socioeconomic status variables was set as the highest socioeconomic status amongst the options. For employment status, the reference group was those employed; for income, the reference group was the highest annual household income bracket; and for education level, was the highest level of education option.

2.11 Lifestyle factors (Chapter Six)

Using the BRFSS (1996 to 2018, except 2006 and 2008), I conducted age- and sex-adjusted logistic regressions on continuous BMI data, calculated from self-reported height and weight, in order to assess whether BMI associated with rheumatic disorder diagnosis.

Using the NHIS, I conducted age- and sex-adjusted logistic regressions on continuous BMI data, calculated from self-reported height and weight, in order to assess whether BMI associated with joint symptoms (2002 until 2018, except 2004) in US residents. I also used NHIS physical activity data (which I had divided into groups that were, or were not, physically active according to the *Healthy People 2010* objective) to assess whether physical inactivity was associated with joint symptoms in US residents (2002 until 2018, except 2004). The reference group was set as those who were physically active.

I repeated the aforementioned NHIS analyses on low back pain (1997 until 2018, except 2004), where I assessed whether BMI was associated with low back pain, by age- and sex-adjusted logistic regressions. I also assessed whether physical inactivity was associated with low back pain, by age- and sex-adjusted logistic regressions, where those categorised as physically active were set as the reference group.

Finally, I used the NHANES (Continuous) (1999-2000 until 2017-2018) to assess whether BMI (calculated from a measured height and weight, by a trained NHANES professional during the examination section of the survey) was associated with arthritis diagnoses, by using age- and sex-adjusted logistic regressions.

CHAPTER THREE

Temporal trends of musculoskeletal pain: painful arthropathies and low back pain

In Chapter One, I discussed the dearth of research looking at pain prevalence across time, in the whole population as well as within various demographic groups (such as by age, sex, and socioeconomic status). Indeed, most research on pain is cross-sectional in nature. Longitudinal pain research tends to be conducted in particular facilities or in particular areas, therefore geographically isolating available temporal data. This chapter consists of two sections, both of which address my first thesis objective: to establish temporal trends of musculoskeletal pain. Section 1 addresses the temporal trends of painful arthropathies, and Section 2 addresses the temporal trends of low back pain.

The Behavioural Risk Factor Surveillance System (BRFSS), National Health Interview Survey (NHIS), and the National Health and Nutrition Examination Survey (NHANES) (Continuous) record self-reported data on painful arthropathies. I used appropriate complex survey design methods and appropriately weighted data to analyse self-reported data on rheumatic disorder diagnoses (BRFSS, telephonic interview survey data), joint symptoms (NHIS, in-person interview survey data), and arthritis diagnoses (NHANES Continuous, in-person interview survey data). These population-based surveys have been administered to US residents over many decades, and my analysis focuses on approximately the last 20 years. Self-reported age, sex, and employment status data are also available in the aforementioned surveys.

SECTION 1: TEMPORAL TRENDS OF PAINFUL ARTHROPATHIES

Section 1 of this chapter therefore addresses temporal trends in the prevalence of painful arthropathies, which includes rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses. I established the prevalence of each painful arthropathy type, for each survey cycle over the last 20 years, and plotted these data. I also calculated the compound annual growth rate (CAGR) to address the trajectory of various painful arthropathies over the past 20 years. I conducted these analyses on the whole US population, and by age group, sexes, and employment statuses.

3.1 *Behavioural Risk Factor Surveillance System (BRFSS)*

Rheumatic disorder diagnosis

The prevalence of US residents who reported having been diagnosed with a rheumatic condition was calculated as the proportion of people who answered "Yes" to the question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?". Appropriate design weights were applied to the data and complex survey design was accounted for. The prevalence was calculated across years 1996 until 2018, with the exception of 2006 and 2008, two years when the question did not feature in the BRFSS questionnaire. I also calculated the compound annual growth rate (CAGR) from 2001 until 2009; and 2011 until 2018, as the weighting methods were improved between 2010 and 2011. I also calculated the CAGR for the whole period, although the estimates should be interpreted with caution due to changed weighting methods affecting the confidence intervals of estimates. The year 2001 was the first year that the rheumatic disorder diagnosis was included in the core BRFSS questionnaire, and 2009 the last before methodology changes. The determination of prevalence and CAGR was done for the whole US population, and by age group, sex, and employment statuses.

The unweighted demographic characteristics of the sample for each year are available in Appendix F, Table I. Tables consisting of all annual prevalence values (95% confidence interval) for the overall population is available in Appendix G. Prevalence (95% confidence interval) is also available by age group (Appendix H, Table I), by sex (Appendix I, Table I), and employment status (Appendix J, Table I).

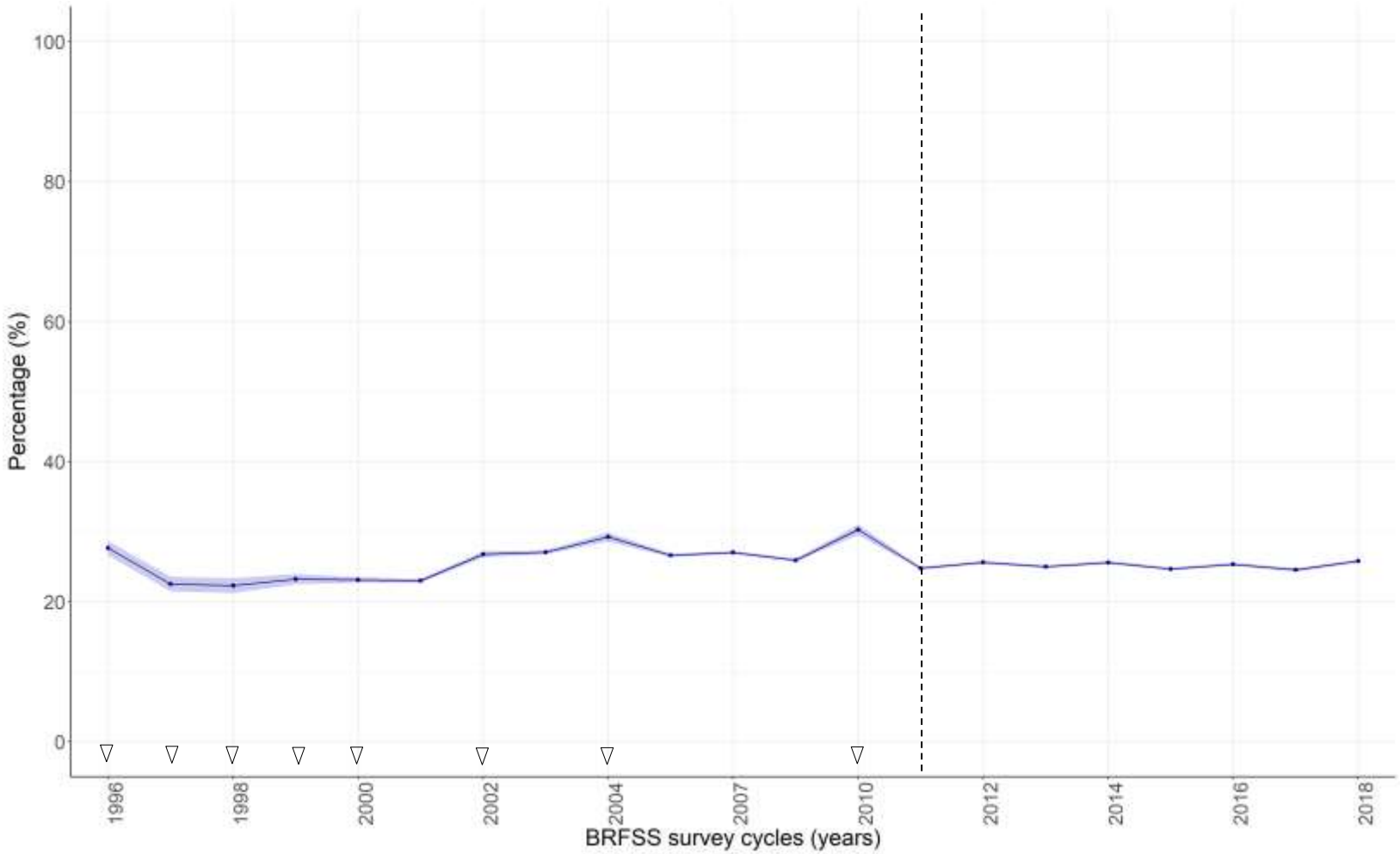


Figure 3.1: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with rheumatic disorder* in their lifetime by a medical doctor, nurse or healthcare worker, from 1996 until 2018 (excluding 2006 and 2008), according to the Behavioural Risk Factor Surveillance System (BRFSS)

*Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

▽ Module questionnaire years

Dashed vertical line: Change in weighting method

3.1.1 Overall prevalence of rheumatic disorder diagnosis over time

The prevalence of a rheumatic disorder diagnosis in US residents overall has remained fairly stable at around a quarter of all people (approximately 25%), for 22 years. Although the compound annual growth rate (CAGR) was 0.013% per year between 2001 and 2009, the growth rate was almost negligible at 0.005% per year between 2011 and 2018 (after the improvement of weighting methodology, as shown by the narrowed confidence intervals and decreased undulation). The CAGR from 2001 until 2018 was 0.006% per year (Figure 3.1).

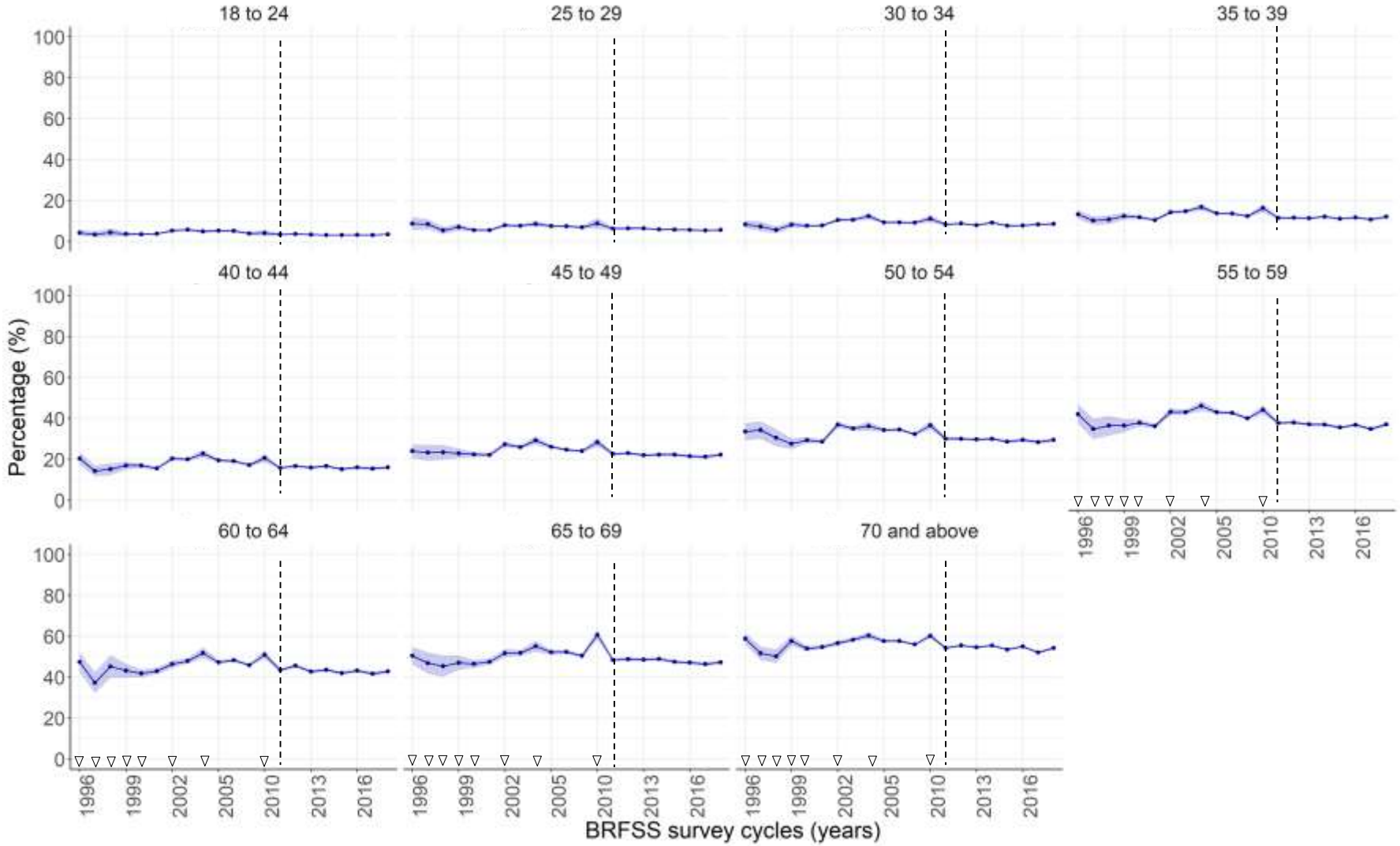


Figure 3.2: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with rheumatic disorder* in their lifetime by a medical doctor, nurse or healthcare worker, by age group; from 1996 until 2018 (excluding 2006 and 2008), according to the Behavioural Risk Factor Surveillance System (BRFSS)

*Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

▽ Module questionnaire years

Dashed vertical line: Change in weighting method

3.1.2 Prevalence of rheumatic disorder diagnosis over time by age

The prevalence of rheumatic disorder diagnoses remained fairly steady over time within age groups (Figure 3.2). In 18- to 24-year-olds, the CAGR from 2001 (3.7%) until 2009 (3.9%) was 0.006% per year, but was 0.001% from 2011 until 2018 (approximately 3.4% in both years). Across the whole time frame (2001 to 2018), the CAGR in 18- to 24-year-olds was 0.005% per year. In those aged 25 to 29 years, the CAGR between 2001 and 2018 was 0.001% per year, while it was 0.027% per year between 2001 (5.5%) and 2009 (6.9%), and -0.014% per year between 2011 (6.3%) and 2018 (5.6%). In 30- to 34-year-olds, the CAGR for the whole timeframe was 0.006% per year. Between 2001 (7.7%) and 2009 (9.1%), the CAGR was 0.019% per year, but was 0.005% per year between 2011 (8.3%) and 2018 (8.6%). In 35- to 39-year-olds, the CAGR for the whole timeframe was 0.008% per year, between 2001 (10.4%) and 2009 (12.4%) was 0.019% per year, and was 0.006% per year between 2011 (11.5%) and 2018 (12.1%). In those aged 40 to 44 years, the CAGR between 2001 (15.5%) and 2009 (17.2%) was 0.011% per year, and was 0.002% per year between 2011 (15.8%) and 2018 (16.1%), as well as for the whole timeframe. In 45- to 49-year-olds, the CAGR between 2001 (22.2%) and 2009 (24.0%) was 0.009% per year, but was -0.002% between 2011 (22.7%) and 2018 (22.3%). The growth over the whole timeframe was < 0.001% per year. In 50- to 54-year-olds, the CAGR between 2001 (22.2%) and 2009 (24.0%) was 0.013% per year, but was -0.002% between 2011 (30.1%) and 2018 (29.5%). Over the entire timeframe, the CAGR was 0.016% per year. In those aged 55 to 59, the CAGR between 2001 (36.2%) and 2009 (40.1%) was 0.011% per year, and -0.002% between 2011 (37.8%) and 2018 (37.1%). For the whole timeframe, the CAGR was 0.001% per year. In 60- to 64-year-olds, the CAGR was 0.007% per year between 2001 (43.1%) and 2009 (45.9%), and -0.002% per year between 2011 (43.4%) and 2018 (42.9%). In 65- to 69-year-olds, the CAGR was 0.007% per year between 2001 (47.6%) and 2009 (50.5%), but was -0.003% between 2011 (48.5%) and 2018 (47.3%). Finally, in those aged 70 and above, the CAGR was 0.002% from 2001 (54.8%) to 2009 (56.0%), but was <<0.001% per year between 2011 and 2018 (~54.3% in both years). In the oldest three groups (those aged 60 to 64 years, 65 to 69 years, and 70 years and above) the CAGR was < 0.001% per year.

The CAGR values from 2011 until 2018 are slightly different from those between 2001 and 2009 due to the improvement of weighting methods. This is supported by the narrowing of the

confidence intervals (Figure 3.2). There is fractional undulation of the line graph in years where the rheumatic disorder diagnosis question was asked as a module, and therefore asked to fewer people in only a few states. From these results, it is clear that the prevalence (%) of people diagnosed with a rheumatic condition, according to the BRFSS, has remained constant over time within specific age groups (Figure 3.2). Despite remaining constant within age groups, the prevalence of rheumatic disease diagnoses rose in a progressive manner with each increasing age group, in the same incremental pattern across time. Further demographic analyses are discussed in Chapter Five of this thesis.

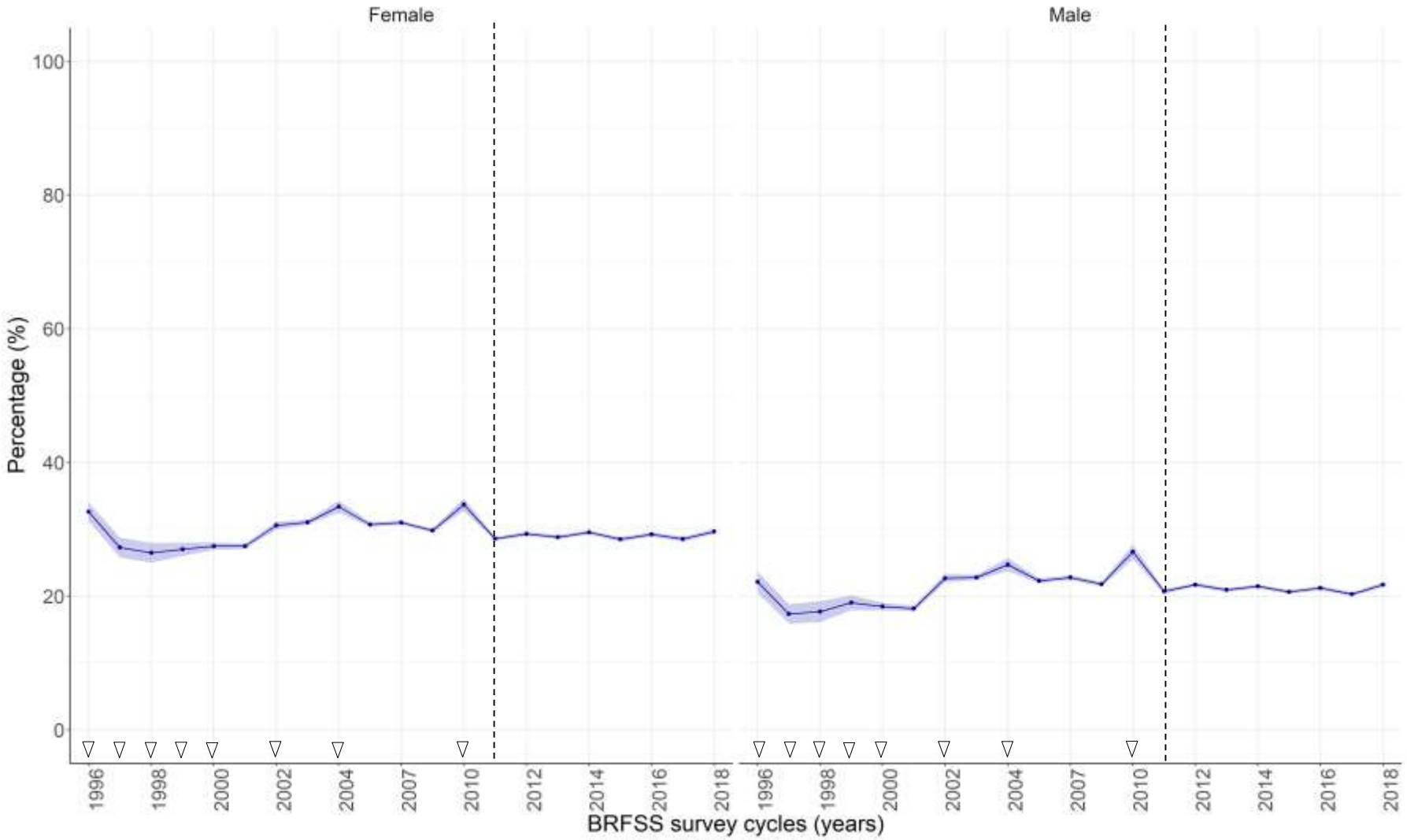


Figure 3.3: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with rheumatic disorder* in their lifetime by a medical doctor, nurse or healthcare worker, by sex; from 1996 until 2018 (excluding 2006 and 2008), according to the Behavioural Risk Factor Surveillance System (BRFSS)

*Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

▽Module questionnaire years

Dashed vertical line: Change in weighting method

3.1.3 Prevalence of rheumatic disorder diagnosis over time by sex

The prevalence of rheumatic disorder diagnoses remained fairly steady over time in both sexes. In males, the CAGR between 2001 (18.2%) and 2009 (21.8%) was 0.020% per year, but was 0.006% between 2011 (20.7%) and 2018 (21.7%). Over the whole 18-year period, the CAGR for males was 0.009% per year. In females, the CAGR between 2001 (27.5%) and 2009 (29.8%) was 0.009%, while between 2011 (28.6%) and 2018 (29.7%), the CAGR was 0.005% per year, and was 0.004% per year over the whole timeframe (Figure 3.3).

The difference between 2001 and 2009, and 2011 and 2018 is likely due to the improvement of weighting methods from 2011 onwards; illustrated by the narrowing of the confidence intervals and decreased undulation during the later timeframe (Figure 3.3). The prevalence (%) of males and females diagnosed with a rheumatic condition, according to the BRFSS, has therefore remained constant over time (Figure 3.3). Notably, however, females had a higher prevalence of rheumatic disorder diagnoses compared to males across time. Further demographic analyses will be discussed in Chapter Five of this thesis.

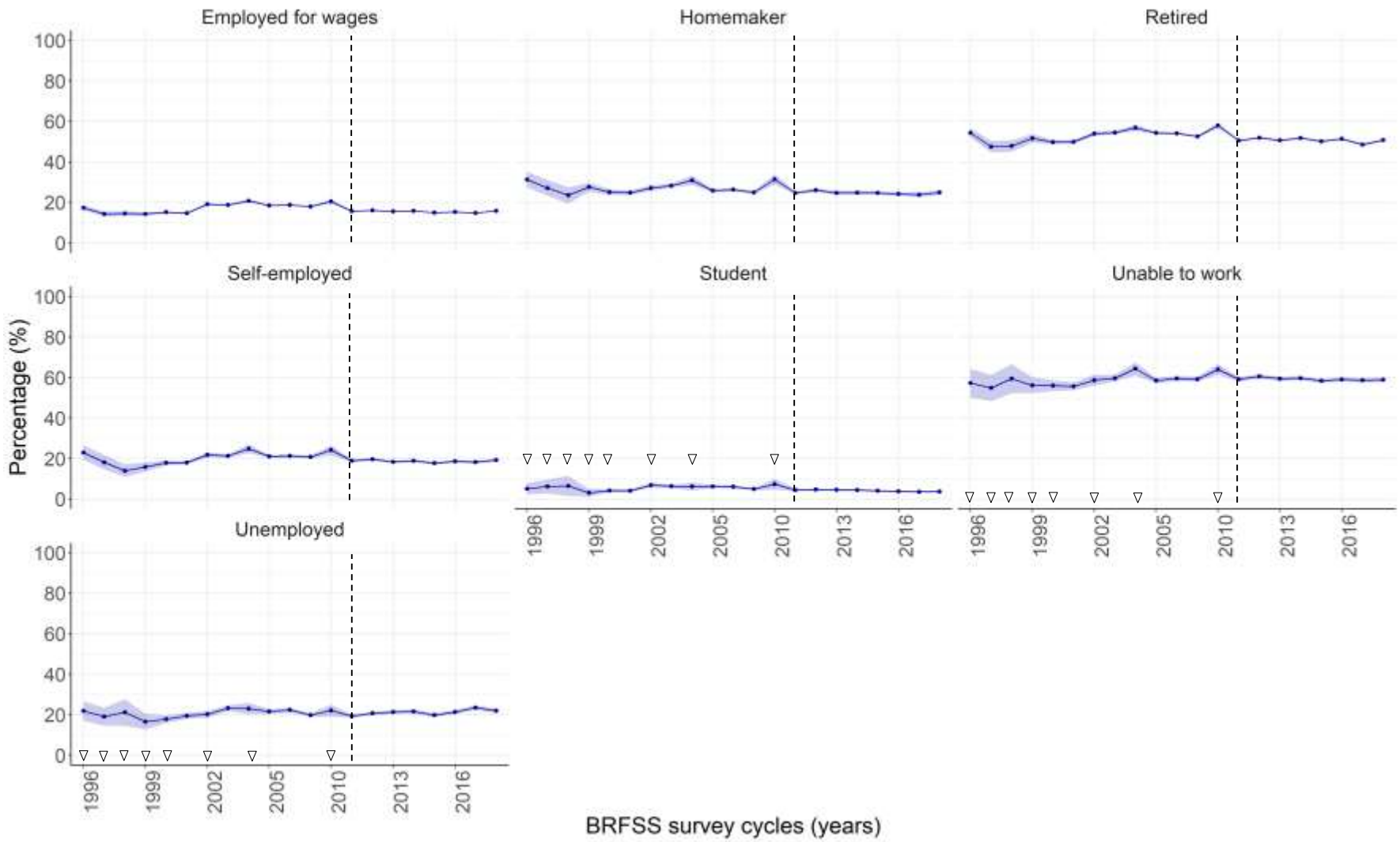


Figure 3.4: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with rheumatic disorder* in their lifetime by a medical doctor, nurse or healthcare worker, by employment status; from 1996 until 2018 (excluding 2006 and 2008), according to the Behavioural Risk Factor Surveillance System (BRFSS)

*Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

▽ Module questionnaire years

Dashed vertical line: Change in weighting method

3.1.4 Prevalence of rheumatic diagnosis by over time employment status

The prevalence of rheumatic disorder diagnoses is different in different employment statuses. Between 2001 (14.6%) and 2009 (17.9%), the CAGR in those employed for wages was 0.022% per year; whilst between 2011 (15.6%) and 2018 (15.8%), it was 0.002% per year. For the entire 18-year timeframe, the CAGR was 0.004% per year in those employed. In the unemployed however, the CAGR between 2001 (19.5%) and 2009 (19.8%) was 0.002% per year; between 2011 (19.3%) and 2018 (21.9%) was 0.016% per year, and was 0.006% per year over the whole time period. Therefore, after the improvement of weighting methods, there is small growth in rheumatic disorder diagnosis in the unemployed, but stability in those employed for wages. In those self-employed, the CAGR over the whole timeframe was 0.004% per year. Between 2001 (17.9%) and 2009 (20.8%), the CAGR was 0.016% per year, whilst between 2011 (18.9%) and 2018 (19.2%), the CAGR was 0.002% per year. Therefore, after the improvement of weighting methods, the growth in the self-employed was stable. In homemakers, the CAGR between 2001 (24.7%) and 2009 (24.9%) was 0.006% per year, whilst from 2011 (24.6%) until 2018 (25.0%), the CAGR was 0.001% per year, and < 0.001% per year for the whole timeframe, indicating that there is very little to no growth of rheumatic disorder diagnoses in homemakers. The retired group predictably has generally high prevalence estimates of rheumatic disorder diagnoses across time. Therefore, although the growth rate is negligible, it is because the prevalence is high generally. Between 2001 (49.9%) and 2009 (52.5%), the CAGR was 0.001% per year, and between 2011 (50.5%) and 2018 (50.8%), the CAGR was 0.007% per year. For the whole timeframe, the CAGR in the retired population was 0.001%. Conversely, in students, the CAGR between 2001 (4.1%) and 2009 (4.9%) was 0.020% per year, between 2011 (4.4%) and 2018 (3.7%) was -0.023% per year, and -0.006% per year for the whole period. Therefore, after the improvement of weighting methodology, there is evidence to suggest a slow decline in rheumatic disorder diagnoses in students. Despite the change from a positive to negative CAGR, the prevalence of rheumatic disorder diagnoses in students has remained low over time. Finally, in those unable to work, the prevalence of a rheumatic disorder diagnosis is stable: the CAGR between 2001 (55.7%) and 2009 (59.2%) was 0.007% per year, whilst between 2011 (60.1%) and 2018 (58.9%), it was -0.001% per year. The CAGR for the whole timeframe was 0.003% per year. Similar to retired people, the growth may appear flat, but the prevalence is generally very high across the board (Figure 3.4).

3.2. National Health Interview Survey (NHIS)

Joint Symptoms

The prevalence of US residents who reported joint symptoms (pain, aching, or stiffness) was calculated (after assigning appropriate design weights, and accounting for complex survey design methods) as the proportion of people who answered "Yes" to the question, "The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?". This calculation was done across the overall US population, five-year age categories, the sexes, and employment statuses. For each group, I then calculated the compound annual growth rate (CAGR) from the starting year (2002) until the most recent year (2018) of results.

The unweighted demographic characteristics of the sample for each year are available in Appendix F, Table II. Tables consisting of annual prevalence values (95% confidence interval) for the overall population are available in Appendix G. The prevalence (95% confidence interval) is available for each age group (Appendix H, Table II), sex (Appendix I, Table II), and employment status (Appendix J, Table II).

3.2.1 Overall prevalence of joint symptoms over time

The prevalence of joint symptoms has remained steady at around 30% of all US residents, from 2002 until 2018. The compound annual growth rate (CAGR) was 0.009% per year (Figure 3.5).

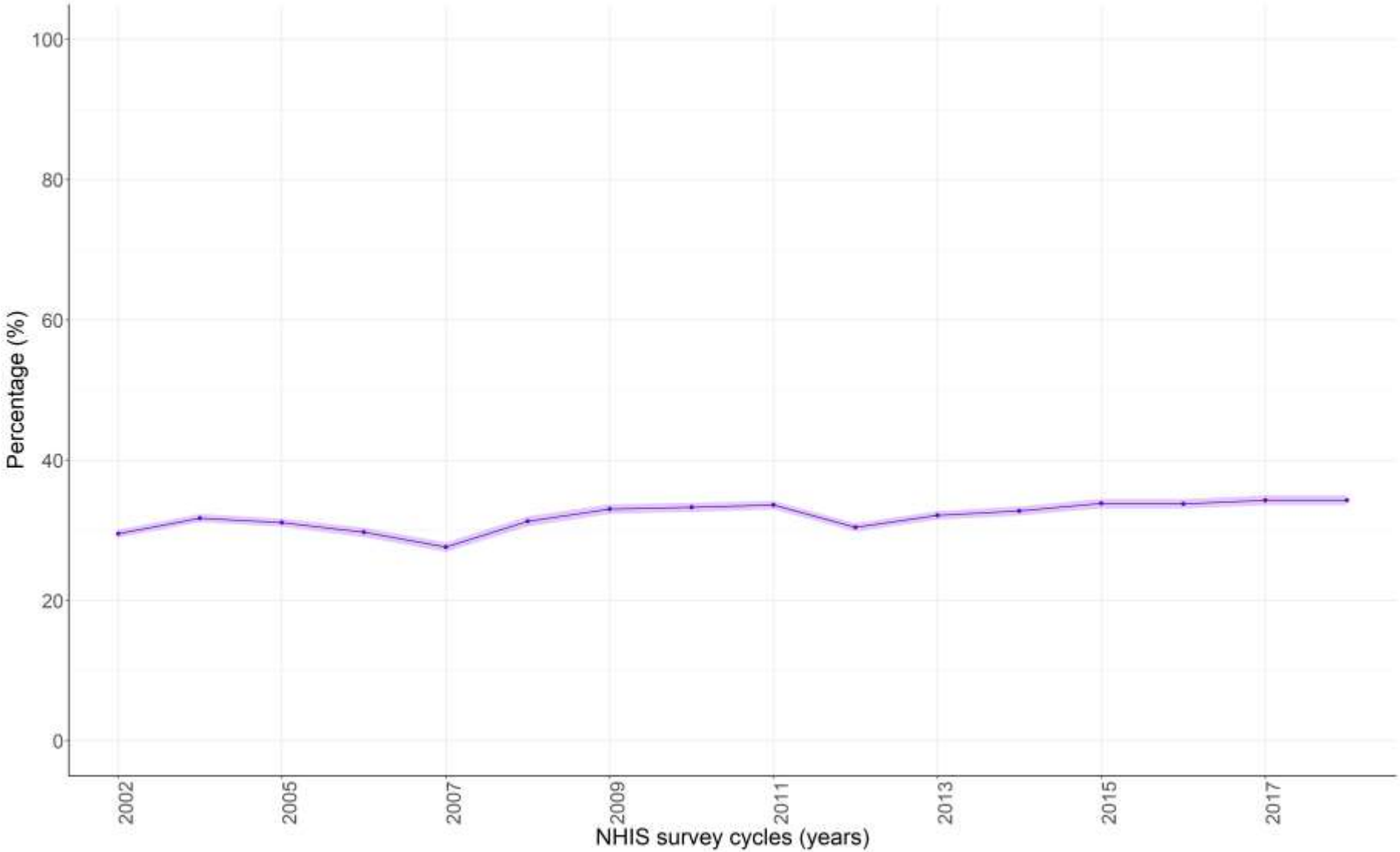


Figure 3.5: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having joint symptoms* in the 30 days before taking the survey from 2002 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

*Joint symptoms (as per the NHIS questionnaire): pain, aching, or stiffness in or around a joint

[α] Sample Adult Questionnaire of the NHIS

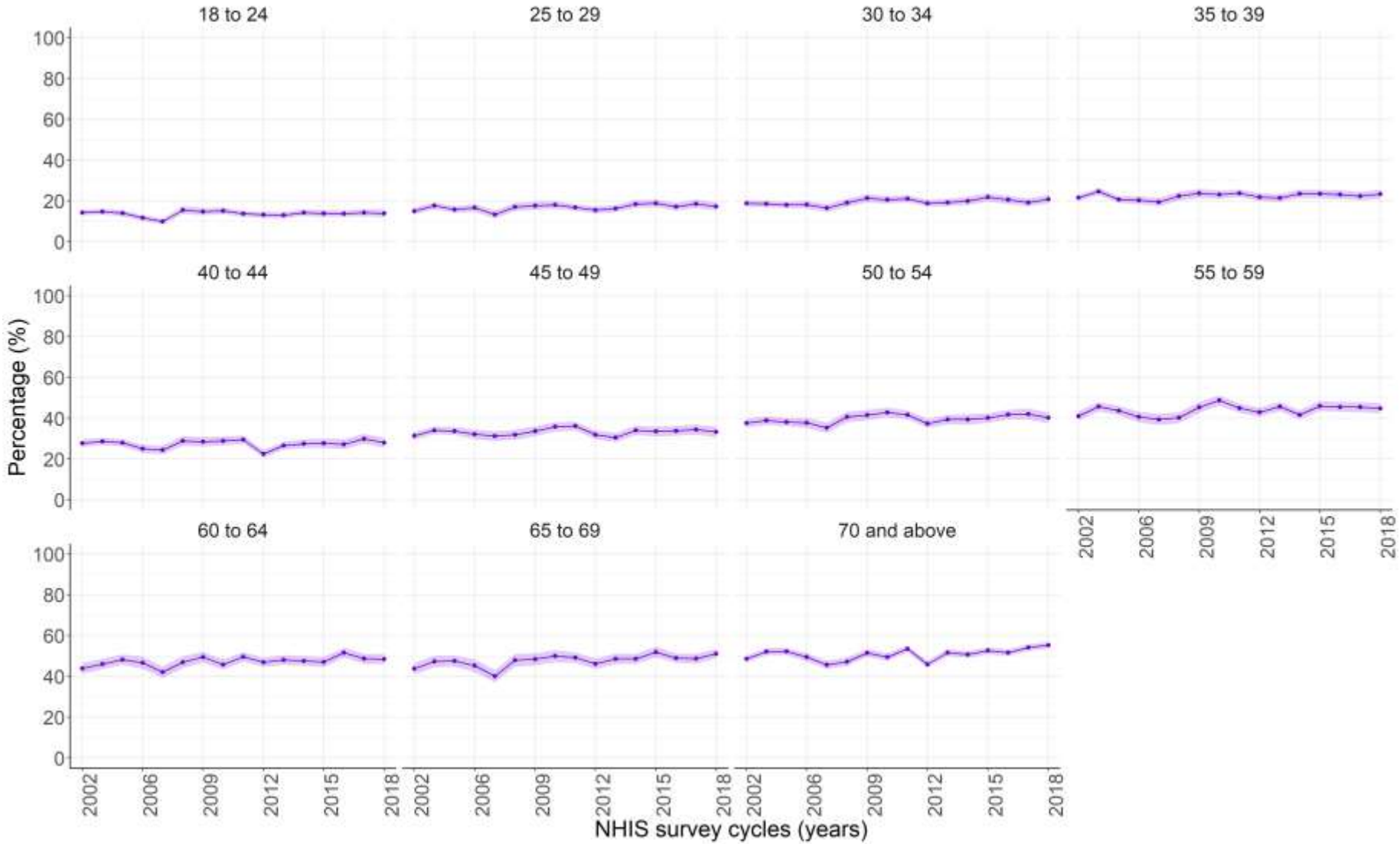


Figure 3.6: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having joint symptoms* in the 30 days before taking the survey, by age group; from 2002 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

*Joint symptoms (as per the NHIS questionnaire): pain, aching, or stiffness in or around a joint

[α] Sample Adult Questionnaire of the NHIS

3.2.2 Prevalence of joint symptoms over time by age

The prevalence of joint symptoms remained fairly steady over time across age groups. In 18- to 24-year-olds, the CAGR was -0.001% per year, going from 14.3% in 2002 to 13.9% in 2018. In 25- to 29-year-olds, the CAGR between 2002 (15.0%) and 2018 (17.3%) was 0.008% per year. In those aged 30 to 34 years, the CAGR was 0.006% per year (18.8% in 2002, and 20.9% in 2018), while in 35- to 39-year-olds it was 0.005% per year (21.6% in 2002, and 23.4% in 2018). In those aged 40 to 44 years, the CAGR was 0.001% per year between 2002 (27.7%) and 2018 (28.0%). In 45- to 49-year-olds, the CAGR was 0.003% per year, going from 31.4% to 33.3%. In those aged 50 to 54 years, the CAGR was 0.004% per year (from 37.6% in 2002 to 40.3% in 2018), while in those aged 55 to 59 years, the CAGR was 0.005% per year (from 41.1% to 44.9%). In 60- to 64-year-olds, the CAGR was 0.006% per year (from 43.9% to 48.4%). In 65- to 69-year-olds, the CAGR was 0.009% per year from 2002 (43.7%) to 2018 (51.1%). In those aged 70 years and older, the CAGR was 0.008% per year from 2002 (48.5%) until 2018 (55.3%).

From these results, it is clear that the prevalence (%) of people who reported having experienced joint symptoms (pain, aching, or stiffness) within the preceding 30 days, according to the NHIS, has remained constant over time across age groups (Figure 3.6). The progressive increase in joint symptom prevalence was also consistent across time, where each increasing age group had a slightly higher prevalence. Further demographic analyses are discussed in Chapter Five of this thesis.

3.2.3 Prevalence of joint symptoms over time by sex

In females, the CAGR from 2002 (31.2%) until 2018 (35.1%) was 0.007% per year, while in males it was 0.011% per year (from 27.7% to 33.4%). The prevalence of joint symptoms therefore appears steady in females, but may be slowly increasing slightly in males, particularly in the latter part of the timeframe (Figure 3.7). Across time, however, the prevalence of joint symptoms is consistently higher in females compared to that of males.

3.2.4 Prevalence of joint symptoms by over time employment status

The CAGR in the employed for pay category was 0.006% per year, going from 24.8% to 27.5% between 2002 and 2018. However, the CAGR for those not working was 0.020% per year (from 33.4% in 2002 to 46.4% in 2018), indicating that the prevalence of joint symptoms in those not working is increasing, despite already having higher prevalence estimates of joint symptoms across time (Figure 3.8).

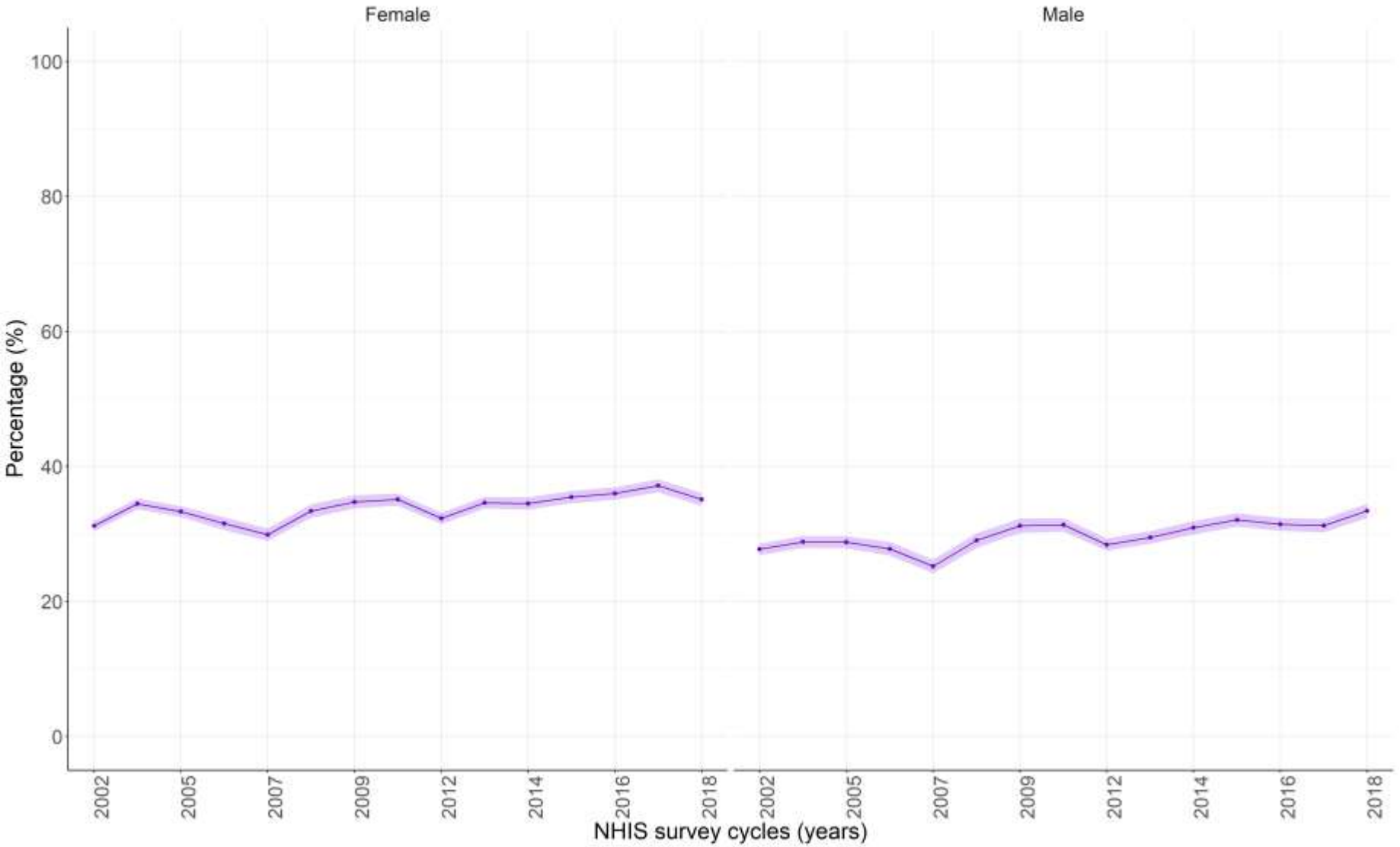


Figure 3.7: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having joint symptoms* in the 30 days before taking the survey, by sex; from 2002 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

*Joint symptoms (as per the NHIS questionnaire): pain, aching, or stiffness in or around a joint

[α] Sample Adult Questionnaire of the NHIS

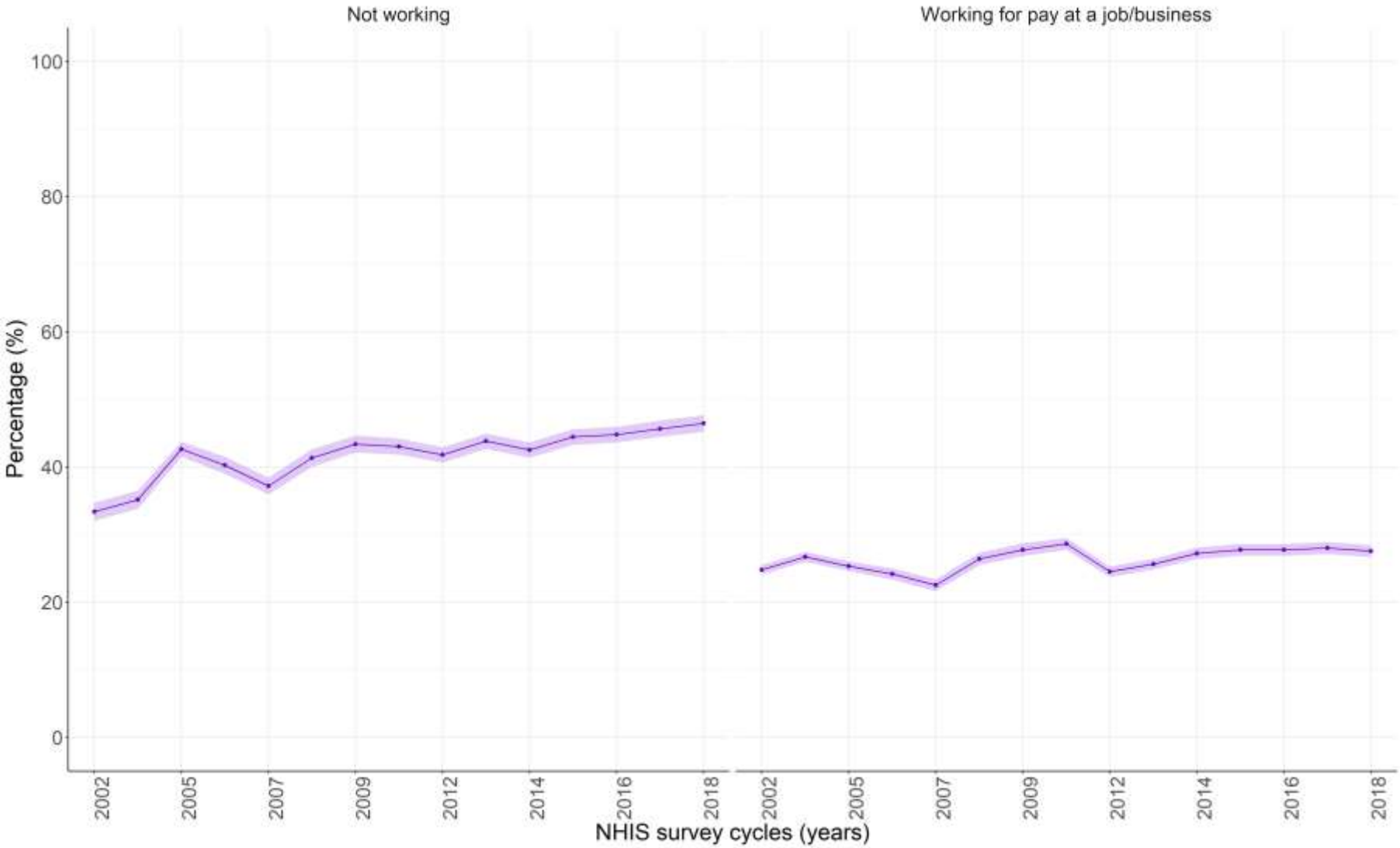


Figure 3.8: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having joint symptoms* in the 30 days before taking the survey, by employment status; from 2002 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

*Joint symptoms (as per the NHIS questionnaire): pain, aching, or stiffness in or around a joint

[α] Sample Adult Questionnaire of the NHIS

3.3 National Health and Nutrition Examination Survey (NHANES) (Continuous)

Arthritis diagnosis

NHANES (Continuous) was used to establish the percentage of people who had been diagnosed with arthritis. After assigning the appropriate design weights, I calculated the proportion of people who answered "Yes" to the question, "Has a doctor or other health professional ever told you that you had arthritis?". This calculation was done for the overall US population, and across age categories, the sexes, and employment status. For each demographic group, I then calculated the compound annual growth rate (CAGR) from the starting year (1999) until the most recent year (2018) of results.

The unweighted demographic characteristics of the sample for each year are available in Appendix F, Table III. Tables consisting of each survey cycle's prevalence values (95% confidence interval) for the overall population are available in Appendix G. The prevalence (95% confidence interval) is available for each age group (Appendix H, Table III), sex (Appendix I, Table III), and employment status (Appendix J, Table III).

3.3.1 Overall prevalence of diagnosed arthritis over time

According to the NHANES, the prevalence of arthritis diagnoses has remained fairly constant, at a CAGR of 0.008% per year. The prevalence of arthritis diagnoses in 1999-2000 was 20.2%, and reached 27.9% by 2017-18 (Figure 3.9).

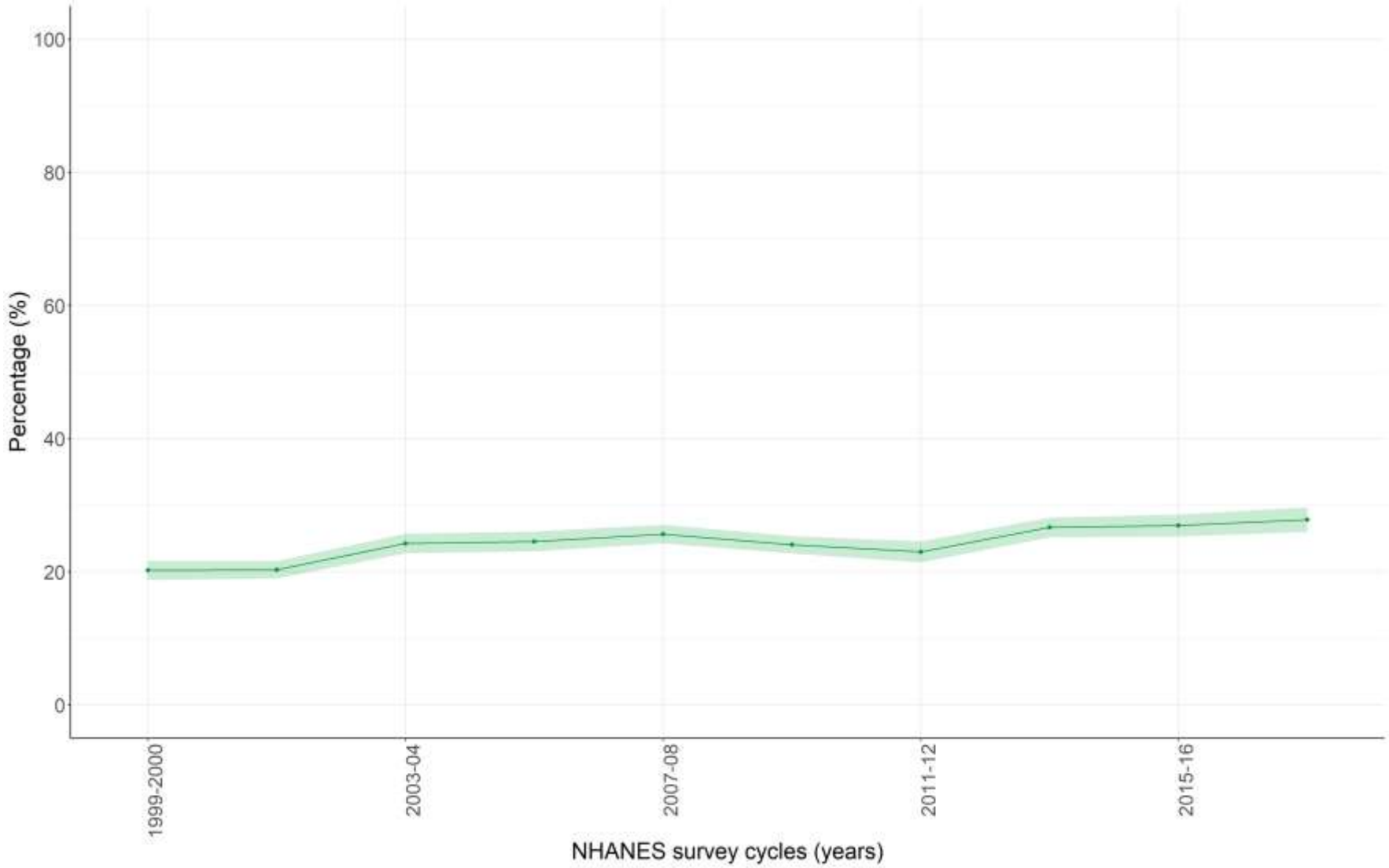


Figure 3.9: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with a form of arthritis in their lifetime by a medical doctor or healthcare worker, from 1999 until 2018 (where survey cycles are every two years), according to the National Health and Nutrition Examination Survey (NHANES [Continuous])

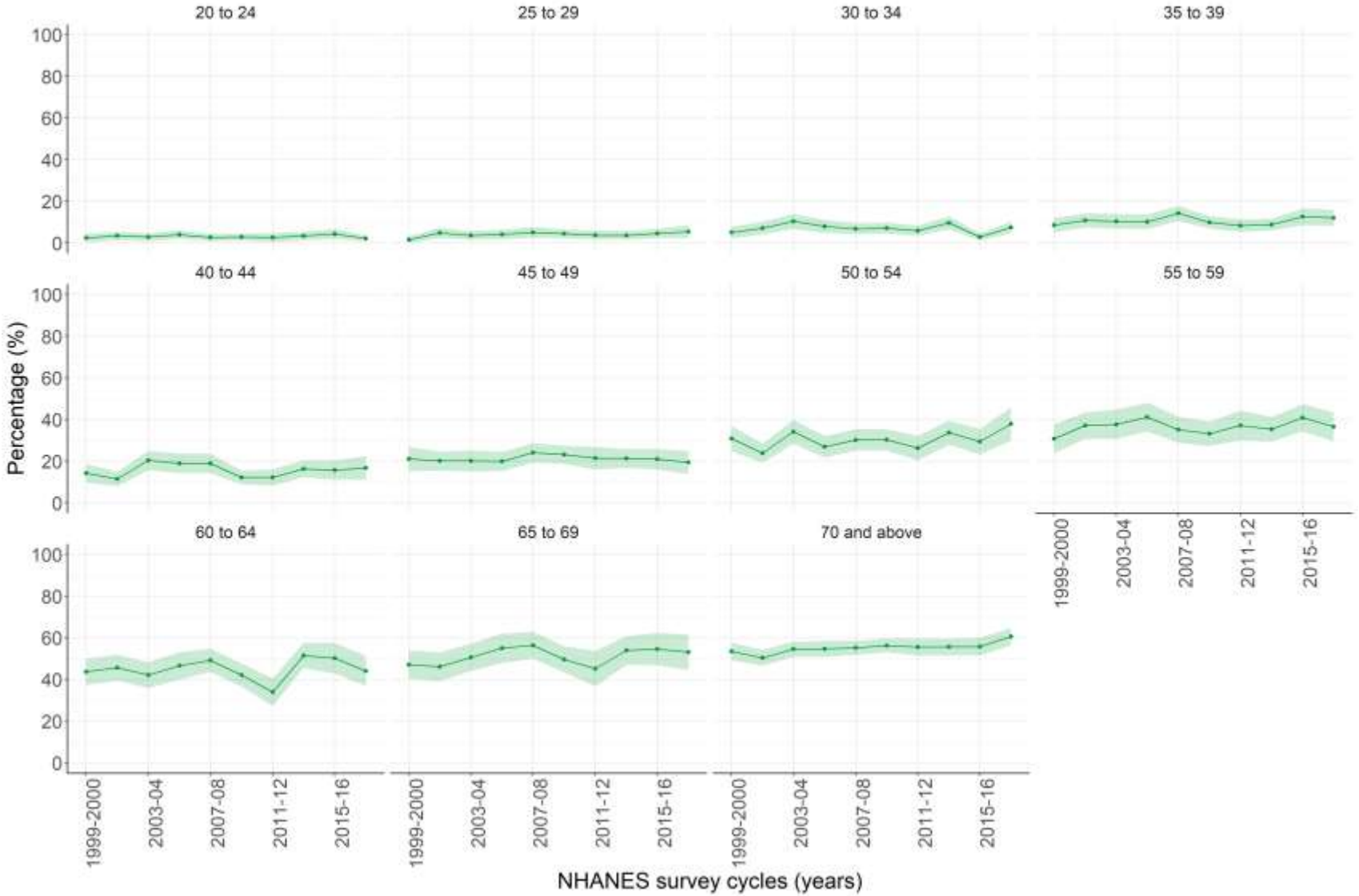


Figure 3.10: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with a form of arthritis in their lifetime by a medical doctor or healthcare worker; by age group, from 1999 until 2018 (where survey cycles are every two years), according to the National Health and Nutrition Examination Survey (NHANES [Continuous])

3.3.2 Prevalence of diagnosed arthritis over time by age

The prevalence of an arthritis diagnosis remained fairly steady over time in most age groups, from 1999 until 2018. In 20- to 24-year-olds, the CAGR was -0.003% per year, where the prevalence of arthritis diagnoses was 2.5% in the 1999-2000 survey cycle, and 2.2% in the 2017-18 survey cycle. The CAGR increased slightly in 25- to 29-year-olds was 0.030% per year (from 1.6% to 5.5%); and by a CAGR of 0.010% per year in 30- to 34-year-olds (from 5.1% to 7.5%). In those aged 35 to 39 years, the CAGR was 0.009% per year, where the prevalence of arthritis was 8.5% in 1999-2000 and 12.1% in 2017-18. In 40- to 44-year-olds, the CAGR of arthritis prevalence was 0.004% per year, where the arthritis prevalence was 14.3% in 1999-2000 and 16.8% in 2017-18. The CAGR of arthritis prevalence in those aged 45 to 49 years was -0.002% per year, going from 21.1% in 1999-2000 to 19.4% in 2017-18. In 50- to 54-year-olds, the prevalence of arthritis was 30.9% in 1999-2000, and was 37.9% in 2017-18, yielding a CAGR of 0.005% per year. In 55- to 59-year-olds, the prevalence of arthritis was 30.8% in 1999-2000 and was 36.5% in 2017-18, yielding a CAGR of 0.004% per year. The prevalence of arthritis in 60- to 64-year-olds in 1999-2000 was 43.7% and was 44.1% in 2017-18, which was a CAGR of <0.001% per year. In 65- to 69-year-olds, the prevalence of arthritis was 47.1% in 1999-2000, and reached 53.1% in 2017-18, yielding a CAGR of 0.003% per year. Finally, the prevalence of arthritis in those aged 70 years and above was 53.5% in 1999-2000 and was 60.6% in 2017-18, yielding a CAGR of 0.003% per year.

Therefore, from the age-based results yielded from the NHANES, there is a very small increase in arthritis diagnoses only in those aged 25 to 29 years (Figure 3.10), but is otherwise fairly stable across time in other age groups. Furthermore, there was a progressive increase in arthritis diagnoses over time in each successively older age group consistently over time, however, the prevalence within age groups was fairly stable (Figure 3.10). The demographic trends of arthritis diagnoses will be further discussed in Chapter Five of this thesis.

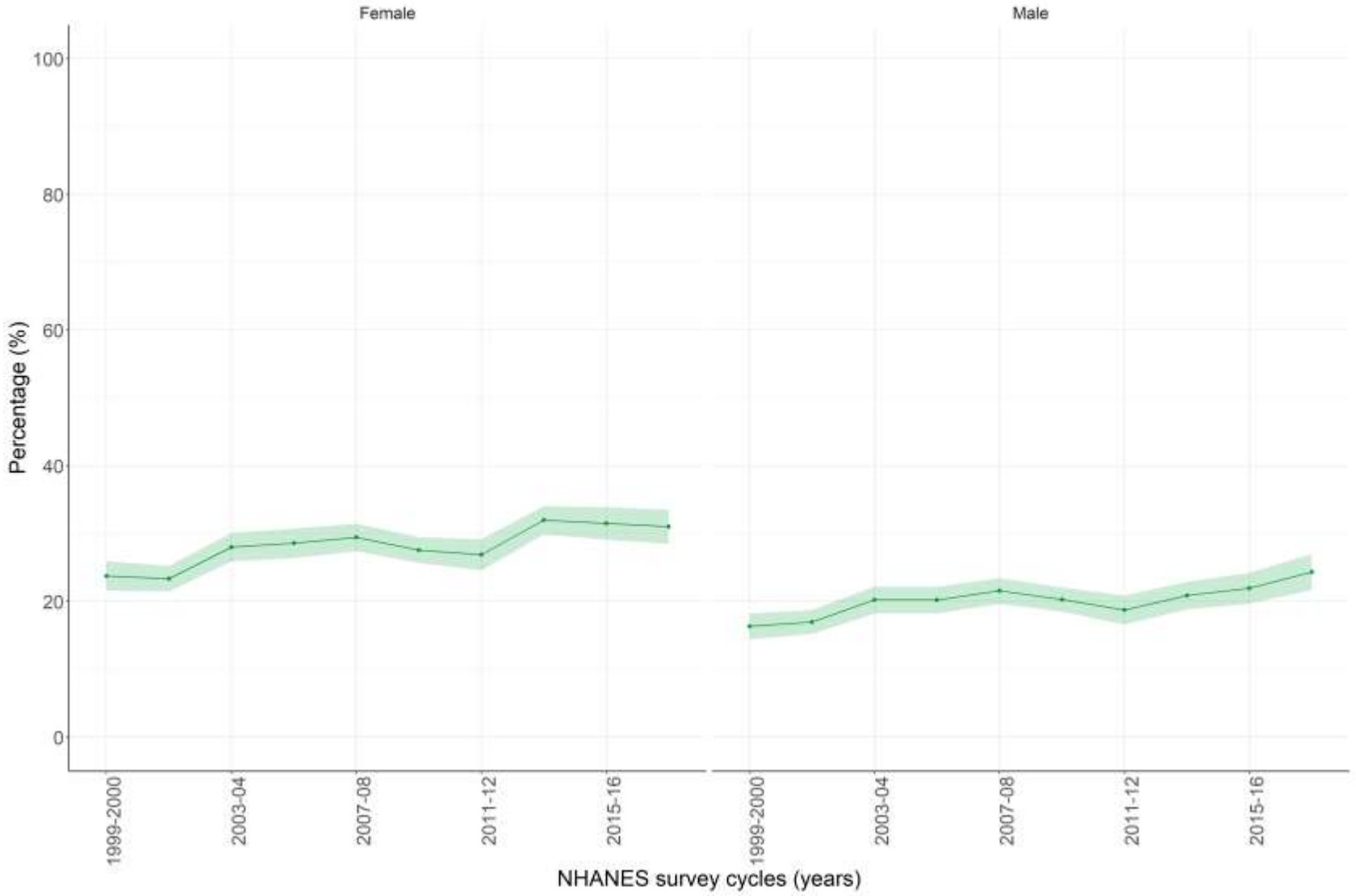


Figure 3.11: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with a form of arthritis in their lifetime by a medical doctor or healthcare worker; by sex, from 1999 until 2018 (where survey cycles are every two years), according to the National Health and Nutrition Examination Survey (NHANES [Continuous])

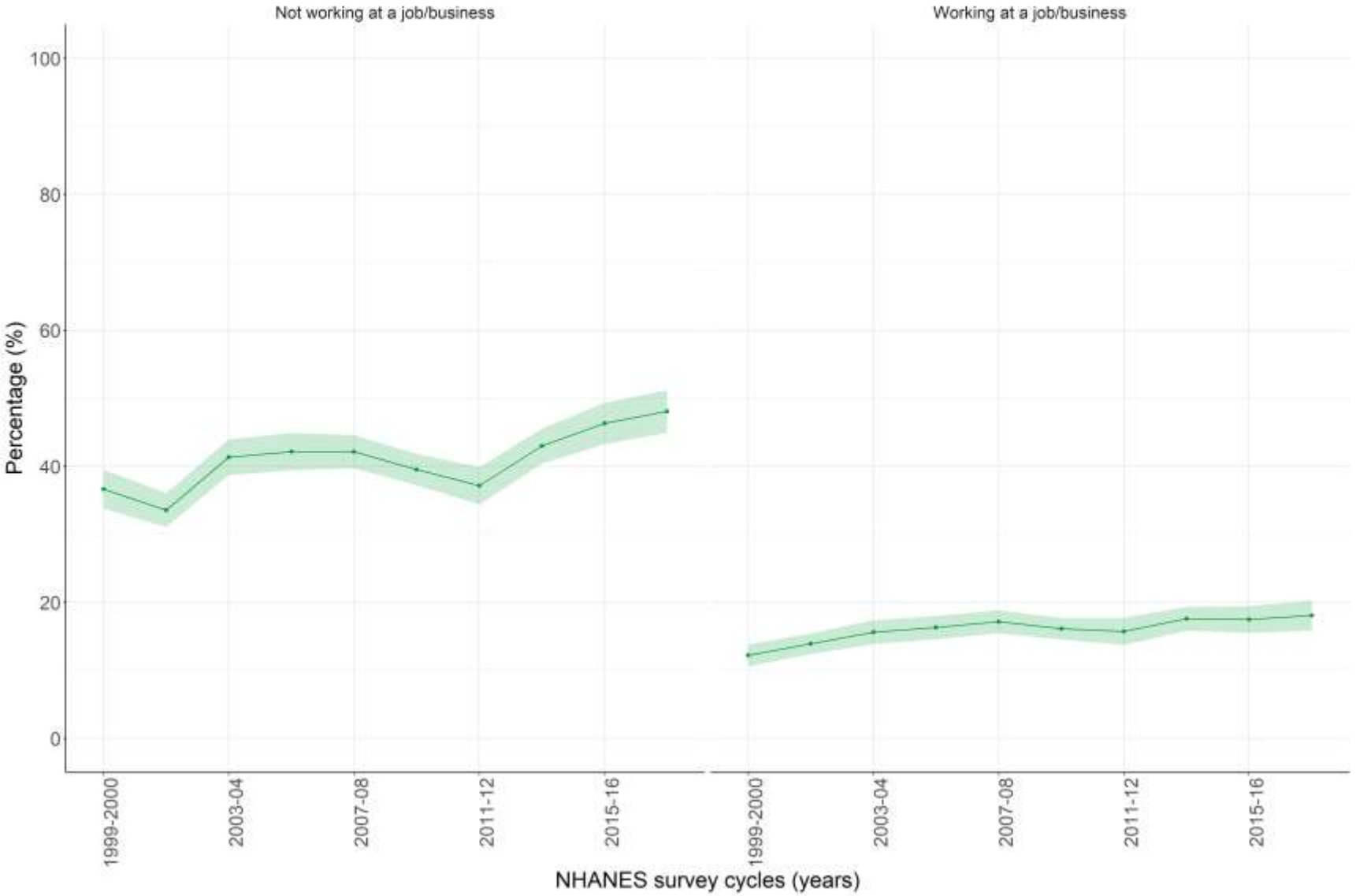


Figure 3.12: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having been diagnosed with a form of arthritis in their lifetime by a medical doctor or healthcare worker; by employment status, from 1999 until 2018 (where survey cycles are every two years), according to the National Health and Nutrition Examination Survey (NHANES [Continuous])

3.3.3 Prevalence of diagnosed arthritis over time by sex

Although the overall prevalence was consistently higher in females across time, the incremental increase across time was fractionally higher in males. The CAGR in females was 0.007% per year, going from 23.8% to 31.0% between 1999-2000 and 2017-18, but was 0.010% per year in males (Figure 3.11), going from 16.4% in 1999-2000 to 24.4% in 2017-18.

3.3.4 Prevalence of diagnosed arthritis over time by employment status

The prevalence of arthritis diagnoses saw a very slight increase in the employed between the 1999-2000 and 2017-18 NHANES survey cycles. In those working for pay, the CAGR was 0.010% per year (going from 12.2% to 18.1%). In those not working, the CAGR was 0.007% per year (going from 36.7% to 48.1%). Although the CAGR was slightly higher in the employed, there are far more people who are unemployed with an arthritis diagnosis (Figure 3.12)

SECTION 1 DISCUSSION

Temporal trends of painful arthropathies using the BRFSS, NHIS, and NHANES (Continuous) surveys

Summary of findings

I used the Behavioural Risk Factor Surveillance System (BRFSS) to calculate the annual prevalence of rheumatic disorder diagnoses amongst US residents between 1996 and 2018. I then calculated the compound annual growth rate (CAGR) between 2001 and 2009, between 2011 and 2018, and between 2001 and 2018, to assess whether there was a change in rheumatic disorder diagnosis prevalence over time. According to the BRFSS data, the overall prevalence of rheumatic disorder diagnoses remained fairly constant over time, at approximately 25% of the population.

I calculated the annual prevalence and CAGR values in 11 age groups [ages (in years) 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. The prevalence of rheumatic disorder diagnoses remained constant in all age groups across time, and the corresponding CAGR values were very small. There was a progressive increase in rheumatic disorder diagnoses with each increasing age group, which also remained steady across time. The incremental percentage differences in age group prevalence data therefore also remained constant over time.

I also calculated the annual prevalence and CAGR values in males and females. The prevalence of rheumatic disorder diagnoses was constant across time in females. In males, there appeared to be small growth, but this growth flattened after the introduction of improved weighting methodology in 2011. Furthermore, females had a higher prevalence of rheumatic disorder diagnoses (approximately 28%) compared to men (approximately 20%) across time.

I finally calculated the annual prevalence and CAGR values by employment status, namely employed for wages, unemployed, unable to work, retired, self-employed, and students. The only group for which there was some small growth was the unemployed, growing by 2.4% from 2011

until 2018. Those employed for wages had a temporally stable prevalence across time, of approximately 15%. Homemakers too had a fairly stable prevalence of rheumatic disorder diagnoses over time, at approximately 24%, as did the self-employed (approximately 19%). Students were the only group for which there was a slight decline in rheumatic disorder diagnoses, but the prevalence of rheumatic disorders in students was generally low, likely as a result of being younger. Conversely, the retired had very high annual prevalences of rheumatic disorder diagnoses (approximately 50%), likely as a result of older age, however, these prevalence data were temporally stable. Another group with high but temporally stable rheumatic disorder diagnosis prevalences was those unable to work (approximately 58%).

I used the National Health Interview Survey (NHIS) to calculate the annual prevalence of joint symptoms amongst US residents between 2002 and 2018. I also calculated the CAGR to assess whether there was a change in joint symptom prevalence over time. In the overall US population, the prevalence of joint symptoms was approximately 30%, and remained steady across time.

I calculated the annual prevalence and CAGR values in 11 age groups [ages (in years) 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. The prevalence of joint symptoms, although different across the age groups, remained steady across time. There was progressive incremental increase in joint symptom prevalences in each increasing age group, and this pattern remained steady across time too.

I also calculated the annual prevalence of joint symptoms in males and females. The prevalence of joint symptoms was stable in females, remaining around approximately 33.2%. There was however a small increase in the prevalence of joint symptoms in males, increasing by almost 6% to a prevalence of 33.4%. These results indicate a slow potential conversion of joint symptoms between the sexes.

I calculated the prevalence and CAGR values of joint symptoms by employment status, in those employed for wages and the unemployed. The prevalence of joint symptoms in people employed for wages was stable across time. Conversely, the prevalence of joint symptoms increased by 13% in the unemployed, reaching 46.4%, which is almost half of the unemployed population. The unemployed had a higher prevalence of joint symptoms compared to those employed for wages across time.

Finally, I used the NHANES (Continuous) survey to calculate the prevalence of arthritis diagnoses and the corresponding CAGR from 1999 until 2018 in the US population. The prevalence of arthritis diagnoses amongst US residents increased by approximately 7% between survey cycles 1999-2000 and 2017-18, to reach a most recent prevalence of 27.9%.

I also calculated the prevalence and corresponding CAGR of an arthritis diagnosis across time in various age groups [(in years) 20 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. There was a small increase in arthritis diagnosis prevalence in those aged 25 and 29 years old, and a very slight increase in those aged 30 to 34 years. In those aged 20 to 24 years, and groups aged 35 years and above, the prevalence of arthritis diagnoses was steady. Furthermore, there were progressive incremental increases with each age category as they increased with age. The progressive pattern, as well as the percentage increases between age groups were also steady across time, where arthritis diagnosis prevalence increased from approximately 2% in those aged 20 to 24 years, to approximately 55% in those aged 70 years and above.

The prevalence of arthritis diagnoses in females was stable, according to the CAGR; and the percentage increase (approximately 7%) aligned with the overall population increase. In males, there was a very small increase according to the CAGR, increasing by approximately 8%.

I finally calculated the prevalence and CAGR values by employment status, in those employed for wages and in those unemployed. The CAGR of those employed for wages showed a very small increase, while the CAGR of those unemployed remained stable. The prevalence of arthritis diagnoses in the employed reached approximately 18% in 2017-18, while the prevalence of arthritis diagnoses in the unemployed was approximately 40% over the timeframe. Although the growth of arthritis diagnosis prevalence was higher in those employed, the overall prevalence of arthritis diagnoses was higher in those unemployed across time.

Prevalence of painful arthropathies in the US population

Although the prevalence estimates of rheumatic disorder diagnoses (BRFSS) and joint symptoms (NHIS) appear to remain fairly stable across time, the increase in population size means that

more people are experiencing painful arthropathies. For example, according to the BRFSS, around 25% of all people had been diagnosed with a rheumatic disorder between 2001 and 2018. The population at the start of nation-wide rheumatic disorder diagnosis data collection (2001) was 288 368 698 people (US Bureau of the Census collaborators, 2002), while in 2018, the US population was 328 231 337 (US Bureau of the Census collaborators, 2019a). Therefore, where 72 092 174 people reported having been diagnosed with a rheumatic disorder in 2001, the number of people diagnosed in 2018 was 82 057 834, having increased by just shy of 10 million people. The statistics regarding joint symptoms are higher still: in 2002, 85 068 765 people reported having experienced joint symptoms in the 30 days prior to taking the NHIS interview, compared to 112 583 348 people in 2018. This difference translates to 27 514 583 more people reporting joint pain in 17 years. However, the population is not just growing, it is also aging. My analysis also shows how rheumatic disorders increase in prevalence in older people. In 2002, the population of US residents aged 65 and over was 33 769 000, whereas in 2018 the same age group consisted of 52 517 013 people. Therefore, the number of US residents over 65 reporting having been diagnosed with a rheumatic disorder or having joint symptoms went from approximately 16 884 500 in the early 2000's to 26 258 506 people in 2018.

Most literature available on various types of painful arthropathies is largely cross-sectional in nature, therefore making temporal trajectories difficult to measure. One US study however (Park, Mendy and Vieira, 2018) used NHANES (Continuous) data on doctor-diagnosed arthritis from 1999 until 2014 to show that the prevalence of doctor-diagnosed arthritis was approximately 24%, and did not change significantly over time. Much of the remaining literature, if not cross-sectional, sampled people at two instantaneous time points a few years apart. These research strategies have been used in research conducted using national surveys. The National Arthritis Data Workgroup, for example, analysed data across national complex surveys (including the National Health Interview Survey 1989 to 1991, and the National Health and Nutrition Examination Survey 1990) in order to try to establish an arthritis trajectory. They found from these data that, in 1990, 15% of US residents had a form of arthritis (Lawrence *et al.*, 1998). This prevalence estimate is lower than our estimates, and indicates that there may have been a growth in arthritis prevalence just before the national surveys were restructured to be the versions that we used. However, it is also possible that the measurements became more refined after the restructuring of national surveys due to the improvement of weighting methodology. By 2001,

the cross-sectional national prevalence of arthritis or chronic joint symptoms in the US was calculated at 33% (CDC, 2002). Later research, conducted on CDC data (NHIS) from 2010 and 2012, established that the prevalence of doctor-diagnosed arthritis was 22.7% of all adults (Hootman *et al.*, 2016). Data from 2014 analysed by the CDC indicated that the prevalence of an arthritis diagnosis was 27.2% (Barbour, Boring *et al.*, 2016), which aligns well with our rheumatic disorder and arthritis diagnoses prevalence estimates for the same timeframe. Doctor-diagnosed arthritis data from the NHIS in 2015 was used to establish Bayesian estimates for arthritis prevalences, where 25.8% of respondents reported having been diagnosed (Jafarzadeh and Felson, 2017).

Prevalence of painful arthropathies by age in the US population over time

Establishing the prevalence of painful arthropathies in the nationally representative population across annual time points to establish a temporal trajectory by age group is a novel aspect of my research. My findings can, therefore, only really be placed in context with other previously cross-sectional prevalence data, at particular time points, or by specific age categories. One identified longitudinal study on NHANES data did show that the prevalence of doctor-diagnosed arthritis increased from 33.5% to 37% in the small timeframe of 1999-2000 to 2007-08, and was only on adults aged 40 and above (Ong *et al.*, 2013). When broken down into 10-year age groups from age 40 years to age 80 years and above, the only statistically significant increase in arthritis prevalence was in 40- to 49-year-olds. All older age groups saw no significant difference in the arthritis diagnosis prevalence between the two timeframes (Ong *et al.*, 2013). The findings from this research supports my own findings of fairly stable age-specific arthritis diagnosis trajectories across time. Cross-sectional research has otherwise shown that the prevalence of arthritis in the elderly (those aged 65 and above) was approximately 60% in 2003 (CDC, 2003). A decade later, European national survey data indicated that the prevalence of chronic musculoskeletal pain (including chronic joint and/or back pain) in those aged 50 and above was 35.7% (Cimas *et al.*, 2018). Specifically, between age 50 and 59 years, the prevalence of chronic musculoskeletal pain was 30.3%; 33.7% in age 60 to 66 years; 36.5% in age 67 to 76 years; and 45.1% in those older than 75 years old (Cimas *et al.*, 2018). These data not only align fairly well with my own

analyses with respect to prevalence data, but also with respect to the progressive increase in prevalence that emerged.

My analyses showed that there was a consistent progressive increasing trend in painful arthropathy prevalence with increasing age across time. Cross-sectional nationally-representative research showed that the step-wise trend dates back to the late 1980's and early 1990's (Lawrence *et al.*, 1998). The prevalence of self-reported arthritis was 1.3% in US residents below 25 years old, and increased incrementally in the same fashion as I showed in my analyses, reaching 57.1% in adults aged 85 or above (Lawrence *et al.*, 1998). Cross-sectional data from nationally-representative samples from 2010 and 2012 showed similar results, where the prevalence of doctor-diagnosed at age 18 to 34 was between 3.9% and 5.2%, increasing incrementally to reach between 48.6% and 57.1% in those aged 85 and above (Hootman *et al.*, 2016). The aforementioned research papers also, therefore, give insight not only into the prevalence of arthropathies in their respective timeframes, but also its age-related distribution. They, furthermore, indicate that the age-related progressive trend indeed has also remained steady across time. My findings that all sub-types of painful arthropathies increased in prevalence with increasing age consistently across time are, therefore, supported by the literature, and I have further shown that these trajectories are fact stable.

Prevalence of painful arthropathies by sex in the US population

By comparing cross-sectional research that examines specific time points to the same time points in my temporal analysis, I was able to contextualise my sex-specific prevalence temporal research. In years preceding my analysis (1989 to 1991), the prevalence of arthritis and its associated symptoms was 18% in females, and 11.7% in males (Lawrence *et al.*, 1998). Both prevalence values from the early 1990's were lower than my start values across all three surveys. The underestimation could either indicate that the arthritis population increased in the population just before my start time; or that once weighting methodology was refined, the true prevalence of arthritis in the sexes was in fact higher than was thought. In the case of males, for whom I found an increasing joint symptoms and arthritis diagnosis trajectory, it is possible that the arthritis diagnosis trajectory is in fact increasing, and has been doing so slowly over the past 30 years.

Cross-sectional data from 2010 to 2012 showed that doctor-diagnosed arthritis was 19.1% in men, and 26.0% in women (Hootman *et al.*, 2016), corroborating my findings for the same time point in both sexes. By 2015, the prevalence of doctor-diagnosed arthritis was 14.4% in men, and 28.0% in women (Jafarzadeh and Felson, 2017). The population percentage presented in Jafarzadeh & Felson (2017) aligned with the prevalence results I generated for females, but does underestimate the prevalence in males (which the authors addressed as being the result of a Bayesian approach and estimating apparent prevalence, rather than using the weighting design).

The prevalence of painful arthropathies was generally stable across time in females, but there was evidence to suggest there may be a slow growth of joint symptoms (NHIS) and arthritis diagnoses (NHANES (Continuous)) in males. The BRFSS, however, showed a flat trajectory when weighting methods were refined, and the confidence intervals were reduced. It is also possible that painful arthropathies increase in specific age groups in males. Indeed, longitudinal research has shown that there is a statistically significant increase in arthritis diagnoses in males aged 40 and above, going from 28.7% to 31.1% (Ong *et al.*, 2013). Although small growth was observed in females aged 40 and above, the increase was statistically not significant, going from 40.1% to 42.3%. Despite the potential growth in males, the overall prevalence of painful arthropathies of all kinds was consistently higher in females compared to males. The higher prevalence of painful arthropathies in females has been shown in much arthritis literature across numerous time points (Lawrence *et al.*, 1998; Hootman *et al.*, 2016; Jafarzadeh and Felson, 2017; Cimas *et al.*, 2018), therefore supporting my finding.

Prevalence of painful arthropathies by socioeconomic (employment) status in the US population

Two notable trends emerged in my socioeconomic temporal analysis regarding the unemployed group. Firstly, the unemployed had a higher prevalence of all three types of painful arthropathies compared to the employed, across the entire timeframe. Previous research using national surveys has supported this finding, where the results of the research showed that the prevalence of chronic musculoskeletal pain is higher in the unemployed (39.2%) compared to those employed (31.8%) (Cimas *et al.*, 2018). My second finding regarding the unemployed was that the painful arthropathy reports in the unemployed were increasing across time in all three types of painful arthropathies. When considering that the socioeconomic status of the unemployed would be low,

there is a possibility that the prevalence generated from the BRFSS (rheumatic disorder diagnosis) and NHANES (Continuous) (arthritis diagnosis) may even be underestimating the true prevalence within the population. Both the BRFSS and NHANES (Continuous) questions require an official diagnosis, which the unemployed may not be able to afford. The NHIS showed that in fact the prevalence of joint symptoms in the unemployed is almost half the entire unemployed population, confirming that the symptoms and consequential burden of painful arthropathies could in fact be higher in the unemployed. One potential reason for the increased prevalence of arthritis-related reports in the unemployed, as well as the increasing trend in these reports, could be to do with early exit from work. Cross-sectional population-based research from Portugal showed that of the one third of people in their late career (age 50 to 64 years) who had osteoarthritis, more than half did not have paid work (Laires *et al.*, 2018). Indeed, the prevalence of arthritis is high in those retired (38.4%) and those sick or disabled (50.2%) (Cimas *et al.*, 2018). The economic and social burden of painful arthropathies is, therefore, high, and is on an upward trajectory.

The burden of painful arthropathies is, however, also present within the workforce. My analysis showed that the prevalence of painful arthropathies in the workforce (all surveys) was between 15.8% and 27.5% by 2018. In the early- to mid-2000's, cross-sectional research showed that the prevalence of arthritis in the US workforce was 14.7% (Ricci *et al.*, 2005). A 2008 study that used US population-based surveys found higher prevalences still, as well as an age-related trend where the older workforce reports more arthritic pain. Of working US resident adults between 20 and 39 years, 20.8% reported arthritis pain; compared to 79.2% of working adults aged between 40 and 64 years (McDonald, daCosta DiBonaventura and Ullman, 2011). European survey data indicated that the prevalence of chronic musculoskeletal pain in those aged 50 and above who are employed was 31.8% (Cimas *et al.*, 2018). Painful conditions, including painful arthropathies, cause a loss in productivity in the work place, and can even result in early exit from work (Laires *et al.*, 2018). In 2006, the cost of arthritis was measured at CAN $11 533 per person with arthritis per year, and 37% of that amount was attributed to loss of wages due to stopping work or changing jobs (Li, Gignac and Anis, 2006). The aforementioned research however pre-dates the 2008 financial crisis, and is therefore likely an underestimation of the true cost of painful arthropathies. Indeed, a recent systematic review on the prevalence, costs, and work limitations on common conditions requiring rehabilitation showed that osteoarthritis was

the second most prevalent condition (10.4%). Furthermore, osteoarthritis was estimated to contribute $460 billion in all-cause medical costs in the same research (Lo, Chan and Flynn, 2020).

Limitations and section conclusion

The temporal research presented here does present some limitations. The largest limitation to temporal research is changed weighting methodologies, such as those that occurred in the BRFSS from 2011 onwards. The prevalence measurements post-2010 are more precise and are a far better indicator for rheumatic disorder diagnoses across the US population. However, there are only eight years' worth of prevalence data with the new weighting method to examine. This is the case for all the demographic categories I analysed (age, sex, and employment status). Furthermore, the module-year analyses contain fewer participants, and are localised in particular states, and thus the precision of the measurements is lower (as seen by the wider confidence intervals in these years). This lower precision is particularly true for years 1996 to 1999 and year 2010 due to sampling fewer than six states or territories. Another limitation I faced was subtle changes in the questions asked to participants. A question would be asked about arthritis particular type of painful arthropathy for a set time scale over a few years, but would then change to a time scale that was not comparable. For example, the NHIS question on whether participants had experienced joint symptoms applied to the 30 days before taking the interview. Before 2002, the same question was asked, but the timeframe given was 12 months. Thus, consistent longer term temporal trends became impossible to establish for time frames over approximately 20 years. There is a cost-benefit scenario to changing survey questions: by reviewing questions, questions can remain as up to date as possible according to most recent definitions, however, the potential temporal analysis for periods of multiple decades is then lost. Ultimately, it is more important to be in line with most recent research, in order to obtain real-time data on the health needs and burdens within the population.

Establishing a temporal trajectory of various types of painful arthropathies (including rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses) using population-based surveys, in the overall population as well as by age, sex, and employment status, was a novel approach to musculoskeletal pain methods. The temporal trajectories that I have shown could therefore be

used in projecting future costs of disease, such that health systems, social grants, insurance companies, and individuals can be prepared for these costs. Financial allocations can also be better distributed according to which demographic groups showed consistently high prevalences of painful arthropathies (such as the elderly, females, and the unemployed, retired, and those unable to work). Particular planning and attention should be paid to the burden of painful arthropathies in the unemployed, as the prevalence is high as well as on an upward trajectory in a group that may be less able to financially handle the cost. Finally, pain (including painful arthropathies) tends to associate with numerous aspects of a person's wellbeing and health (such as mental health, disability, sleep, and overall health-related quality of life) (James *et al.,* 2019). Public health scientists could therefore benefit from using painful arthropathy trajectory data in their models for the aforementioned areas of wellbeing, as well as predict the associated costs.

SECTION 2: TEMPORAL TRENDS OF LOW BACK PAIN

Chapter One of this thesis discussed the lack of research that looked at pain prevalence across time in the whole population, as well as within demographic groups (such as by age, sex, and socioeconomic status). Research on musculoskeletal pain, including low back pain, is often cross-sectional and geographically localised. One study however, The Global Burden of Disease 2017 Study, plotted global low back pain prevalences between 1990 and 2017, and found that the prevalence of low back pain was temporally stable (Wu *et al.*, 2020). However, the findings did not extend to a demographic-specific low back pain prevalence trajectory. Furthermore, although country-specific data was available at start- and end-time points, the study did not show a trajectory per country for the overall population of that country (for example a US-specific trajectory plot).

The Sample Adult Questionnaire of the National Health Interview Survey (NHIS) recorded self-reported data on low back pain in the three months preceding interview time. The NHIS also records data on age, sex, and employment status. Section 2 of this chapter addresses my first thesis objective within the context of low back pain: to establish temporal trends in the prevalence of low back pain. I established the annual prevalence of low back pain over the last 22 years, and plotted these data. I also calculated the compound annual growth rate (CAGR) to address the trajectory of low back pain. I conducted these analyses on the whole US population, by age group, sex, and employment statuses.

3.4 National Health Interview Survey (NHIS)

The prevalence of US residents who reported having low back pain in the three months prior to taking the National Health Interview Survey (NHIS) Sample Adult supplement was calculated (after appropriate design weights were applied) as the proportion of people who answered “Yes” to the question, “DURING THE PAST THREE MONTHS, did you have low back pain?”. Prevalences were calculated across years 1997 until 2018, with the exception of 2004. The calculation was done for the overall population, across five-year age groups, across sexes, and employment status (2002 until 2018 only). For the overall US population as well as for each demographic group, I then calculated the compound annual growth rate (CAGR) from the

starting year (1997, or 2002 in the case of employment status) until the most recent year (2018) of results.

The unweighted demographic characteristics of the sample for each year are available in Appendix F, Table IV. Tables consisting of annual prevalence values (95% confidence interval) for the overall population are available in Appendix G. The prevalence (95% confidence interval) is also available by age group (Appendix H, Table IV), sex (Appendix I, Table IV), and employment status (Appendix J, Table IV).

3.4.1 Overall prevalence of low back pain over time

The prevalence of low back pain has remained steady at approximately 30% of all US residents, across time from 1997 until 2018. The compound annual growth rate (CAGR) was 0.003% per year (Figure 3.13).

3.4.2 Prevalence of low back pain over time by age

In 18- to 24-year-olds, the CAGR between 1997 (21.9%) and 2018 (16.5%) was -0.013% per year. In those aged 25 to 29 years, the CAGR between 1997 (25.0%) and 2018 (24.8%) was < -0.001% per year. In the 30- to 34-year-old (26.2% to 26.3%), 35- to 39-year-old (28.7% to 28.8%), and 40-to 44-year-old (29.0% throughout) age categories, the CAGR between 1997 and 2018 was < 0.001% per year. In those aged 45 to 49 years, the CAGR was 0.002% per year between 1997 (29.8%) and 2018 (31.0%). In those aged 50 to 54 years, the CAGR between 1997 (33.1%) and 2018 (31.3%) was -0.002% per year. In 55- to 59-year-olds, the CAGR was 0.002% per year between 1997 (31.6%) and 2018 (31.3%). In those aged 60 to 64 years, the CAGR was 0.008% per year between 1997 (30.8%) and 2018 (36.4%); and in those aged 65 to 69 years, it was 0.007% per year between 1997 (30.0%) and 2018 (34.9%). Finally, in those aged 70 years and above, the CAGR between 1997 (29.3%) and 2018 (37.8%) was 0.012% per year (Figure 3.14). To summarise, in the youngest age category, low back pain decreased very slightly over the years for which we have data, and appears to be on a downward trajectory. Thereafter, in adults between 25 and 69 years old, there was little to no difference in low back pain over time. In the oldest age category (70 years or above) however, the prevalence of low back pain grew slightly. Furthermore, the range in prevalences of low back pain across the age groups is approximately 20%, and only 13% between those aged 25 to 29 years and those aged 70 years and above.

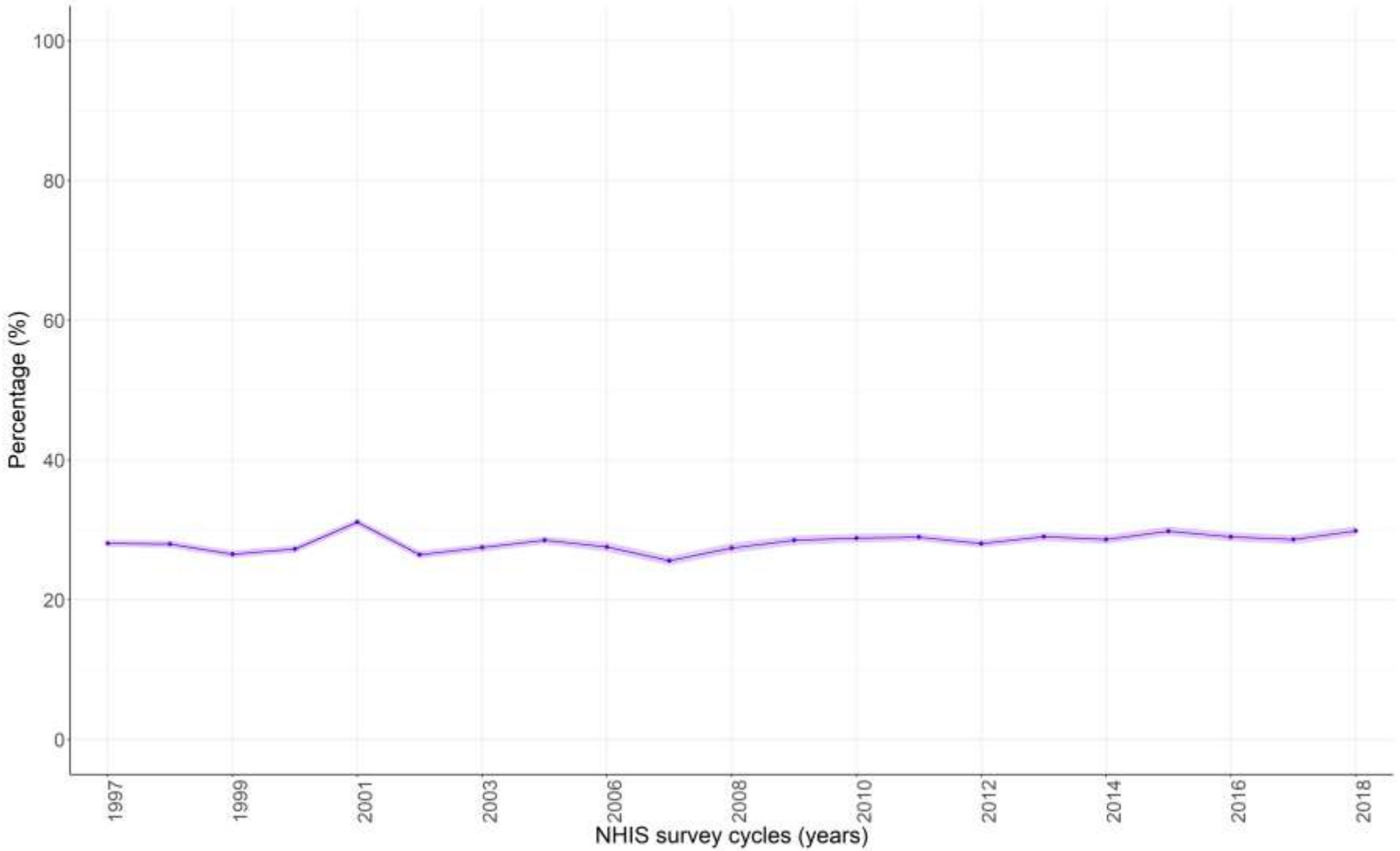


Figure 3.13: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having low back pain in the three months before taking the survey from 1997 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

[α] Sample Adult Questionnaire of the NHIS

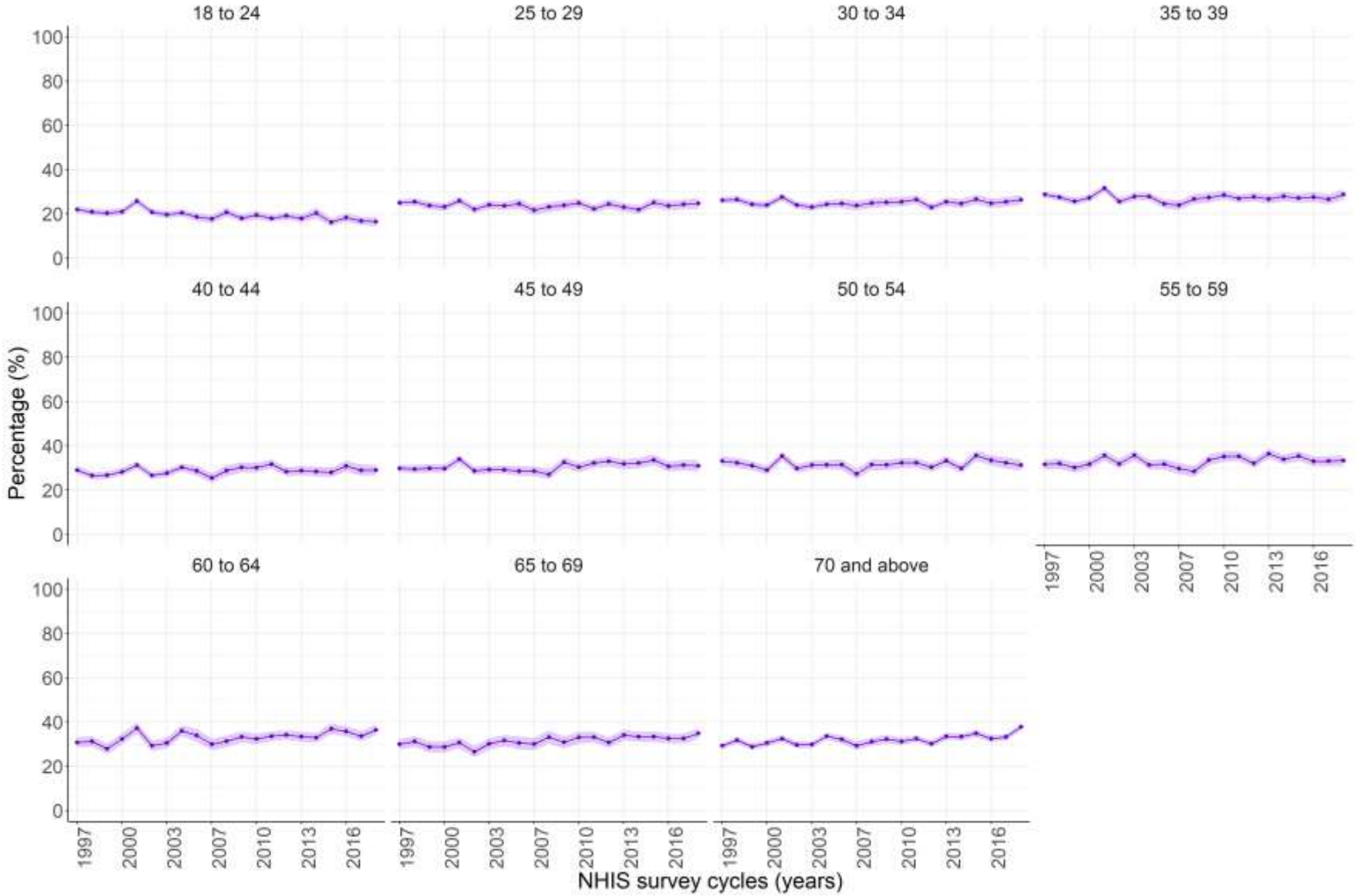


Figure 3.14: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having low back pain in the three months before taking the survey; by age group, from 1997 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

[α] Sample Adult Questionnaire of the NHIS

3.4.3 Prevalence of low back pain over time by sex

The prevalence of low back pain has remained fairly consistent across time in both sexes. The CAGR between 1997 and 2018 was 0.003% per year in females, and was 0.002% per year in males. In females, the prevalence in 1997 was 29.6%, and only reached 31.6% by 2018. In males, the prevalence was 26.5% in 1997, and reached 28% by 2018 (Figure 3.15).

3.4.4 Prevalence of low back pain over time by employment status

The CAGR in the employed for pay category was 0.004% per year, and went from 24.0% in 2002 to 25.8% in 2018. In those unemployed, the prevalence of low back pain in 2002 was 32.9%, while in 2018 it was 37.5%, yielding a CAGR of 0.008% per year (Figure 3.16).

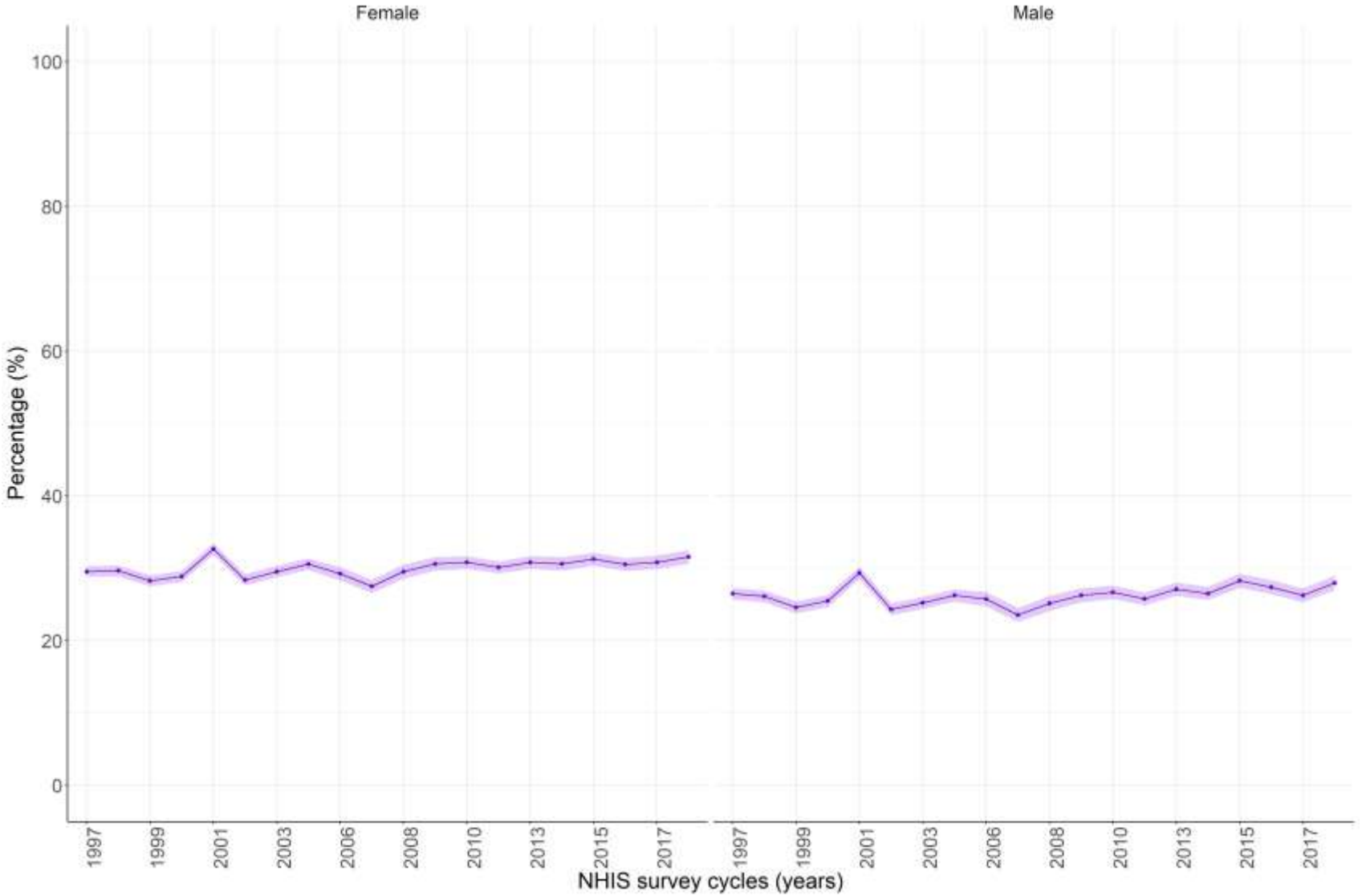


Figure 3.15: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having low back pain in the three months before taking the survey; by sex, from 1997 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

[α] Sample Adult Questionnaire of the NHIS

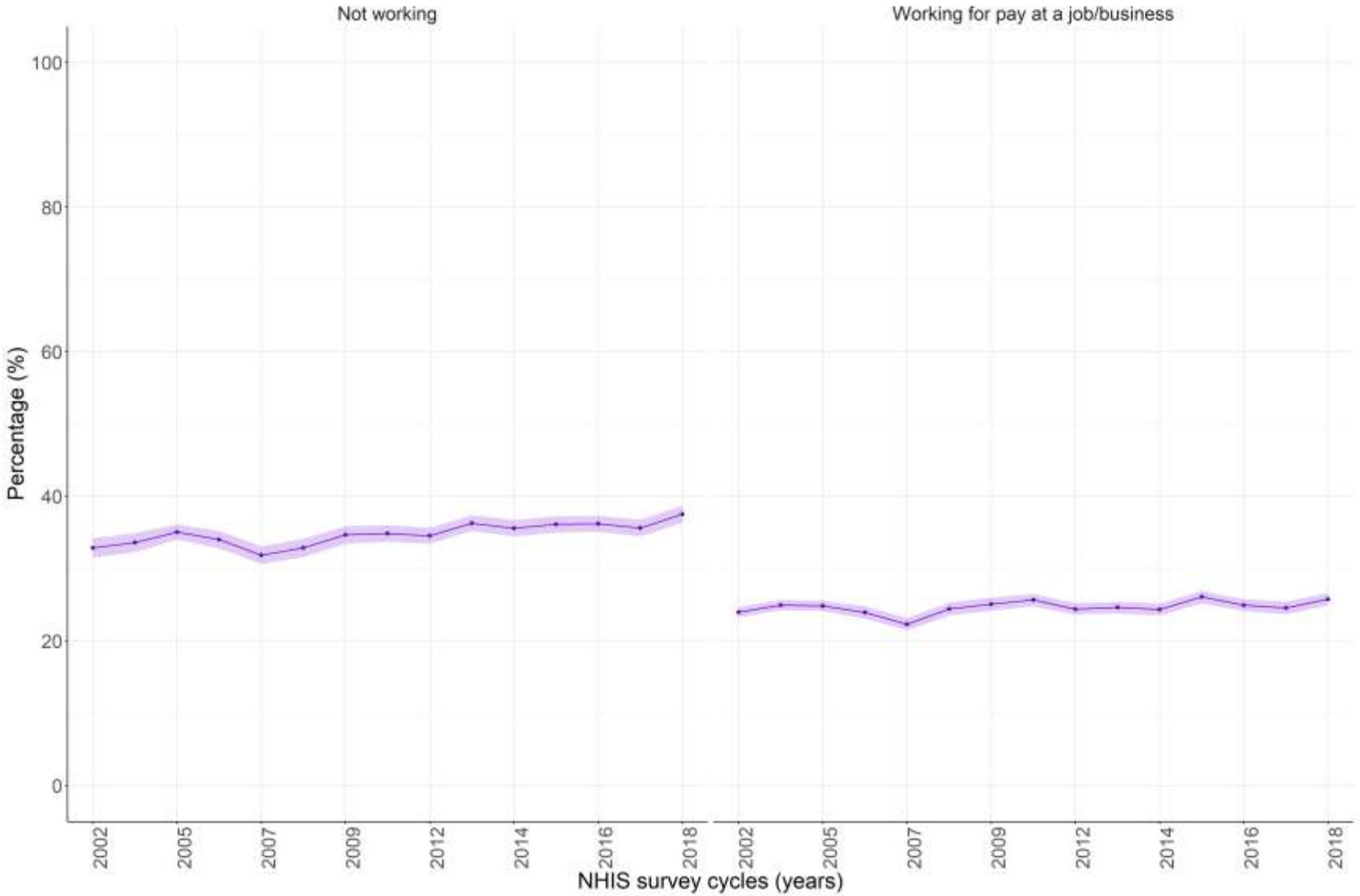


Figure 3.16: Prevalence (solid line) with 95% confidence interval (shaded area) (%) of US residents who reported having low back pain in the three months before taking the survey; by employment status, from 2002 until 2018 (excluding 2004), according to the National Health Interview Survey (NHIS)[α]

[α] Sample Adult Questionnaire of the NHIS

SECTION 2 DISCUSSION

Temporal trends of low back pain using the NHIS

Summary of findings

I calculated the prevalence of low back pain in nationally representative samples of US residents from 1997 until 2018 (except 2004), using data from the Sample Adult Questionnaire of the National Health Interview Survey (NHIS). I also calculated the CAGR using the start (1997, or 2002 for employment status) time to the end (2018) time. The prevalence of low back pain remained stable across time, at approximately 30% of all US residents.

I repeated the prevalence and CAGR calculations on age groups [age (in years): 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. Across time, the only group that had a decrease, albeit small, in low back pain prevalence was the youngest group (age 18 to 24 years). The oldest age group (age 70 years and above) had a small increase in low back pain prevalence. Over time, there was a progressive incremental increase in low back pain prevalences only in the youngest three age groups, but the incremental increases are very small (at times, only 1%) after the age of 35 years old. The overall change of low back pain prevalence between the youngest and oldest age groups was 20%, and majority of the change occurs between 18- and 34-years-old.

I repeated the prevalence and CAGR calculations on males and females. The prevalence of low back pain in fairly temporally stable in both males and females, at between 23.6% to 29.4%, and 27.55 to 32.7%, respectively. Although annual statistical comparisons of low back pain reports between males and females will be covered in Chapter Five, it is clear, in terms of the descriptive statistics, that the prevalence of low back pain in females was consistently higher than that in males over the entire timeframe analysed.

I finally repeated the prevalence and CAGR calculations on those employed for pay, and those unemployed. The prevalence of low back pain was constant across time in both employment statuses, at approximately 25% in those employed, and approximately 35% in those unemployed. Although annual statistical comparisons of low back pain reports between employed people and unemployed people will be covered in Chapter Five, it is clear, in terms of the descriptive

statistics, that the prevalence of low back pain was consistently higher in the unemployed compared to the employed.

Prevalence of low back pain in the US population

To my knowledge, the only study that presented consistent annual longitudinal data at population level was the Global Burden of Disease Study 2017, which makes use of population-based surveys from across the world, the NHIS included. The study addressed the low back pain prevalence and burden from 1990 to 2017 (Wu *et al.*, 2020), where the authors plotted the global temporal trends of low back pain over the full timeframe. Global low back pain point prevalence in an age-adjusted population has remained stable across the years in the global population, which strongly supports my own temporally stable low back pain prevalence findings. The Global Burden of Disease Study also acknowledges that, although the prevalence of low back pain may be stable across time, the number of people with low back pain is increasing due to population growth (Wu *et al.*, 2020). More people with low back pain results in incrementally increasing costs associated with low back pain for public health structures and society, particularly within the context of an aging population where the burden of disability also comes into play.

There are various ways to collect prevalence estimates of low back pain (point prevalence, one-month prevalence, three-month prevalence, one-year prevalence), and the contextualisation of low back pain-related findings can be challenging due to the heterogeneity in measurements. Furthermore, much of the available specifically longitudinal research on low back pain assess baseline and outcome comparison data (Dunn, Jordan and Croft, 2006), making continuous trajectories difficult to track. Finally, longitudinal data available (available in short spells such as a few weeks, or one year) are often collected at general practices and health centres. These data could therefore exclude those who do not seek healthcare for the low back pain, perhaps because they do not feel their pain is severe enough to get treatment, or even because they cannot afford care. The findings I present in my analysis are therefore more likely to include non-healthcare-seekers and less severe cases, yielding a more accurate figure on low back pain in the population. The NHIS question is also phrased to ask about low back pain over the last three months, but is

not specific on whether pain was episodic or chronic, therefore giving an estimate of the overall prevalence of low back in the population, irrespective of its nature.

The prevalence of any type of low back pain therefore appears to have remained constant over the previous 22 years. Although the proportion of people with low back pain in the US may have remained constant, population growth must be considered. For perspective, the population of the US at the start of 1997 was 266 490 000 people (US Bureau of the Census collaborators, 1998), whilst at the end of 2018 it was 328 231 337 people (US Bureau of the Census collaborators, 2019). In 1997, the prevalence of US residents with low back pain was 28.1%, which translated to 74 883 690 people. In 2018, the prevalence of low back pain was 29.9%, which translated to 98 141 169 people. There is therefore an increase of over 23 million people overall with low back pain between 1997 and 2018.

Prevalence of low back pain by age in the US population

The prevalence trends (as well as the temporally stable nature) of age-ranked low back pain data until 2017 in this thesis aligned well with the Global Burden of Disease Study (Wu *et al.*, 2020). The point prevalence of low back pain in early adulthood (age 18 to 39 years) was between 5% and 12% in both 1990 and 2017. In middle adulthood (between age 40 and 59 years), the point prevalence was between 10% and 18% in both 1990 and 2017. In older people (age 60 years and above), the point prevalence of low back pain was between 15% and 25% in 1990 and between 15% and 23% in 2017. In all age groups, the range in prevalence data is attributable to age and not time. The slight difference between my own prevalence results and the global prevalence data however is that the global data have a slightly more obvious progressive age-related increase in prevalence due to wider age ranges, and the prevalence results were slightly lower than the US-based data. The slight discrepancy could be due to the burden of an aging population in the developed world, as well as the burden of obesity in the US specifically, which will be described in greater detail in Chapters Five and Six of this thesis.

Other research that made use of population-based survey data often offered a cross-sectional snapshot of low back pain prevalences. Early measures from the late 1990's and early 2000's indicated that approximately 20% of people aged 18 to 34 years had low back pain, and

gradually increased with age until approximately 30% of the elderly had low back pain (Deyo, Mirza and Martin, 2006; Strine and Hootman, 2007). Swedish population-based research (using World Health Organisation MONICA population-based surveillance) found that the prevalence of low back pain in adults between the ages of 35 and 74 years old was between 18% and 26.3%, increasing with age; which aligned well with my findings. At the age limits however, the prevalence of low back pain was in fact lower than what I established in US-based research, specifically: 6.3% for those aged 25 to 34 years, and only 3.4% in those aged 75 to 79 years old) (Björck-van Dijken, Fjellman-Wiklund and Hildingsson, 2008). Data collected in nationally representative samples in Scandinavia are therefore similar to those in the US for the majority of the adult population, but not necessarily at the age limits.

Recent estimates from Spanish as well as broadly European population-based survey data indicated that the prevalence of low back pain (although lower than US-based prevalences) were also stable over a three-year timeframe in age-ranked categories (Palacios-Ceña *et al.*, 2015). Specifically, young adults (16- to 30-years-old) had a low back pain decrease of 0.77%, from 3.97% (2009) to 3.20% (2012). Middle-aged adults (age 31- to 50-years-old) had low back pain prevalence of 8.03% (2009) to 8.38% (2012), increasing by 0.35%. Older adults (aged 51- to 70-years-old) had low back pain prevalence of between 9.67% (2009) and 11.45% (2012), increasing by 1.78%. Finally, the elderly (aged 70 years and above) had low back pain prevalence of between 10.52% (2009) and 11.52% (2012), increasing by 1%. Although the demographic differences will be directly discussed in Chapter Five, the Spanish and European data support the finding of stable low back pain prevalence over time in various age groups.

Although the prevalence of low back pain does not increase in large intervals with age in five-year intervals (in the manner of painful arthropathies, for example), the oldest people in the US population still had the highest prevalences of low back pain. Crucially, they are also a growing demographic group, as well as a group for which there is a greater burden on society. Those 65 years and older accounted for 12.8% of the US population at the end of 1996 (US Bureau of the Census collaborators, 1998), therefore 34 110 720 million people, of whom (by our prevalence data) 10 233 216 would have had low back pain. In 2018, the proportion of the US population that was 65 years or above was 16% (52 517 013 people) (US Bureau of the Census collaborators, 2019b), of whom – according to our prevalence measurements - 19 089 934 had

low back pain. There was, therefore, an increase in absolute numbers of people with low back pain in the elderly of the US by almost nine million people.

Prevalence of low back pain by sex in the US population

Longitudinal prevalence data from North America in Wu *et al*. (2020) (the Global Burden of Disease Study 2017) appears substantially lower than my results at first glance (9.80% [male] and 11.55% [female] versus my findings of 26.3% [male] and 30.8% [female], for 2017). However, the disparity is due to my sex result not being age-adjusted. When I examined the global point prevalence figures, divided by age and sex, and not just as an age-adjusted sex variable, in the Global Burden of Disease Study in both 1990 and 2017, the age and sex point prevalence of global low back pain aligned well with my own NHIS data. These longitudinal data also supported my findings of females having a consistently higher prevalence of low back pain compared to males across time. Moreover, these data showed that the prevalence of low back pain in females was also consistently higher across all age groups across time. Analyses on US-based data should confirm whether this finding extends to the US, and therefore potentially address the greater burden of low back pain in the female population.

Cross-sectional Norwegian population-based research (the HUNT studies) aligned with the sex-specific low back pain data I presented here, where 20.9% of men had chronic low back pain, and 26.3% of women had chronic low back pain (Heuch *et al.*, 2010). Sex-based data from other nationally representative survey research also indicated a low back pain prevalence of around 28% in females, and 24% in males, during the late 1990's and early 2000's (Deyo, Mirza and Martin, 2006; Strine and Hootman, 2007). Although the data available from Spanish population-based surveys are lower in prevalence, they are also stable, where the growth in low back pain between 2009 and 2012 was only 0.5% (from 8.10% to 8.60%) in males and 0.9% (from 7.62% to 8.52%) in females (Palacios-Ceña *et al.*, 2015). Furthermore, the point prevalence of low back pain in the sexes remained stable in their respective age group from 1990 to 2017 in the Global Burden of Disease study too (Wu *et al.*, 2020).

Prevalence of low back pain by socioeconomic (employment) status in the US population

To my knowledge, my research is the first to plot a continuous trajectory of annual low back prevalence in various employment groups. The literature I use for context is, therefore, cross-sectional at various time points. Although there is a dearth of longitudinal research on the prevalence of low back pain by employment, low back pain is in fact the leading cause of job-related disability (Strine and Hootman, 2007), and therefore warrants research. According to my findings, low back pain is consistently higher in people without work compared to those employed, which is confirmed by other cross-sectional research at various time points (Strine and Hootman, 2007; Van Oostrom *et al.*, 2011; Balagué *et al.*, 2012). The picture is more complicated, however, as longitudinal research has shown that people with more severe low back pain were less likely to be re-employed after leaving work (Nwaru, Nygård and Virtanen, 2016). Low back pain is also the leading health problem pushing the older workforce into early retirement (Maher, Underwood and Buchbinder, 2017). Low back pain is also the leading condition requiring rehabilitation in all-cause medical costs, which are estimated to be approximately $365 billion (Lo, Chan and Flynn, 2020). If people are being pushed out of employment, it is reasonable to assume some form of income loss would occur as a consequence, which would in turn result in decreased capacity to obtain healthcare or rehabilitation for the low back pain. Inability to obtain care to improve low back pain could then further limit the chances someone has of returning to work, and the cycle could just continue, resulting in increased low back pain prevalences in the unemployed.

Low back pain was temporally stable within those employed for work according to my findings. Yang *et al.* (2016) showed in cross-sectional research that, when dividing the workforce into age, sex, and race demographic groups, the respective low back pain prevalences aligned with the same groups in the overall population. Given that my own analyses showed that low back pain prevalence within age and sex groups is constant over time, it is reasonable to suggest that the prevalence of low back pain in the workforce is also likely to be stable, supported by my analysis of the employed group, and the population trends aligning with workforce population trends of Yang *et al*. (2016).

Limitations and section conclusion

The analysis presented here had some limitations. Low back pain data were only available in one survey used in our work (the NHIS Sample Adult Supplement). Thus, there were no other survey results with which to compare or supplement these results in the way we did with the painful arthropathies. Furthermore, the major restructuring of the NHIS, with the new format containing a Sample Adult supplement being introduced in 1997, made the data from years before this change incomparable. The data presented here are therefore limited to 22 years' worth of trends. Whilst the 22 years' worth of trends is valuable information, it is a limitation to this body of work as the NHIS has been collecting health surveillance data since the early 1960s. In addition, the employment categories from the NHIS do not consist of a "Retired" option (with the exception of 2002 and 2003), thus the "Not working" category also includes the retired population, who are often old and thus have a slightly higher low back pain prevalence. Future research could thus dissect the "Not working" population into categories "retired", "unable to work", and "unemployed" (similar to the BRFSS) in order to see how the prevalence trajectory of low back pain compares in these categories. The NHIS question on low back pain refers to a three-month timeframe. Whilst it is advantageous to know the prevalence of low back pain in the population overall (and three months allows for the inclusion of episodic and chronic pain), it may also be useful to know what the prevalence of episodic and/or chronic pain individually are at the level of the population.

Despite our research indicating that the prevalence of low back pain has remained relatively stable within specific demographic groups over time, there are aspects about low back pain that should be investigated further. Low back pain is the leading cause of years lived with a disability (Maher, Underwood and Buchbinder, 2017). Despite a stable prevalence, future research should evaluate whether the prevalence of low back pain *resulting in disability* is actually on the rise. The 2015 Global Burden of Disease study found that low back pain had resulted in 60.1 million years lived with disability, which was an increase of 54% compared to the same research question in 1990 (GBD and Injury Incidence and Prevalence collaborators, 2016). Finally, low back pain has been measured across the literature in a variety of ways, including point prevalence, one-month prevalence, three-month prevalence, one-year prevalence. The prevalence period discrepancy has previously resulted in significantly different results in prevalence

estimates (Hoy *et al.*, 2012), which poses a huge limitation for meta-analyses and reviews. Population-based surveys can be used to streamline the assessment of low back pain in the population in order to try to standardise low back pain estimates.

Overall, the research on low back pain is indeed quite extensive, but there is a limitation in the cross-sectional nature of the available studies, as well as the heterogeneity in the way that low back pain has been measured. Given that low back pain is one of the most common disability-causing conditions, as well as the socioeconomic burden that comes with the condition, establishing its trajectory was essential. Addressing the potential burden of disability as a result of low back pain is particularly important in the context of the US, as the developed world has high prevalence estimates of low back pain compared to developing countries (Maher, Underwood and Buchbinder, 2017; Hartvigsen *et al.*, 2018). Estimating the extent of disability in relation to low back pain can only accurately be obtained if we know the extent of low back pain in the population. The analyses in this chapter showed that the prevalence of low back pain is in fact steady in the overall population, in five-year age groups, in both sexes, and in those employed and unemployed. However, with an increasing population size, the absolute number of people with low back pain has increased. Using these findings, costs can be predicted for public health spending prioritisation, insurance requirements, as well as costs to government in grants and healthcare, as well as personal costs.

CHAPTER FOUR

Geospatial trends of musculoskeletal pain: painful arthropathies and low back pain

Chapter One of this thesis highlighted the dearth of geospatial data on musculoskeletal pain. The Behavioural Risk Surveillance System (BRFSS) survey does have an online platform where various disease prevalences may be viewed by state, and some research has been published on state-based data from the BRFSS on rheumatic disorder diagnosis (Barbour *et al.*, 2016b). These data are, however, a snapshot, and do not provide context on whether or not state-based prevalences stand the test of time.

Furthermore, musculoskeletal pain has been associated with age (Maher, Underwood and Buchbinder, 2017; González-Chica *et al.*, 2018; Park, Mendy and Vieira, 2018) and sex (Kvien *et al*., 2006; Barnabe *et al*., 2012; Maynard *et al*., 2020; Wu *et al*., 2020). Therefore, state-based trends within these specific demographic groups may in fact exist, but are under-researched, and hence are not being addressed by the current pain literature available, resulting in geospatial pain trends presently being inconclusive. Chapter Four of this thesis, therefore, aims to address my second objective: to establish spatial trends in the prevalence of painful arthropathies (Section 1) and low back pain (Section 2).

SECTION 1: GEOSPATIAL TRENDS OF PAINFUL ARTHROPATHIES

The painful arthropathy type assessed by the BRFSS is lifetime rheumatic disorder diagnosis, and the BRFSS records and releases data on state residence, age, and sex. The National Health Interview Survey (NHIS) asks participants about joint symptoms within the previous 30 days, and also collects and releases data on regional (Midwest, Northeast, South, and West) residence, age, and sex. Using the BRFSS and NHIS data, I calculated the prevalence of painful arthropathies across geospatial areas (states and regions); as well as the prevalence of these painful arthropathies within age groups, and between sexes, by state and region.

4.1 Behavioural Risk Surveillance System (BRFSS)

Rheumatic disorder diagnosis

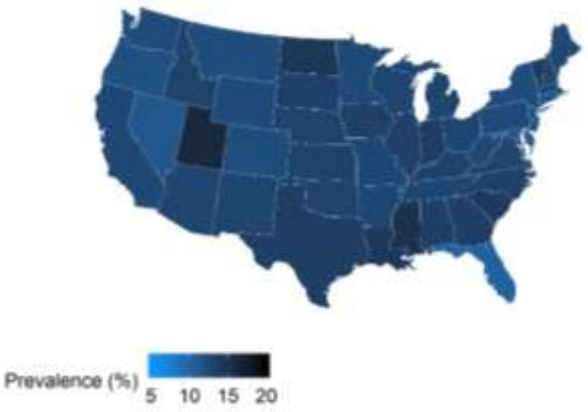
The prevalence of US residents who report having been diagnosed (by a medical doctor or healthcare practitioner) with a rheumatic was taken as the proportion of people who answered "Yes" to the question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?" The prevalence was calculated for each state in years where state-specific data was available, namely: 2001, 2003, 2005, 2007, 2009, and 2011 to 2018. To illustrate these data, I made choropleth maps of the US in order to show the state-specific prevalence of a rheumatic disorder diagnosis, for each year of analysis. Maps for every four years (2001, 2005, 2009, 2013, and 2017) are shown in this chapter, while the remaining maps for all other years are available on GitHub (https://github.com/AnneIoannides/BRFSS_Musculoskeletal-Pain/tree/master/Figures). After the prevalence for each state was obtained, a Global Moran's I was done to assess whether there was a spatial correlation.

I also created choropleth maps of the US age and sex demographic distributions in order to interpret my results against any confounding demographic distributions for each year (Figures 4.1.1 to Figure 4.1.10), as both older age as well as female sex are associated with various types of rheumatic diseases (Kvien *et al.*, 2006; Barnabe *et al.*, 2012; González-Chica *et al.*, 2018; Park, Mendy and Vieira, 2018; Maynard *et al.*, 2020). I have shown these distributions for years 2001, 2005, 2009, 2013, and 2017 in this Chapter, while all other years are available on GitHub (https://github.com/AnneIoannides/BRFSS_Musculoskeletal-Pain/tree/master/Geo-demographic%20distribution%20images).

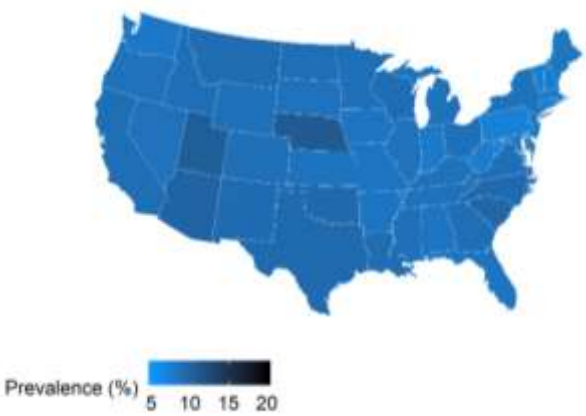
The age distribution differed slightly across states, where I identified Texas, Utah, California, and Georgia as having increased proportions of young and middle-aged adults and decreased proportions of older adults, relative to other states in the same age categories. Furthermore, I identified that the proportion of older adults is slightly higher relative to other states in the same age categories in states West Virginia, Alabama, Montana, Arkansas, Oklahoma, and Tennessee. Furthermore, the US has an increased proportion of adults at either age limit (age 18 to 24, and age 70 and above). The aforementioned demographic features are less stark after 2011 when the

BRFSS improved sampling and weighting calculation procedures. (Figure 4.1.1 to Figure 4.1.10).

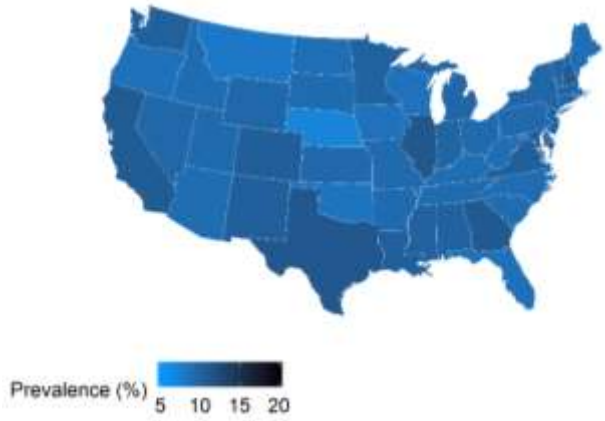
Age 18 to 24 years



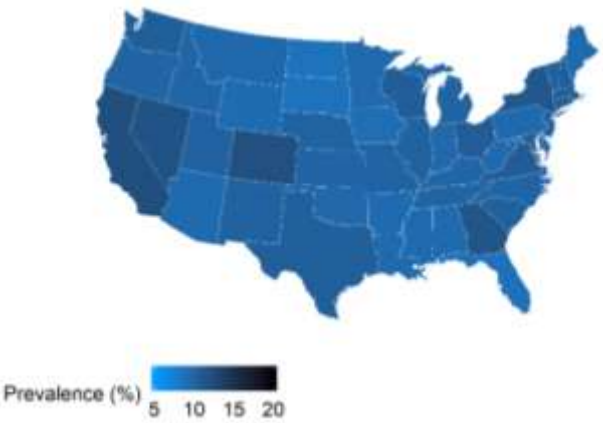
Age 25 to 29 years



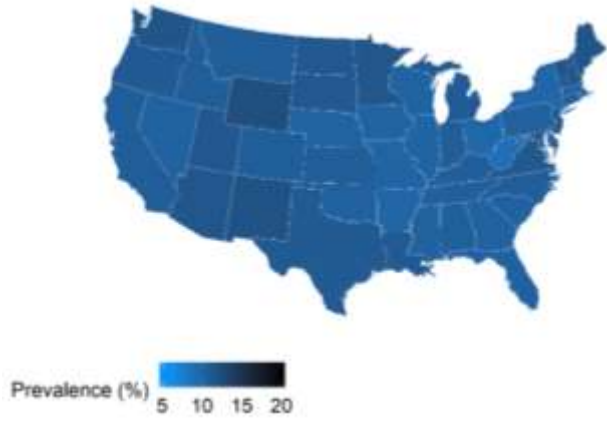
Age 30 to 34 years



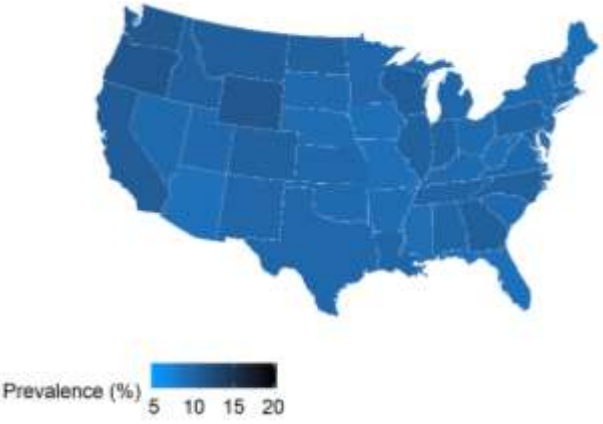
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



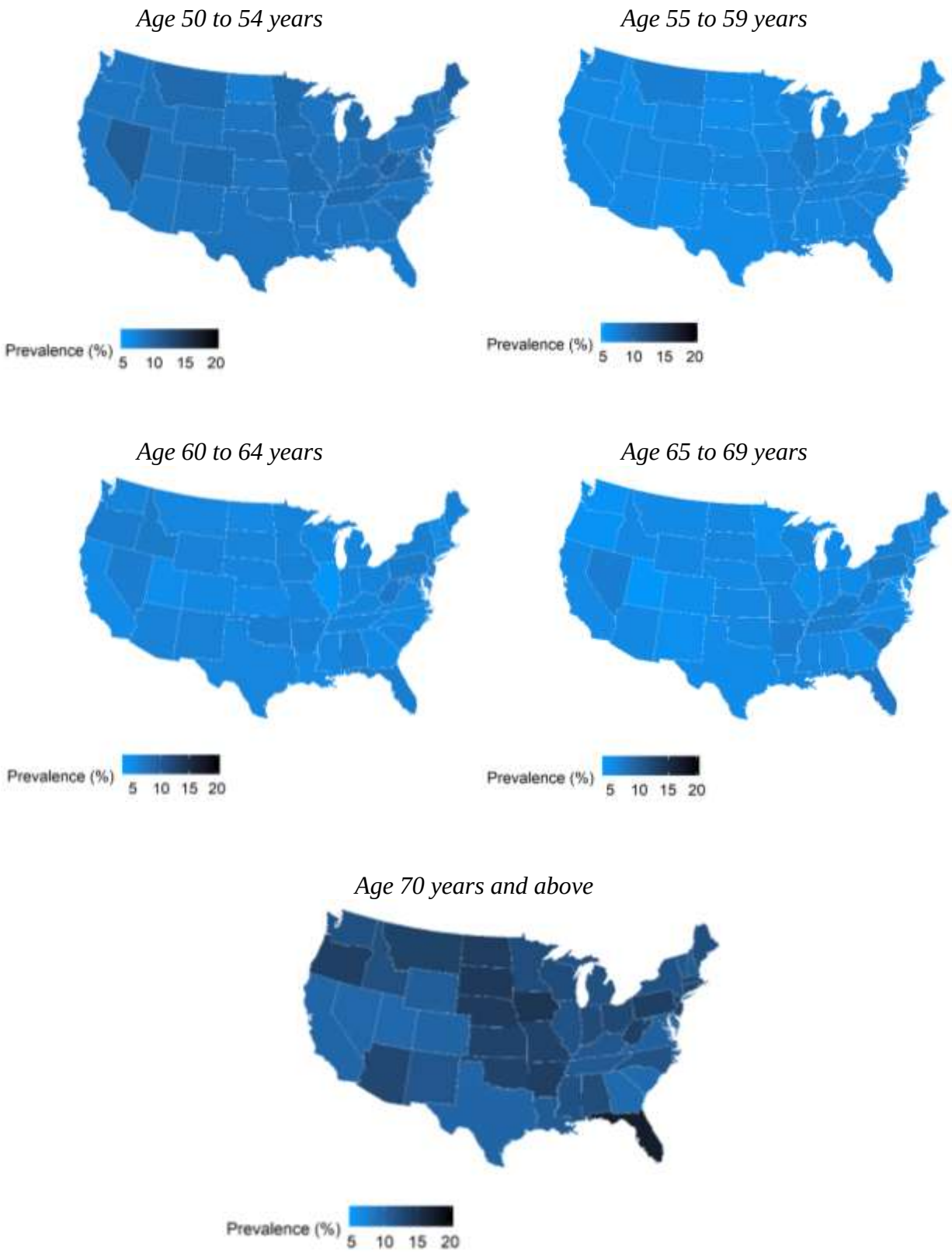


Figure 4.1.1: Distribution of various age groups across the US by state in 2001, according to the BRFSS weighted sample

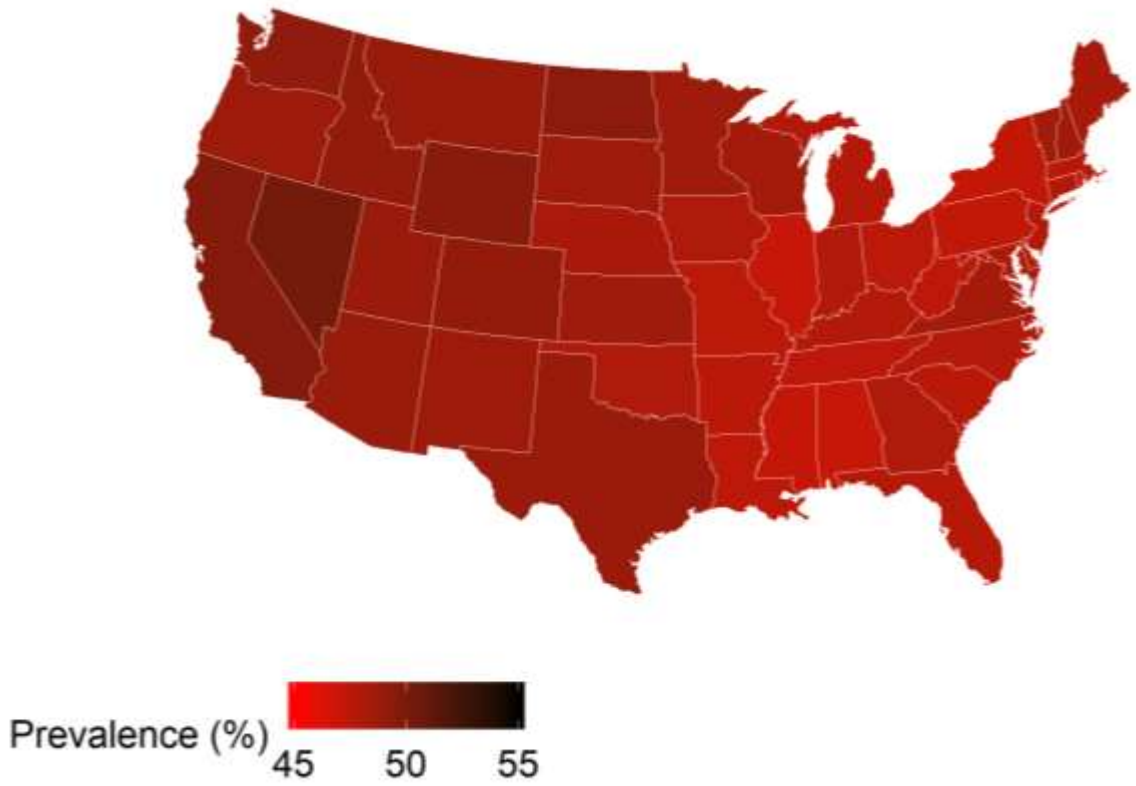
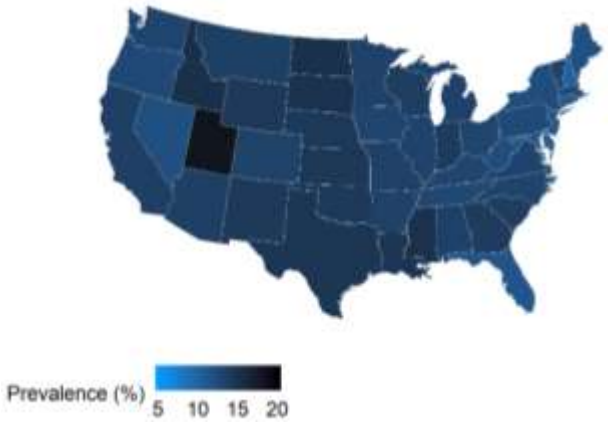
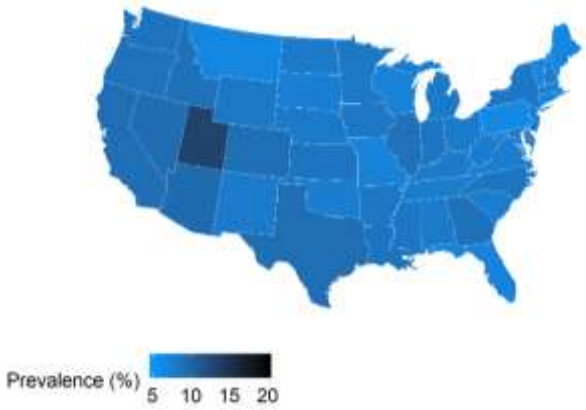


Figure 4.1.2: Distribution of males across the US by state in 2001, according to the BRFSS weighted sample

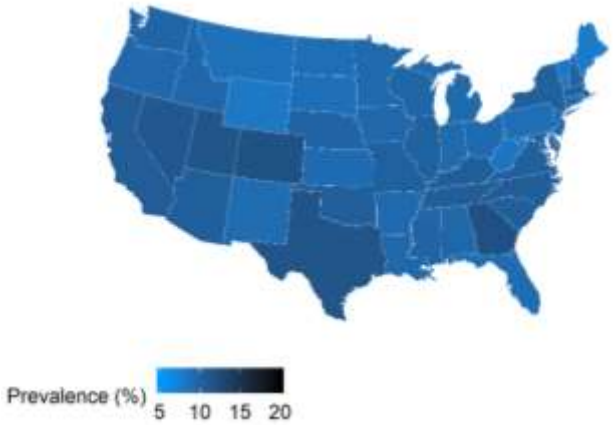
Age 18 to 24 years



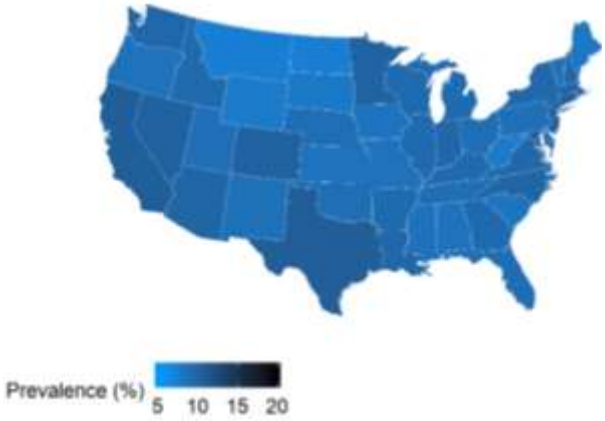
Age 25 to 29 years



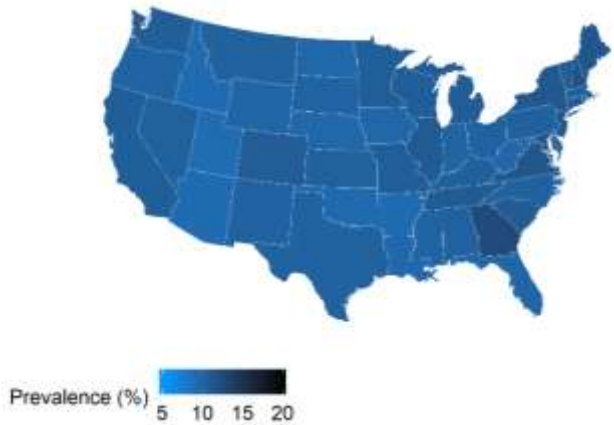
Age 30 to 34 years



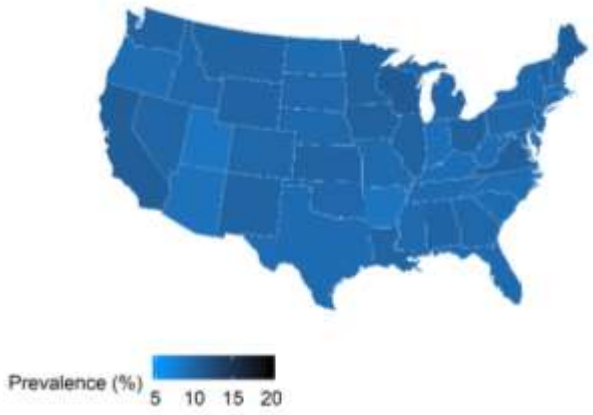
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



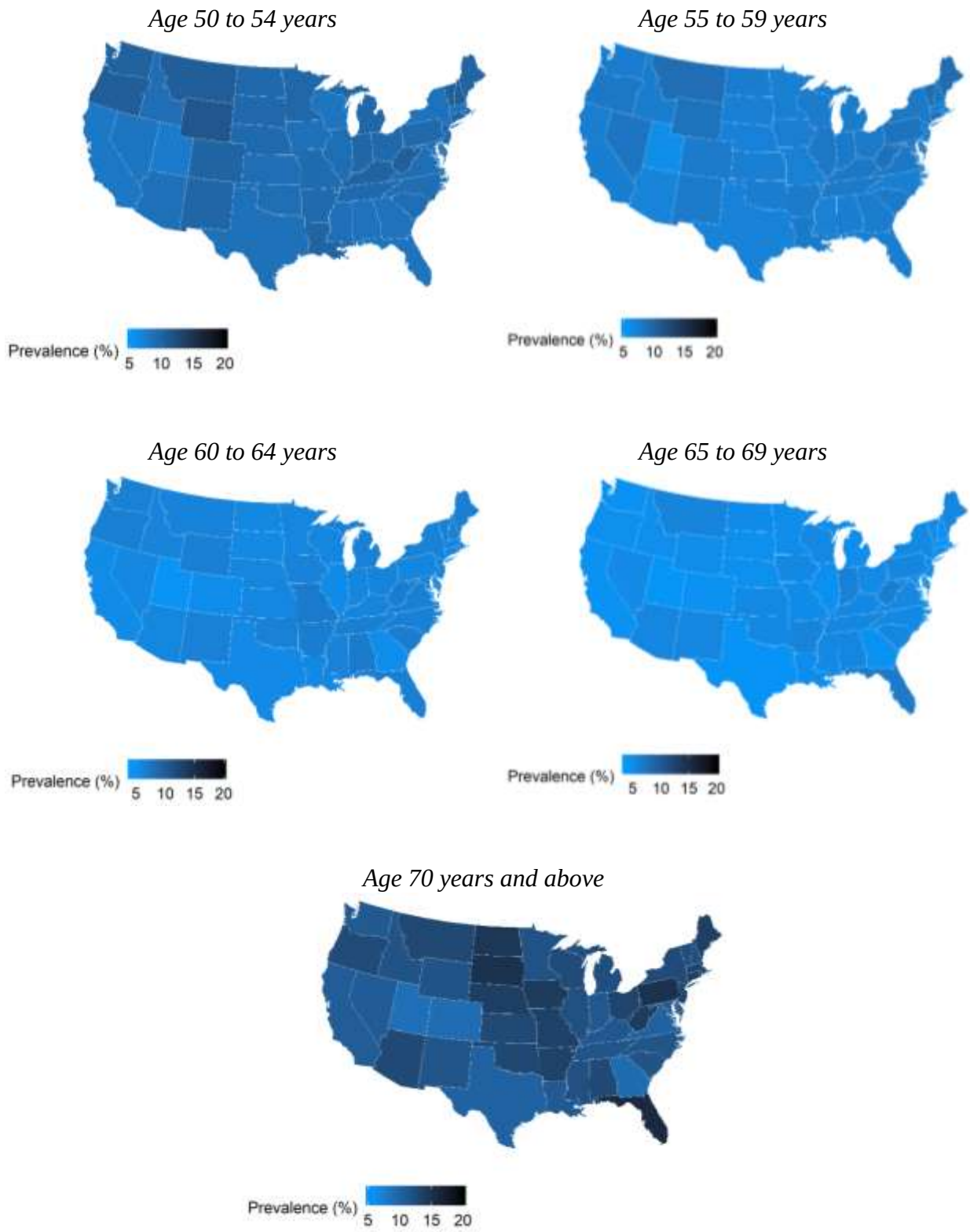


Figure 4.1.3: Distribution of various age groups across the US by state in 2005, according to the BRFSS weighted sample

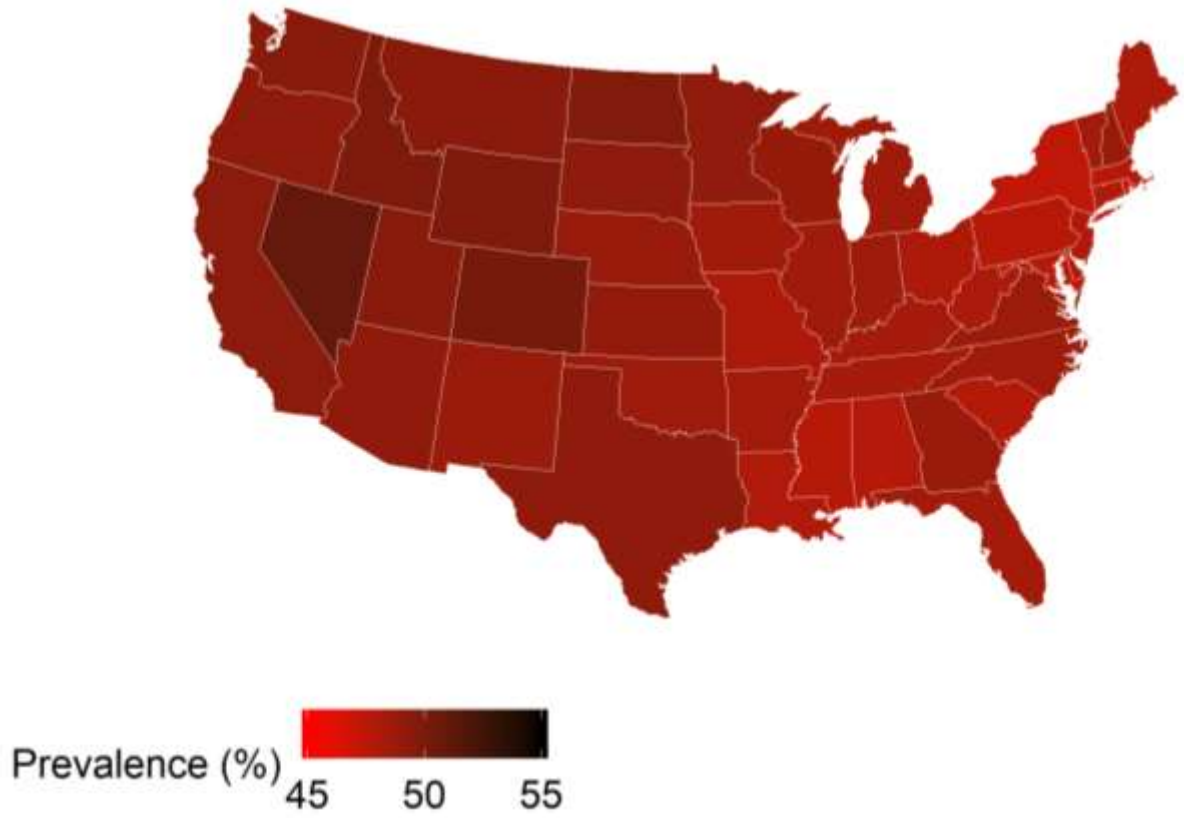
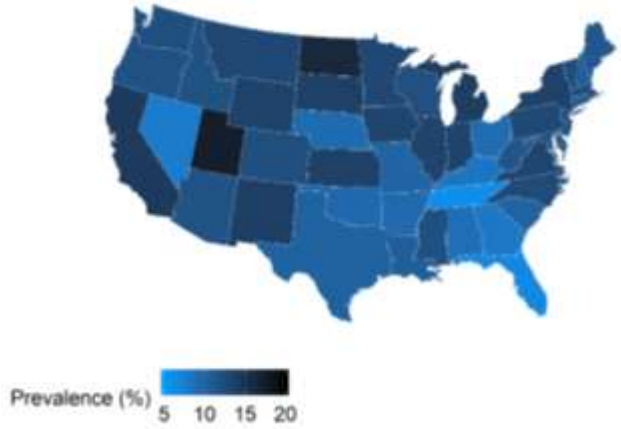
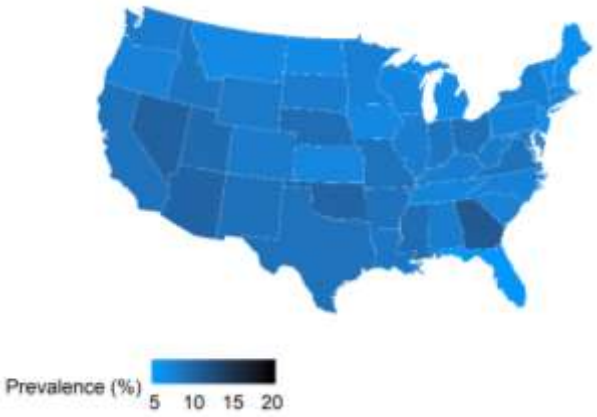


Figure 4.1.4: Distribution of males across the US by state in 2005, according to the BRFSS weighted sample

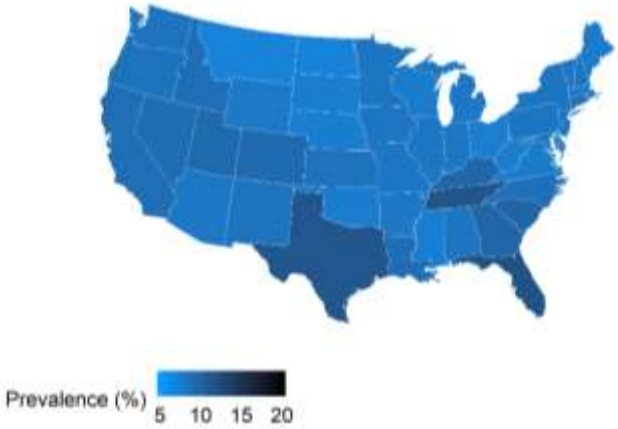
Age 18 to 24 years



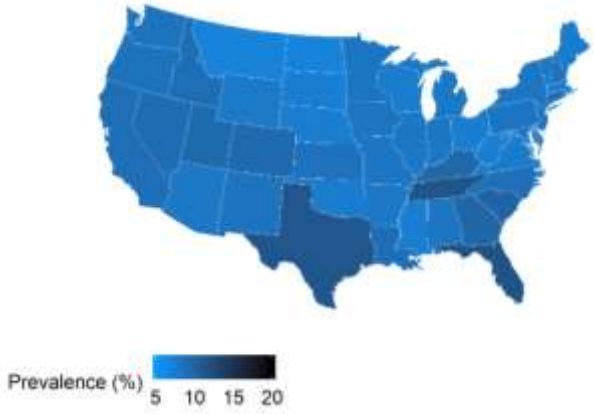
Age 25 to 29 years



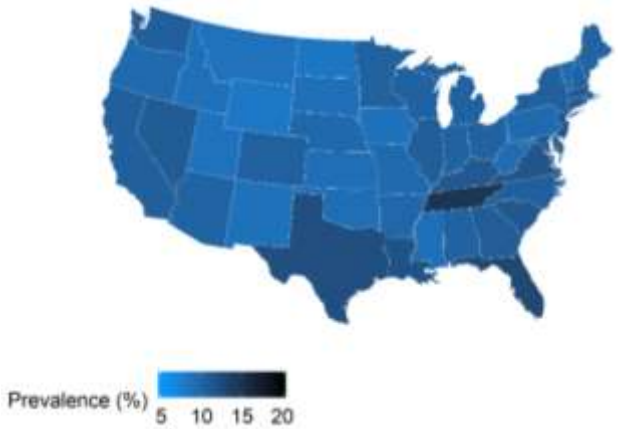
Age 30 to 34 years



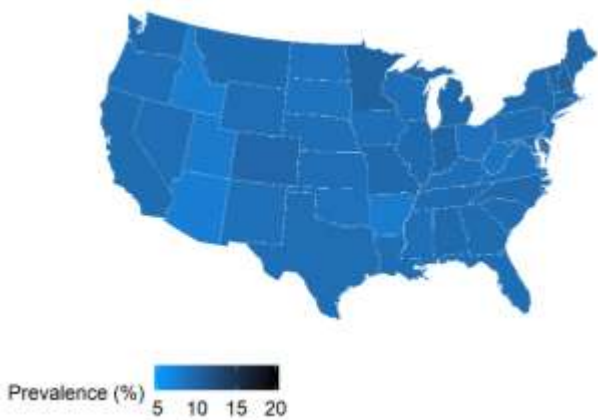
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



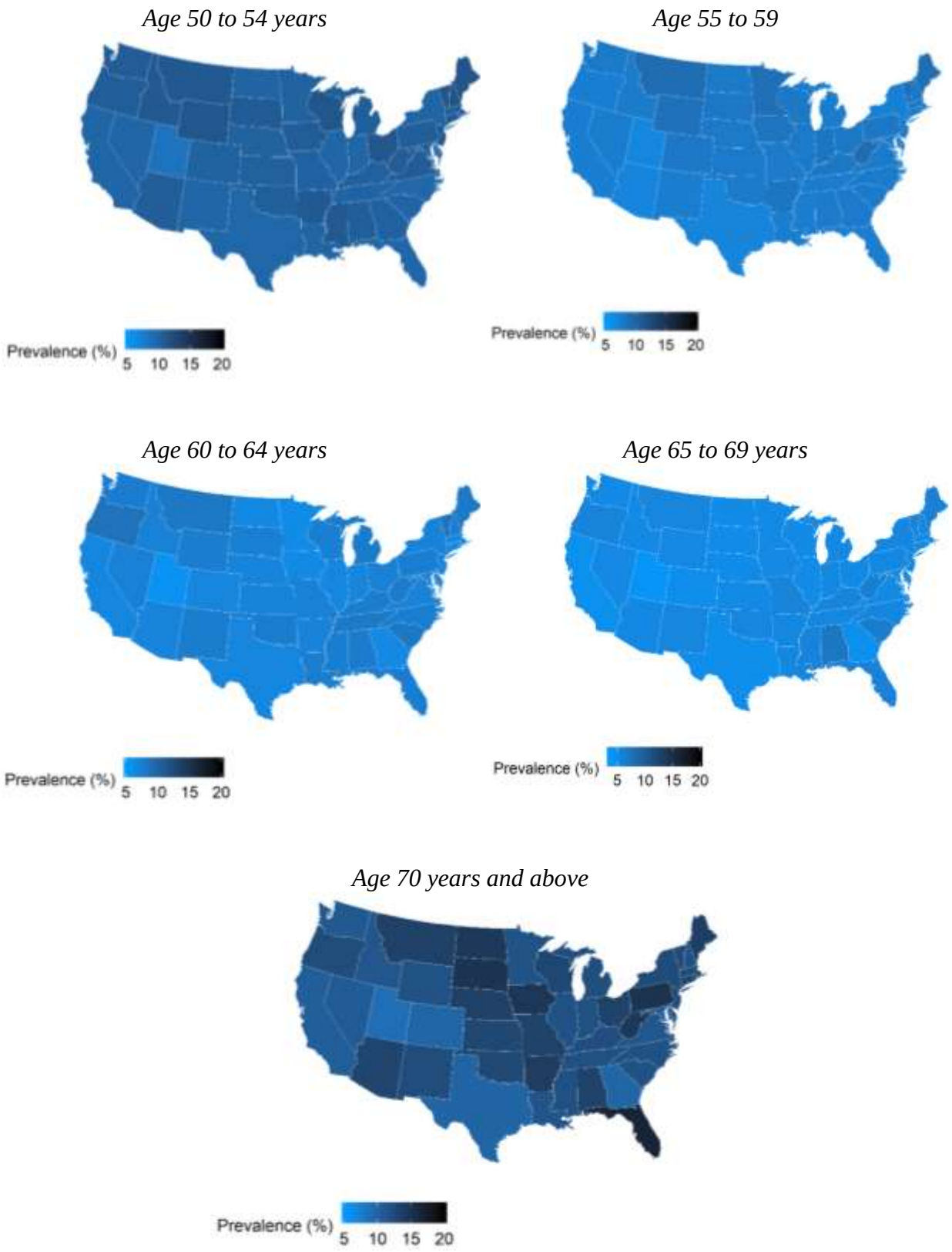


Figure 4.1.5: Distribution of various age groups across the US by state in 2009, according to the BRFSS weighted sample

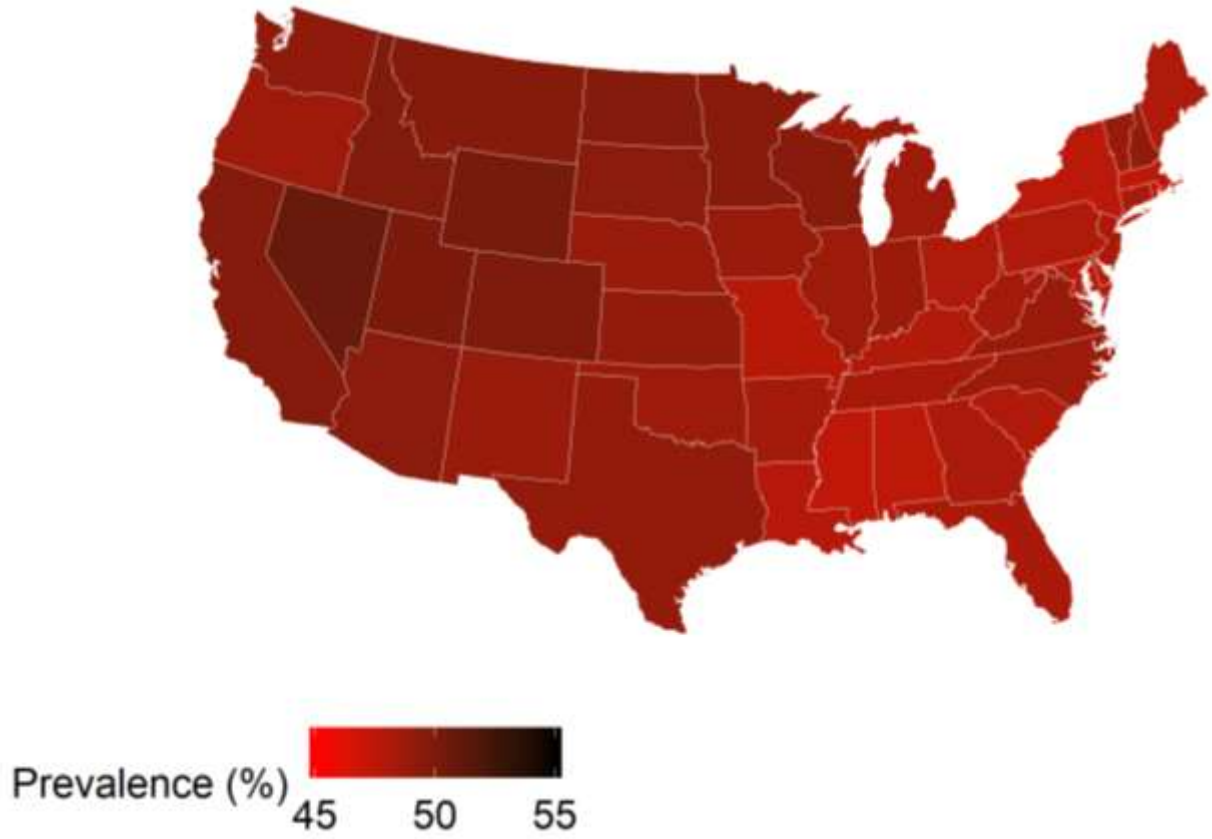
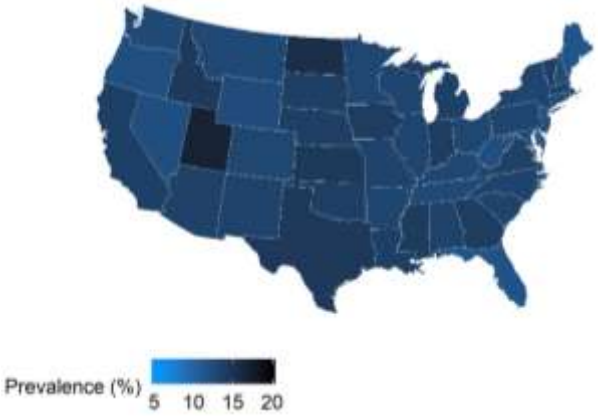
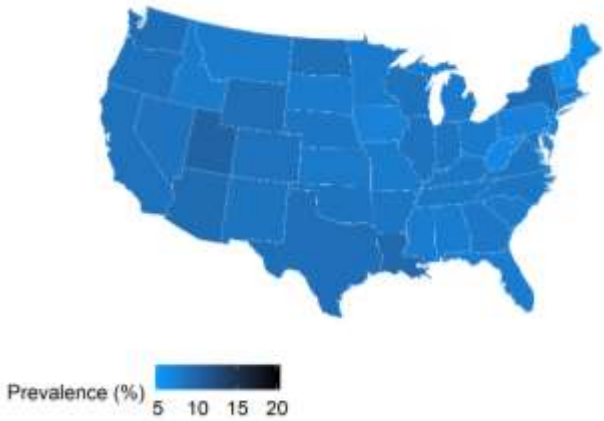


Figure 4.1.6: Distribution of males across the US by state in 2009, according to the BRFSS weighted sample

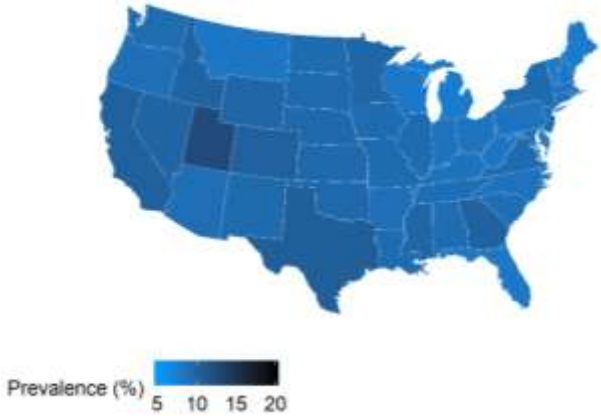
Age 18 to 24 years



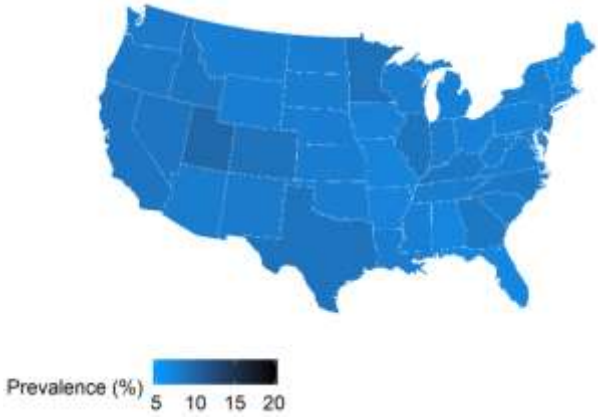
Age 25 to 29 years



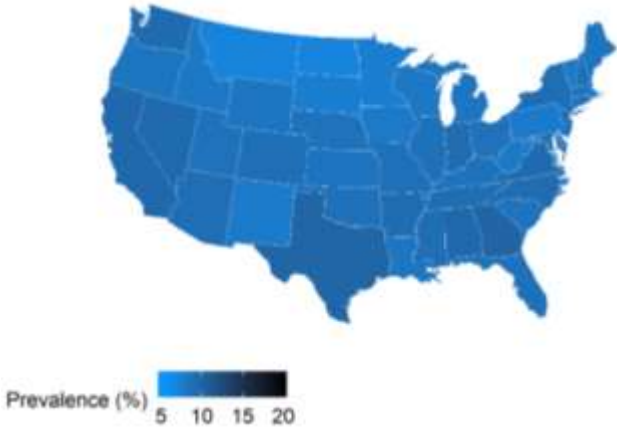
Age 30 to 34 years



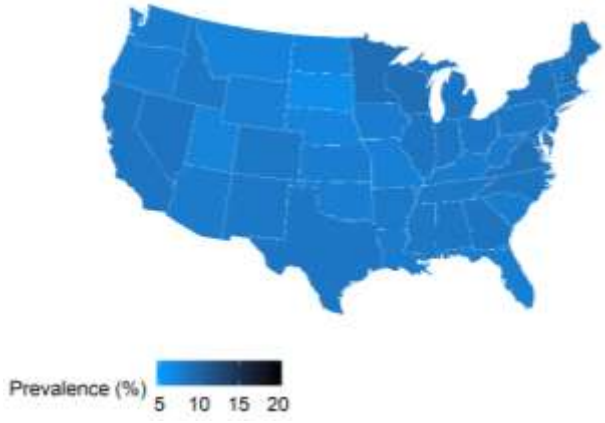
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



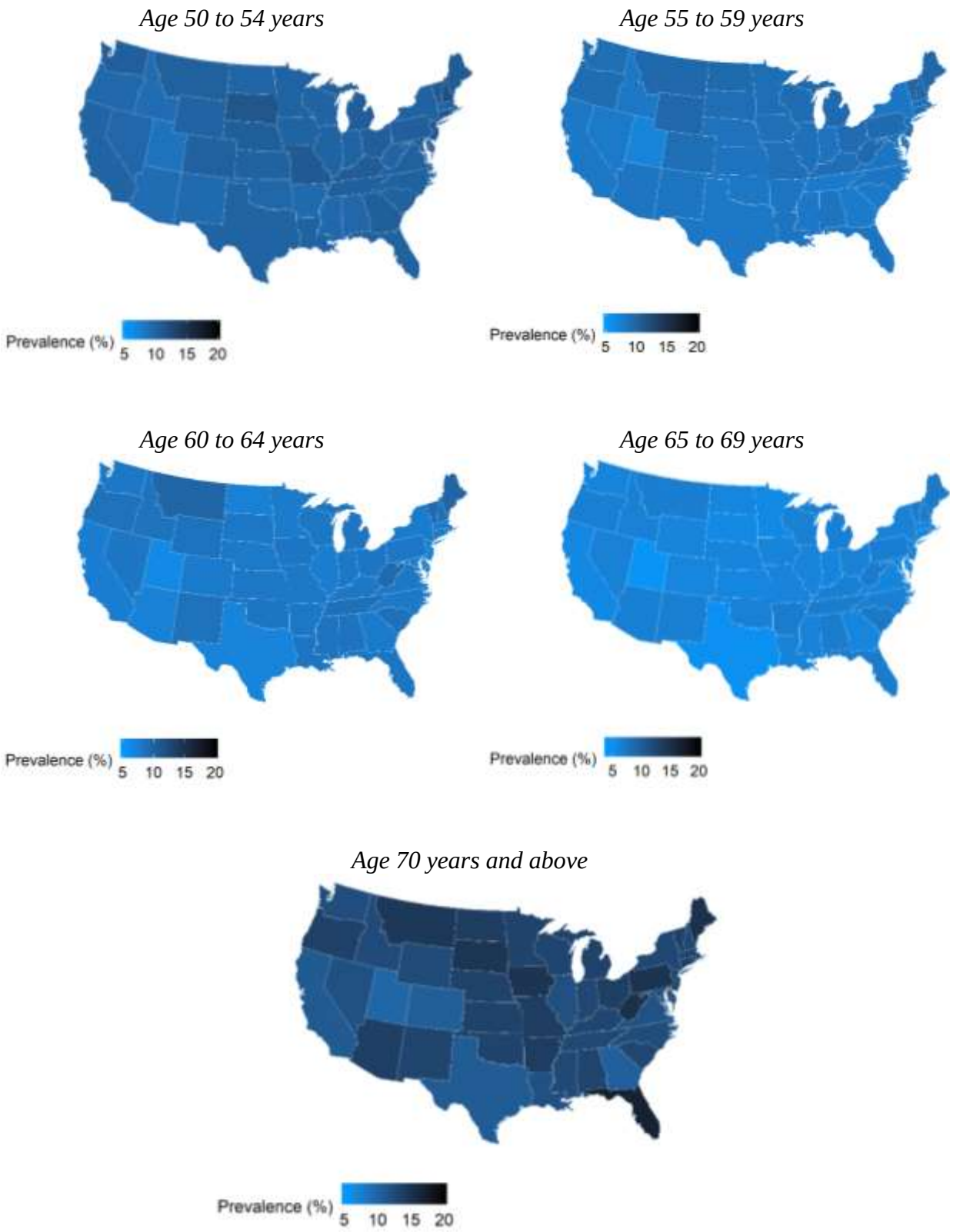


Figure 4.1.7: Distribution of various age groups across the US by state in 2013, according to the BRFSS weighted sample

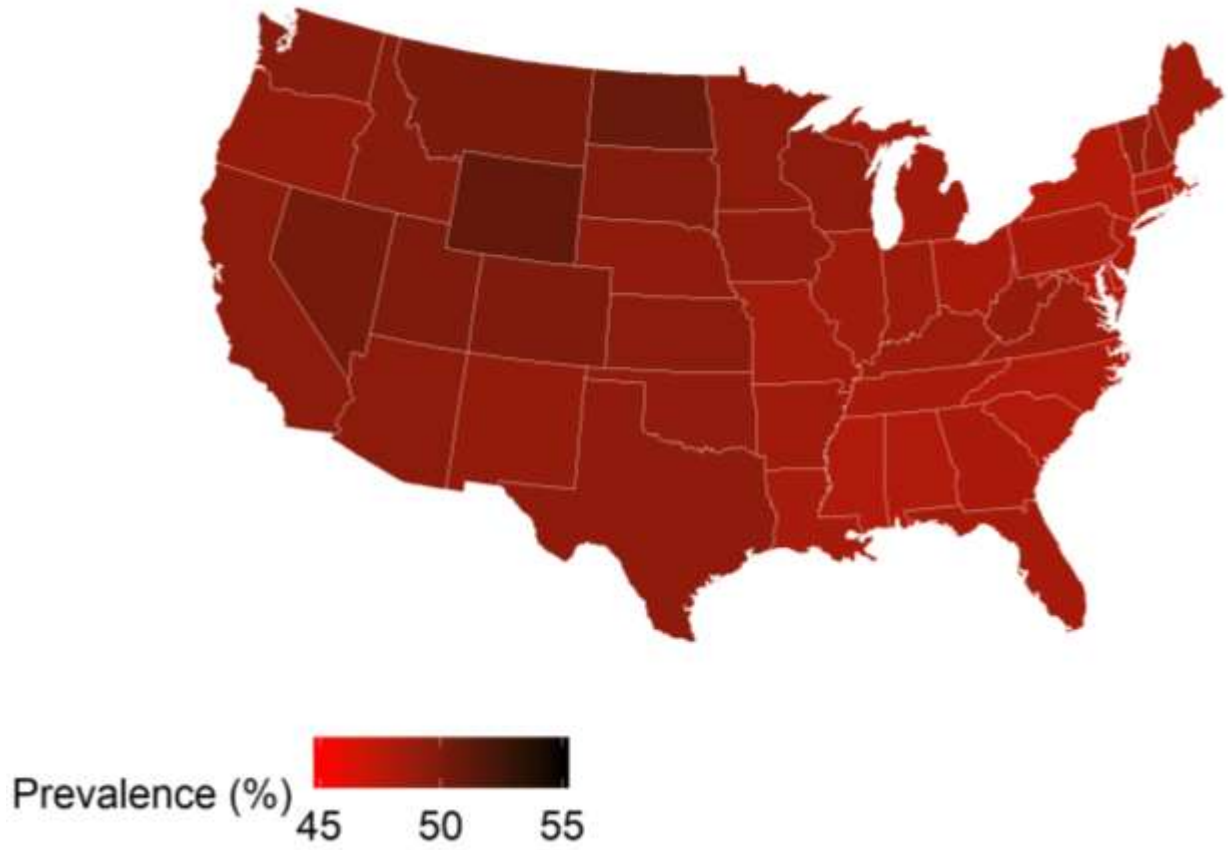
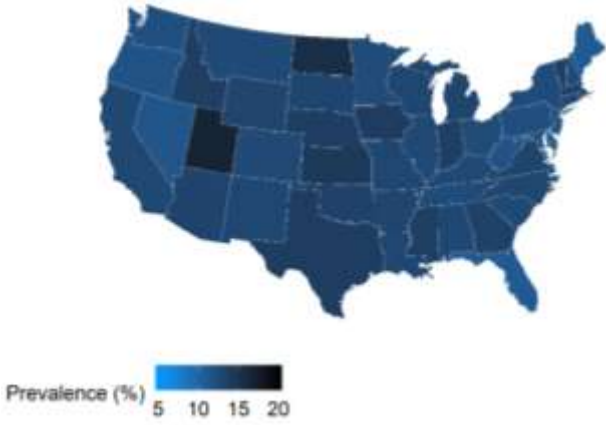
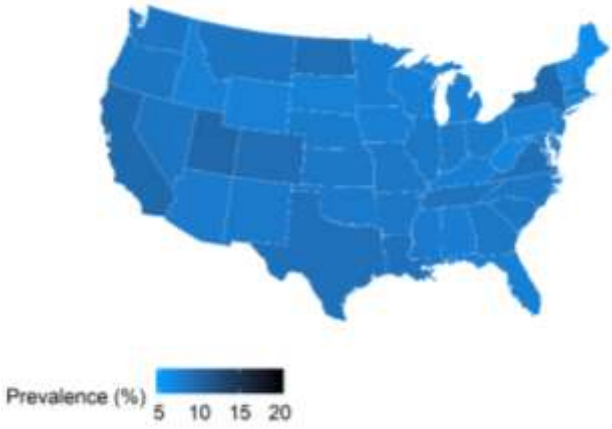


Figure 4.1.8: Distribution of males across the US by state in 2013, according to the BRFSS weighted sample

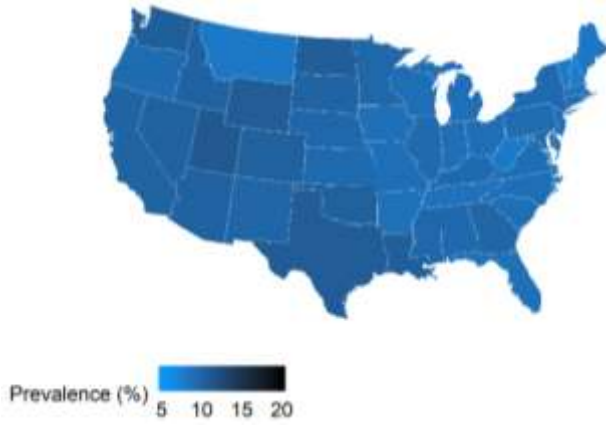
Age 18 to 24 years



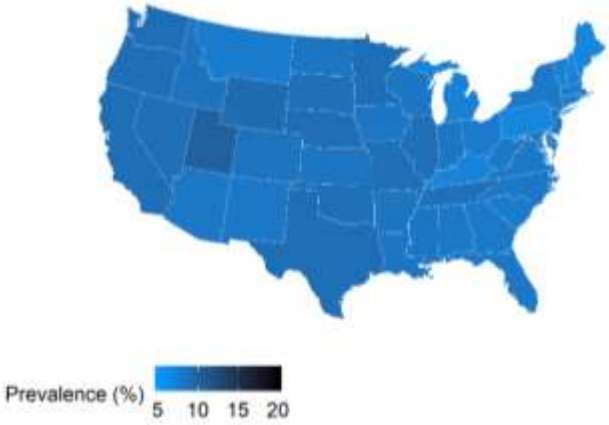
Age 25 to 29 years



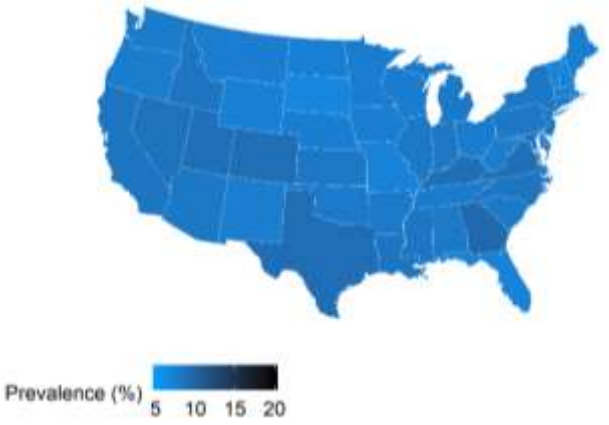
Age 30 to 34 years



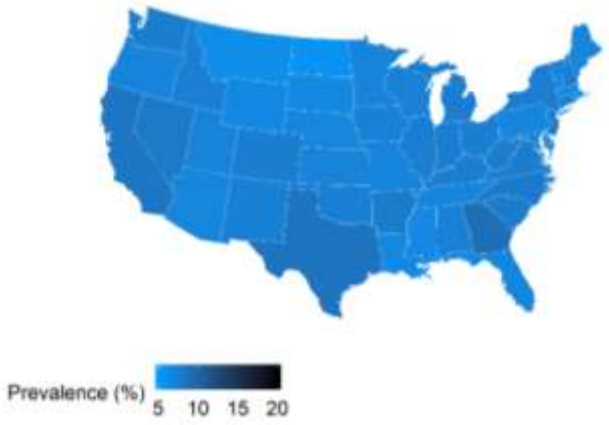
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



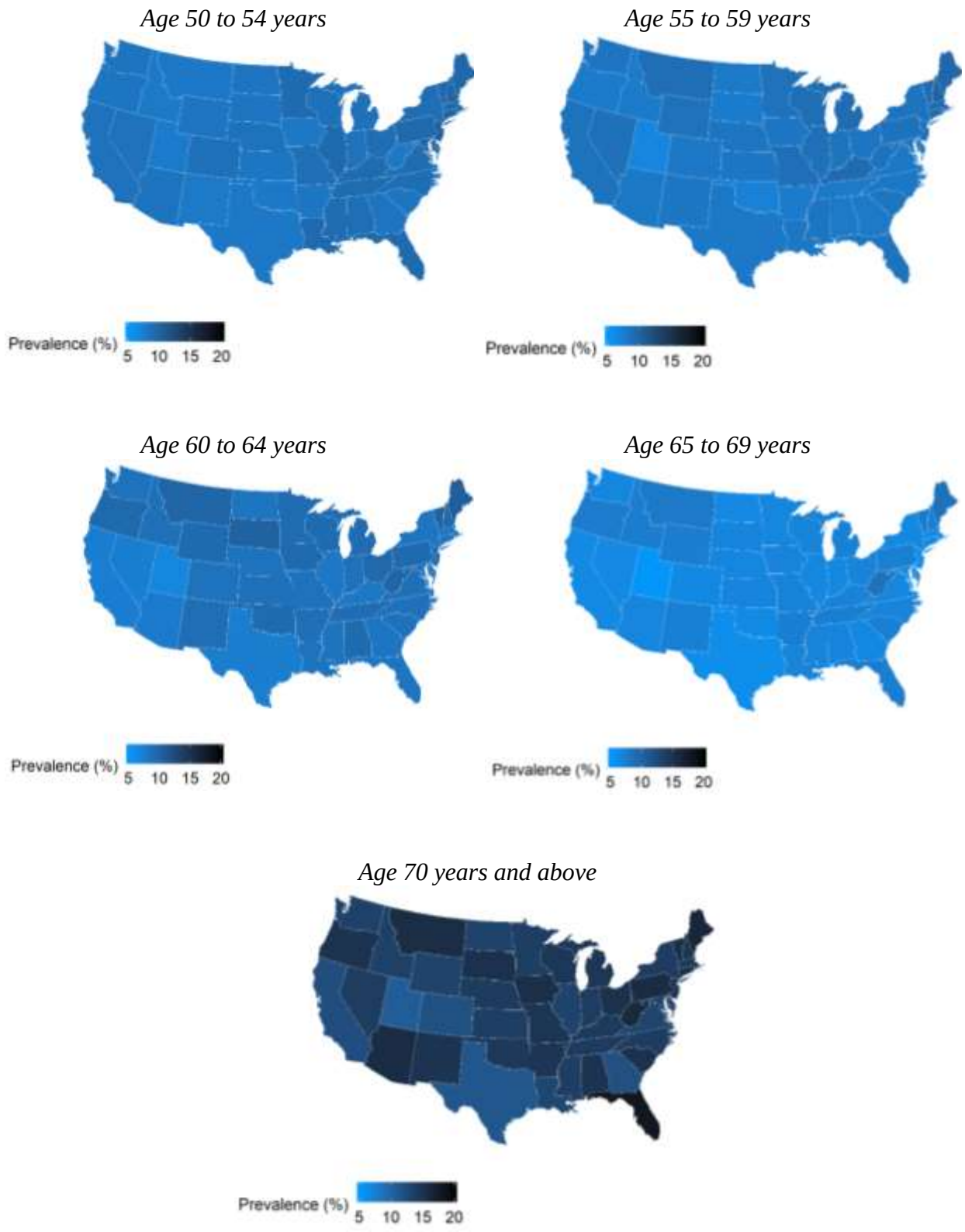


Figure 4.1.9: Distribution of various age groups across the US by state in 2017, according to the BRFSS weighted sample

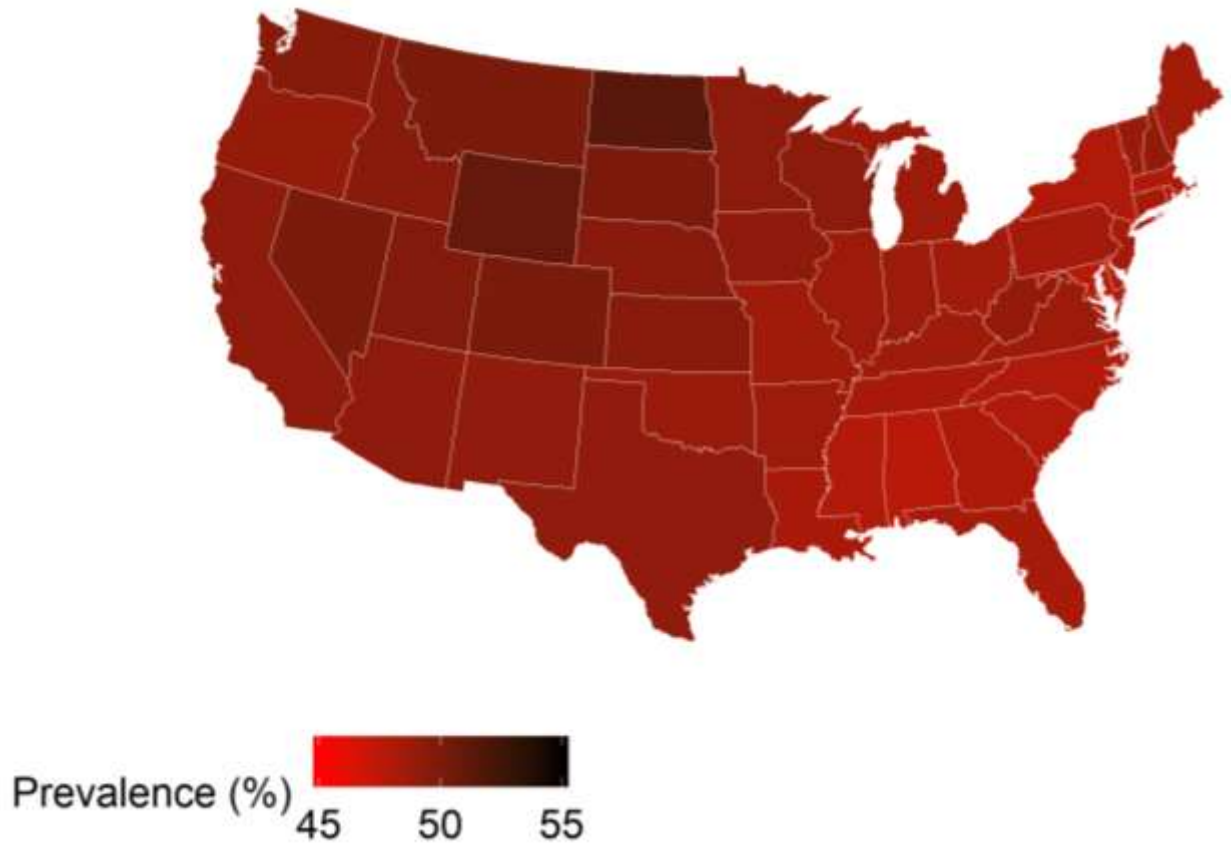


Figure 4.1.10: Distribution of males across the US by state in 2017, according to the BRFSS weighted sample

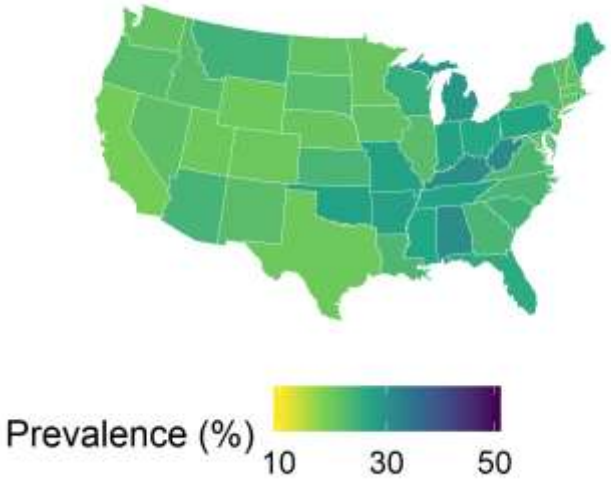
4.1.1 State-specific prevalence of rheumatic disorder diagnosis for US residents

I calculated the prevalence of rheumatic disorder diagnoses per state, and conducted a Global Moran's I on these prevalence data in order to assess state-specific trends across all US residents. The values for Global Moran's I range between zero (indicating perfect randomness, where the areas in question are completely randomly dispersed) and positive one (indicating perfect clustering, where areas with similar values are completely clustered together); or between zero and negative one (indicating perfect dispersion, where like values are perfectly dispersed in the way that a chessboard is). I have omitted the US Virgin Islands and Guam from the lower limit state/territory list reports due to the inconsistent sampling across years. Hawaii and Alaska are not visible on my maps as these maps are of mainland US, however these states' specific prevalence data are found in the tables in the appendices. The median (interquartile range) prevalence data, Global Moran's I statistics, and the five states at the upper and lower prevalence limit, respectively, are available in Table I, Appendix K. Annual prevalence by each state individually per year is available in Table XVII, Appendix K.

The prevalence of rheumatic disorder diagnoses is not uniform throughout US states and US territories (Figure 4.2). States that are geographically closer together are significantly more likely to have similar prevalence data for a rheumatic disorder diagnoses ($0.212 \leq$ Moran's I ≤ 0.354, $P < 0.05$, for all years analysed). There is thus a significant consistent, but weak, spatial correlation between states according to their proximity. The spatial correlation was significant for all years analysed for which there is state-specific data.

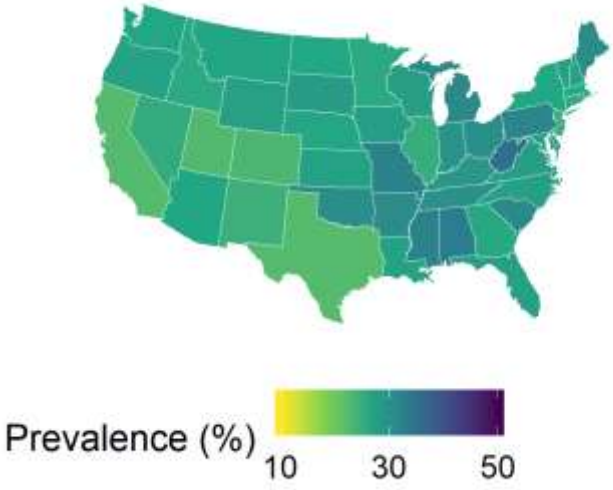
Across the years I analysed state-specific data, the median state prevalence of having a diagnosed rheumatic condition is around a quarter of people overall (approximately 25%) (Figure 4.2). Furthermore, the states at the higher and lower limits were consistent. West Virginia consistently had a much higher prevalence of rheumatic disorder diagnoses compared to other states. Other states with consistently high prevalence measurements included Alabama, Kentucky, Michigan, Arkansas, Pennsylvania, Maine, Missouri, Mississippi, and Tennessee (Figure 4.2). At the low end, Hawaii, California, Utah, Texas, Minnesota, the District of Columbia and Puerto Rico were states/territories with consistently low rheumatic disorder diagnosis prevalences. The confidence intervals for state prevalence as well as the interquartile

ranges were wider in years 2001, 2003, 2005, 2007 and 2009 due to previous weighting methods, which were improved after 2010.



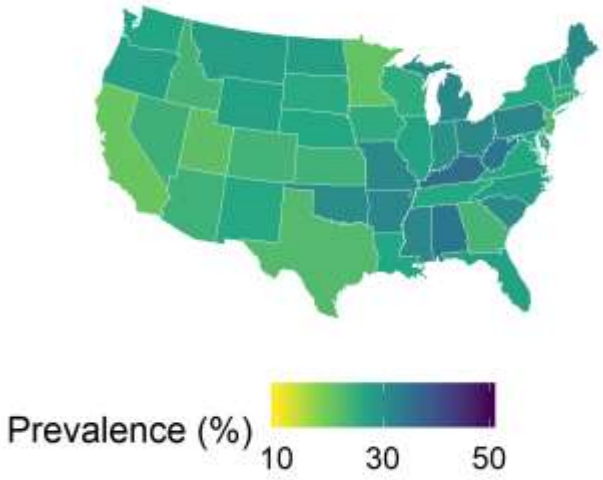
A: 2001

M (IQR)[α] = 22.1 (20.6, 25.6), I (variance)[ι] = 0.354 (0.010), P < 0.001*



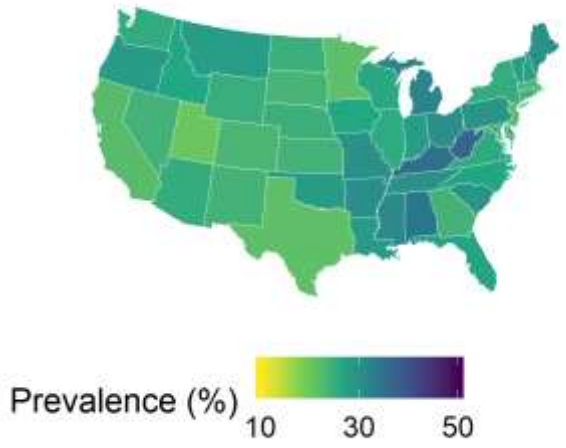
B: 2005

M (IQR)[α] = 26.9 (25.5, 29.3), I (variance)[ι] = 0.239 (0.009), P = 0.004*



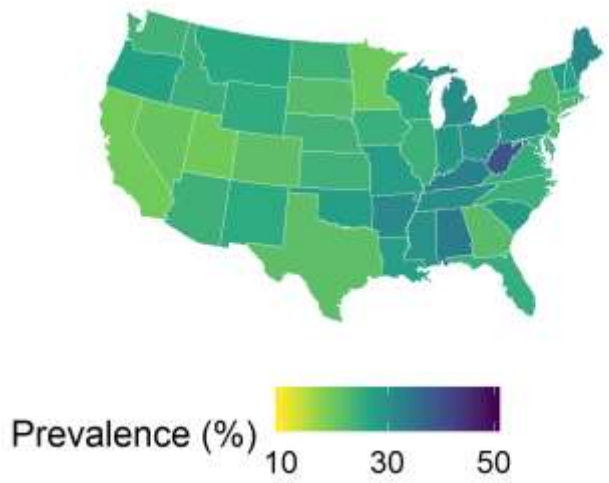
C: 2009

M (IQR)[α] = 25.9 (23.9, 29.1), I (variance)[ι] = 0.212 (0.010), P = 0.008*



D: 2013

M (IQR)[α] = 25.1 (23.6, 27.8), I (variance)[ι] = 0.253 (0.009), P = 0.002*



E: 2017

M (IQR)[α] = 24.8 (22.6, 27.8), I (variance)[ι] = 0.254 (0.009), P = 0.002*

Figure 4.2: Choropleth maps of the US showing the prevalence (%) of a rheumatic disorder diagnosis** in US residents during their lifetime by a medical doctor or healthcare worker, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), across years 2001 (A), 2005 (B), 2009 (C), 2013 (D), and 2017 (E).

Legends per year contain the M (IQR)[α] (median (interquartile range)) prevalence across all states, the I (variance)[ι] (Global Moran's I (variance)) spatial correlation, and the corresponding P-value (*significant), for each year in question.

**Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

4.1.2 State-specific prevalence of rheumatic disorder diagnosis by age

Rheumatic disorders are associated with increasing age (González-Chica *et al.*, 2018; Park, Mendy and Vieira, 2018), thus I conducted a state-specific analysis by age group. The prevalence of rheumatic disorder diagnoses in US residents was taken as the proportion of people who answered "Yes" to the question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?" The prevalence was calculated in each age category, for each state, in years where state-specific data was available, namely: 2001, 2003, 2005, 2007, 2009, and 2011 to 2018. After the prevalence for each state was obtained, a Global Moran's I was done to assess whether there was a spatial correlation within each age group. The analysis was conducted in the following 11 age groups: ages 18 to 24 years, 25 to 29 years, 30 to 34 years, 35 to 39 years, 40 to 44 years, 45 to 49 years, 50 to 54 years, 55 to 59 years, 60 to 64 years, 65 to 69 years, 70 years and above.

The median (interquartile range) prevalence by age data, Global Moran's I statistics, and the five states at the upper and lower prevalence limit, respectively, are available in Tables II to XIV Appendix K, for all years analysed. Annual state-specific prevalences by age, for each year analysed, are available in Tables XVIII to XXVIII, Appendix K. Choropleth maps for every four years of analyses from 2001 (2001, 2005, 2009, 2013, and 2017) are available within this chapter, while the remaining years (2003, 2007, 2011, 2012, 2014, 2015, 2016, and 2018) are available on GitHub (https://github.com/AnneIoannides/BRFSS_Musculoskeletal-Pain/tree/master/Figures).

There is a very distinct increase in the prevalence of doctor-diagnosed rheumatic conditions with age, which will be expanded upon in the next chapter. The confidence intervals for state prevalence in all age groups as well as the interquartile ranges are wider in years 2001, 2003, 2005, 2007 and 2009 due to previous weighting methods, which were improved after 2010. Furthermore, I have omitted the US Virgin Islands and Guam from the lower limit state/territories list reports due to the inconsistent sampling across years. Finally, Hawaii and Alaska are not visible on my maps as these maps are of mainland US, however these states' specific prevalence data are found in the tables in the appendices.

In those aged 18 to 24 years, there was no spatial correlation between state geography and rheumatic disorder diagnosis prevalence, with the exception of 2007 and 2017. This is due to the prevalence of a diagnosis of a rheumatic disorder being generally low across this age group. The median rheumatic disorder diagnosis prevalence for people in the 18 to 24 years' age group, by state, across all years analysed was between 3.1% and 6.0 % across all years analysed, and between 3.1% and 3.8 % from 2011 until 2018, when new and improved weighting methodology was incorporated. The states at the upper limit were not as consistent across the years compared to older age groups. However, the states that appeared most frequently at the upper limit were West Virginia, Kentucky, Arkansas, Pennsylvania, Maine, Missouri, Oklahoma, Oregon, and Delaware. The states/territories at the lower limit included Hawaii, California, District of Columbia, Puerto Rico, Arizona, Nevada, Florida, Nebraska, and New Jersey (Figure 4.3).

In the 25 to 29 years' age group, there was no spatial correlation for most years (a spatial correlation is present for 2013, 2014, and 2017). As is the case in the youngest age category, this is likely due to the fact that the prevalence of rheumatic disorders was generally low in young people. The median rheumatic disorder diagnosis prevalence for people in the 25 to 29 years' age group, by state, was between 5.5% and 8.1% across all years analysed, and between 5.8% and 6.7% from 2011 until 2018. States frequently occurring at the upper limit included West Virginia, Alabama, Kentucky, Missouri, and Tennessee. States/territories frequently occurring at the lower limit included Hawaii, California, the District of Columbia, Puerto Rico, Arizona, and Wisconsin (Figure 4.3).

In those aged 30 to 34 years, there was a weak positive spatial correlation ($0.138 \leq$ Global Moran's $I \leq 0.239$, $P < 0.05$) by state in years 2001, 2003, 2005, 2009, 2011, 2014, 2017 and 2018, meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. However, there was no significant spatial correlation ($P \geq 0.05$) in years 2007, 2012, 2013, 2015 and 2016. The median rheumatic disorder diagnosis prevalence for people in the 30 to 34 years' age group, by state, was between 7.5% and 11.0% across all years analysed, and between 7.8% and 9.4% from 2011 until 2018. States frequently appearing at the upper limit included West Virginia, Kentucky, Tennessee, Maine, Arkansas, Mississippi, Ohio, and Alabama. States/territories frequently at the lower limit

included California, Arizona, Connecticut, the District of Columbia, and Puerto Rico (Figure 4.3).

In those aged 35 to 39 years, there was a weak positive spatial correlation ($0.142 \leq$ Global Moran's $I \leq 0.226$, $P < 0.05$) by state in years 2007, 2011, 2014 and 2016, meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. However, there was no such correlation for years 2001, 2003, 2005, 2009, 2012, 2015, 2017, and 2018 ($P \geq 0.05$). The median prevalence of doctor-diagnosed rheumatic conditions was between 10.5% and 14.7% for all years analysed, and between 11.8% and 13.3% from 2011 to 2018. Furthermore, states frequently having the highest prevalences of rheumatic disorder diagnoses included West Virginia, Alabama, Kentucky, Arkansas, Maine, Mississippi, and Tennessee. Conversely, states/territories with the lowest prevalences of diagnosed rheumatic disorders in this age group included Hawaii, California, Texas, the District of Columbia, Puerto Rico, and Minnesota.

In the 40 to 44 years' age group, there was a weak positive spatial correlation between states across all years of analysis ($0.156 \leq$ Global Moran's $I \leq 0.373$, $P < 0.05$), meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. The median prevalence of doctor-diagnosed rheumatic disorders was between 14.9% and 19.8% for all years analysed, and 14.9% and 17.3% from 2011 to 2018. States at the upper limit of prevalence of rheumatic disorder diagnosis included West Virginia, Alabama, Kentucky, Arkansas, Missouri, Mississippi, and Tennessee. At the prevalence lower limit, states/territories included Hawaii, California, Texas, the District of Columbia, Puerto Rico, Nevada, and Connecticut (Figure 4.3).

In those aged 45 to 49 years, there was a weak positive spatial correlation between states across all years of analysis ($0.190 \leq$ Global Moran's $I \leq 0.352$, $P < 0.05$), meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. Only 2009 data showed no spatial correlation ($P \geq 0.05$). The median prevalence of doctor-diagnosed rheumatic disorders was between 20.2% and 26.9% across all years, but was between 20.2% and 23.9% between 2011 and 2018. The states at the upper limit of prevalences of rheumatic disorder diagnoses included West Virginia, Alabama, Kentucky, Michigan, Mississippi, and Tennessee. At the low end of rheumatic disorder diagnosis prevalences were

states/territories Hawaii, California, Minnesota, the District of Columbia, and Connecticut (Figure 4.3).

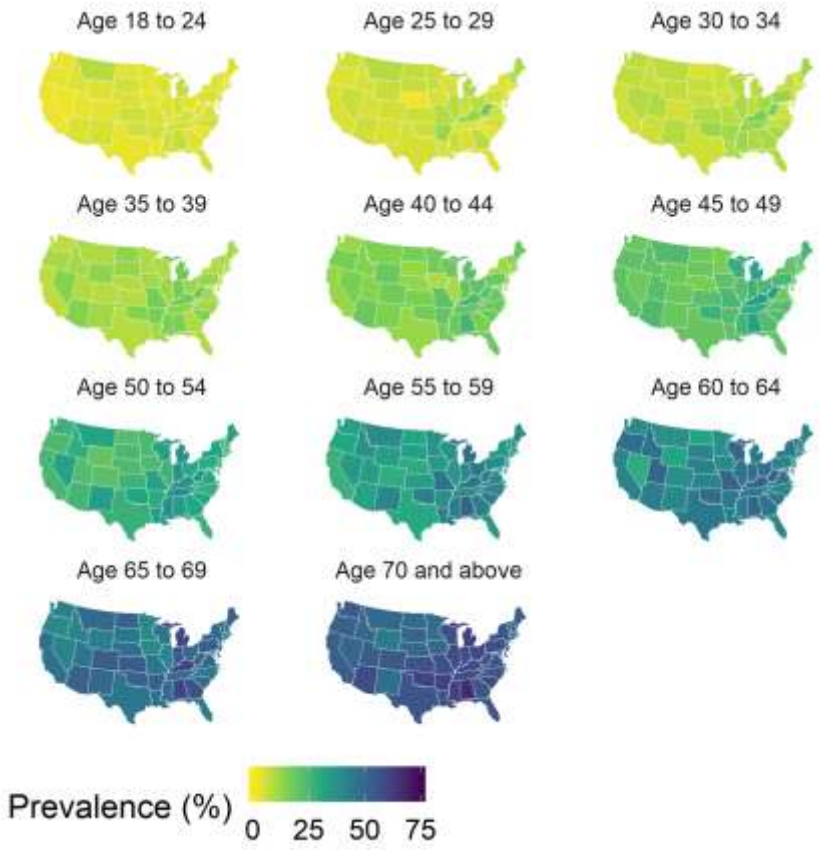
In the 50 to 54 years' age group, there was a weak to moderate positive spatial correlation between state rheumatic disorder diagnoses across all years of analysis ($0.186 \leq$ Global Moran's $I \leq 0.405$, $P < 0.05$), meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. The median prevalence of doctor-diagnosed rheumatic disorders was between 27.1% and 34.2% across all years of analysis, but between 28.7% and 30.8% for years 2011 to 2018. States with the highest prevalences of rheumatic disorder diagnoses included West Virginia, Alabama, Kentucky, Arkansas, Mississippi, and Tennessee. States/territories with the lowest prevalences included Hawaii, California, Minnesota, Puerto Rico, Connecticut, and New Jersey (Figure 4.3).

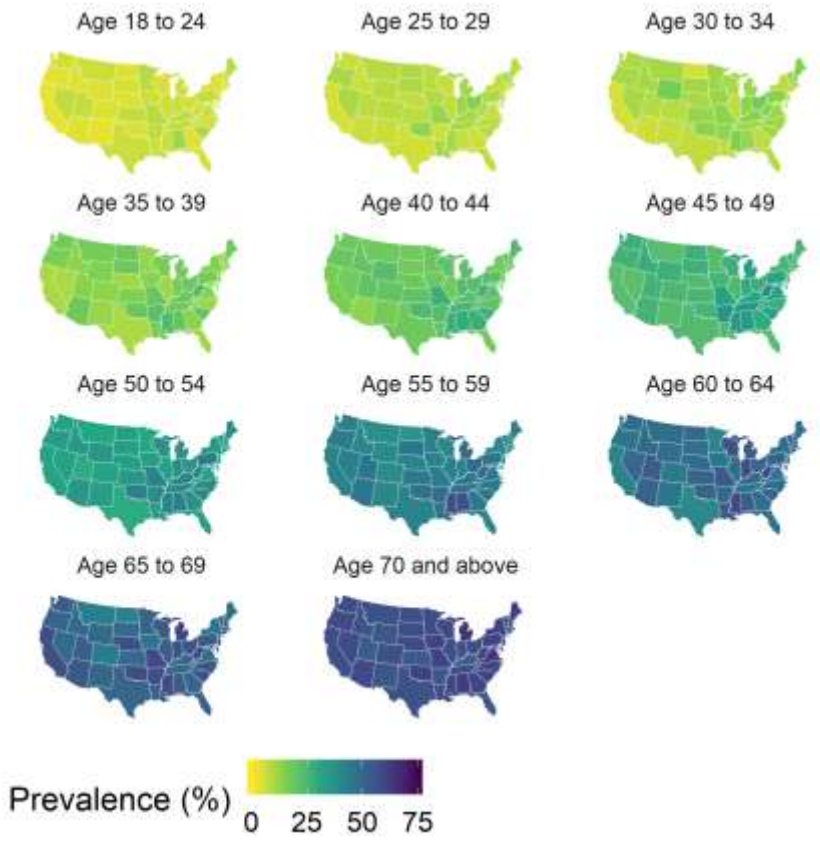
In those aged 55 to 59 years, there was a weak to moderate positive spatial correlation between states across all years of analysis ($0.158 \leq$ Global Moran's $I \leq 0.387$, $P < 0.05$), meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically; with the exception of 2009 ($P \geq 0.05$). The median doctor-diagnosed rheumatic disorder prevalence was between 34.5% and 43.5% in all years analysed, and between 34.5% and 38.1% for years 2011 to 2018. States at the upper limit of prevalence measures included West Virginia, Alabama, Kentucky, Michigan, and Mississippi. States/territories at the low end of the prevalences included Hawaii, California, Minnesota, and New Jersey (Figure 4.3).

In the 60 to 64 years' age group, there was a weak positive spatial correlation between states across 2003, 2007, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2018 ($0.152 \leq$ Global Moran's $I \leq 0.388$, $P < 0.05$), meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. However, there was no spatial correlation for 2001, 2005 or 2009 ($P \geq 0.05$). In contrast to the young age groups, there may be less spatial correlation due to a general high prevalence of rheumatic disease diagnoses in older people. The median prevalence for doctor-diagnosed rheumatic disorders was between 41.3% and 48.2% across all years, and between 41.3% and 44.3% in years 2011 to 2018. States with the highest prevalence estimates across the years included West Virginia, Alabama, Kentucky, Michigan, Mississippi, and Tennessee. States/territories with the lowest prevalences included Hawaii, California, Minnesota, the District of Columbia, and Alaska (Figure 4.3).

In the 65 to 69 years' age group, there was a weak positive spatial correlation between states in years 2001, 2005, 2007, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2017 ($0.146 \leq$ Global Moran's $I \leq 0.308$, $P < 0.05$), meaning that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. However, no such correlation existed for years 2003 and 2009 ($P \geq 0.05$). Much the same as the 60 to 64 years' age group, rheumatic disorder diagnosis prevalence measurements were high and widespread, thus the spatial correlations begin to decrease as so many people have a diagnosis. The median prevalence of rheumatic disorder diagnosis was between 46.9% and 53.2% across all years and from 2011 to 2018. States that frequently appeared at the upper limit of doctor-diagnosed rheumatic disorder prevalence were West Virginia, Alabama, Kentucky, Michigan, Mississippi, and Ohio. Although the states at the lower limit became less consistent in this age group, the states that appeared most frequently in this group were Hawaii, California, Minnesota, and South Dakota. The consistency with which the same states usually appeared at the extremes was, however, not as rigorous as in middle-aged age categories (Figure 4.3).

In the oldest age category (those 70-years-old or above), there was a weak to moderate positive spatial correlation between states in years 2001, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2018 ($0.157 \leq$ Global Moran's $I \leq 0.437$, $P < 0.05$), suggesting that there was similarity in doctor-diagnosed rheumatic condition prevalence between states close to each other geographically. However, no correlation was present in data from 2003, 2005, 2007 and 2009. The median prevalence of doctor-diagnosed rheumatic disorders was between 51.6% and 58.2% across all years analysed, and between 51.6% and 55.7% in years 2011 to 2018. The states most frequently appearing at the upper prevalence limit included West Virginia, Alabama, Kentucky, Michigan, Pennsylvania, and Mississippi. States/territories most frequently at the lower limit included Hawaii, Minnesota, Puerto Rico, and Alaska. Much like the 65 to 69 years' age group, more states tended to appear randomly at the prevalence limits compared with younger groups, likely due to the sheer volume of people who are diagnosed with rheumatic conditions in older age (Figure 4.3)



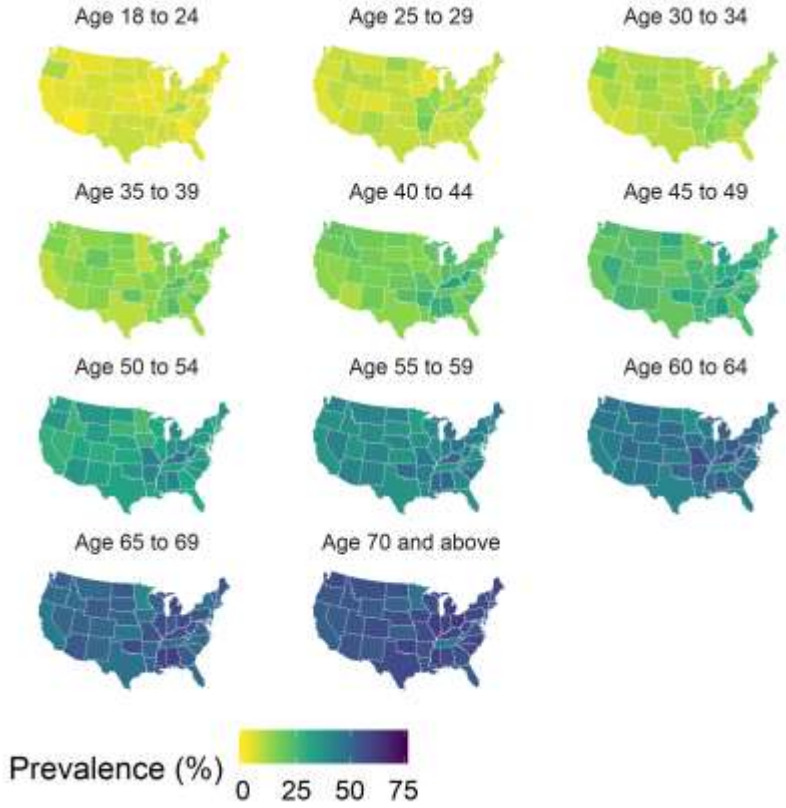


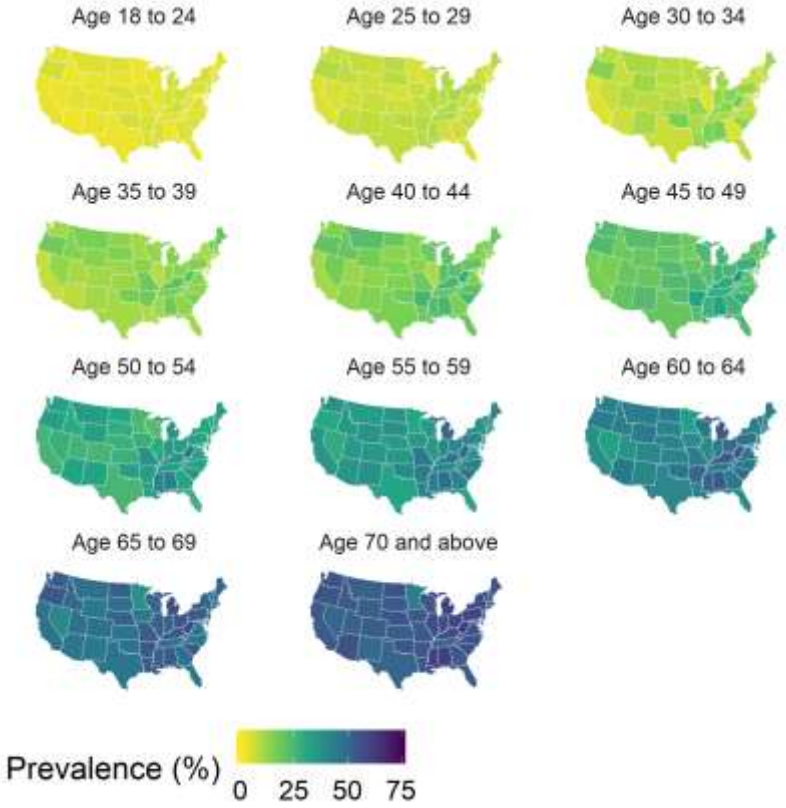
A: 2001

i. M (IQR)$^{\alpha}$ = 3.8 (2.7, 4.8), I (variance)$^{\iota}$ = 0.069 (0.009), P = 0.175
ii. M (IQR)$^{\alpha}$ = 5.5 (4.3, 5.9), I (variance)$^{\iota}$ = 0.108 (0.009), P = 0.084
iii. M (IQR)$^{\alpha}$ = 7.5 (5.7, 9.5), I (variance)$^{\iota}$ = 0.239 (0.009), P = 0.003*
iv. M (IQR)$^{\alpha}$ = 10.5 (8.9, 13.1), I (variance)$^{\iota}$ = 0.096 (0.010), P = 0.117
v. M (IQR)$^{\alpha}$ = 15.5 (12.9, 18.3), I (variance)$^{\iota}$ = 0.226 (0.009), P = 0.002*
vi. M (IQR)$^{\alpha}$ = 21.2 (18.9, 23.8), I (variance)$^{\iota}$ = 0.283 (0.009), P < 0.001*
vii. M (IQR)$^{\alpha}$ = 27.1 (24.2, 31.3), I (variance)$^{\iota}$ = 0.300 (0.010), P < 0.001*
viii. M (IQR)$^{\alpha}$ = 36.8 (32.5, 40.2), I (variance)$^{\iota}$ = 0.321 (0.010), P < 0.001*
ix. M (IQR)$^{\alpha}$ = 42.9 (38.9, 46.3), I (variance)$^{\iota}$ = 0.038 (0.009), P = 0.271
x. M (IQR)$^{\alpha}$ = 46.9 (42.6, 51.1), I (variance)$^{\iota}$ = 0.189 (0.009), P = 0.016*
xi. M (IQR)$^{\alpha}$ = 54.0 (50.1, 57.1), I (variance)$^{\iota}$ = 0.437 (0.009), P < 0.001*

B: 2005

i. M (IQR)$^{\alpha}$ = 5.3 (4.0, 6.2), I (variance)$^{\iota}$ = -0.030 (0.009), P = 0.537
ii. M (IQR)$^{\alpha}$ = 8.1 (6.5, 8.2), I (variance)$^{\iota}$ = 0.079 (0.010), P = 0.153
iii. M (IQR)$^{\alpha}$ = 11.0 (8.4, 12.0), I (variance)$^{\iota}$ = 0.166 (0.010), P = 0.028*
iv. M (IQR)$^{\alpha}$ = 14.4 (12.0, 17.0), I (variance)$^{\iota}$ = 0.121 (0.010), P = 0.073
v. M (IQR)$^{\alpha}$ = 19.8 (17.1, 22.4), I (variance)$^{\iota}$ = 0.370 (0.010), P < 0.001*
vi. M (IQR)$^{\alpha}$ = 26.2 (23.6, 28.0), I (variance)$^{\iota}$ = 0.275 (0.009), P = 0.001*
vii. M (IQR)$^{\alpha}$ = 33.5 (31.5, 37.7), I (variance)$^{\iota}$ = 0.186 (0.010), P = 0.018*
viii. M (IQR)$^{\alpha}$ = 41.8 (40.0, 45.2), I (variance)$^{\iota}$ = 0.371 (0.009), P < 0.001*
ix. M (IQR)$^{\alpha}$ = 48.4 (46.5, 50.9), I (variance)$^{\iota}$ = 0.010 (0.009), P = 0.373
x. M (IQR)$^{\alpha}$ = 51.3 (48.8, 54.8), I (variance)$^{\iota}$ = 0.146 (0.010), P = 0.044*
xi. M (IQR)$^{\alpha}$ = 57.3 (55.0, 59.4), I (variance)$^{\iota}$ = -0.157 (0.010), P = 0.949



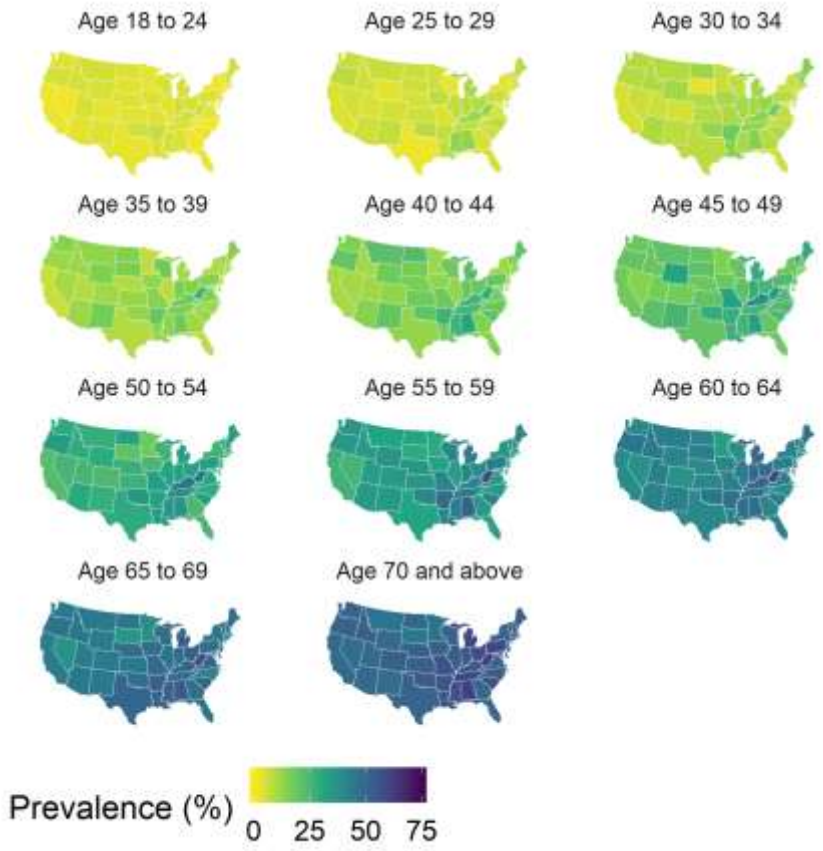


C: 2009

i. M (IQR)$^{\alpha}$ = 4.1 (2.6, 5.6), I (variance)$^{\iota}$ = -0.069 (0.009), P = 0.692
ii. M (IQR)$^{\alpha}$ = 6.9 (5.3, 8.5), I (variance)$^{\iota}$ = 0.051 (0.009), P = 0.225
iii. M (IQR)$^{\alpha}$ = 9.4 (7.5, 12.2), I (variance)$^{\iota}$ = 0.201 (0.010), P = 0.012*
iv. M (IQR)$^{\alpha}$ = 13.3 (10.7, 15.8), I (variance)$^{\iota}$ = -0.013 (0.009), P = 0.467
v. M (IQR)$^{\alpha}$ = 17.3 (14.6, 20.7), I (variance)$^{\iota}$ = 0.240 (0.009), P = 0.004*
vi. M (IQR)$^{\alpha}$ = 23.8 (20.5, 27.2), I (variance)$^{\iota}$ = 0.097 (0.010), P = 0.113
vii. M (IQR)$^{\alpha}$ = 32.7 (28.8, 35.7), I (variance)$^{\iota}$ = 0.216 (0.009), P = 0.007*
viii. M (IQR)$^{\alpha}$ = 40.1 (36.8, 43.4), I (variance)$^{\iota}$ = 0.066 (0.010), P = 0.186
ix. M (IQR)$^{\alpha}$ = 45.9 (42.8, 48.6), I (variance)$^{\iota}$ = 0.059 (0.009), P = 0.206
x. M (IQR)$^{\alpha}$ = 50.2 (47.6, 53.5), I (variance)$^{\iota}$ = 0.071 (0.009), P = 0.172
xi. M (IQR) $^{\alpha}$ = 56.4 (53.6, 58.0), I (variance)$^{\iota}$ = 0.054 (0.009), P = 0.214

D: 2013

i. M (IQR)$^{\alpha}$ = 3.3 (2.4, 4.2), I (variance)$^{\iota}$ = 0.069 (0.010), P = 0.179
ii. M (IQR)$^{\alpha}$ = 6.7 (5.4, 8.1), I (variance)$^{\iota}$ = 0.236 (0.010), P = 0.004*
iii. M (IQR)$^{\alpha}$ = 8.6 (6.6, 11.0), I (variance)$^{\iota}$ = 0.128 (0.010), P = 0.063
iv. M (IQR)$^{\alpha}$ = 12.3 (10.3, 14.3), I (variance)$^{\iota}$ = 0.167 (0.009), P = 0.027*
v. M (IQR)$^{\alpha}$ = 16.4 (13.4, 19.8), I (variance)$^{\iota}$ = 0.218 (0.010), P = 0.007*
vi. M (IQR)$^{\alpha}$ = 22.7 (19.2, 25.2), I (variance)$^{\iota}$ = 0.352 (0.009), P < 0.001*
vii. M (IQR)$^{\alpha}$ = 30.8 (27.3, 32.9), I (variance)$^{\iota}$ = 0.195 (0.009), P = 0.012*
viii. M (IQR)$^{\alpha}$ = 37.0 (34.4, 40.6), I (variance)$^{\iota}$ = 0.244 (0.009), P = 0.003*
ix. M (IQR)$^{\alpha}$ = 42.4 (39.9, 44.7), I (variance)$^{\iota}$ = 0.244 (0.009), P = 0.003*
x. M (IQR)$^{\alpha}$ = 47.2 (45.8, 52.2), I (variance)$^{\iota}$ = 0.153 (0.010), P = 0.037*
xi. M (IQR)$^{\alpha}$ = 54.4 (52.6, 56.0), I (variance)$^{\iota}$ = 0.157 (0.009), P = 0.031*



E: 2017

i. M (IQR)$^{\alpha}$ = 3.6 (2.6, 4.7), I (variance)$^{\iota}$ = 0.279 (0.010), P = 0.001*
ii. M (IQR)$^{\alpha}$ = 5.8 (4.4, 7.2), I (variance)$^{\iota}$ = 0.165 (0.009), P = 0.027*
iii. M (IQR)$^{\alpha}$ = 9.2 (7.4, 11.3), I (variance)$^{\iota}$ = 0.190 (0.009), P = 0.015*
iv. M (IQR)$^{\alpha}$ = 11.9 (9.4, 14.2), I (variance)$^{\iota}$ = -0.008 (0.009), P = 0.447
v. M (IQR)$^{\alpha}$ = 17.1 (12.8, 20.3), I (variance)$^{\iota}$ = 0.226 (0.009), P = 0.006*
vi. M (IQR)$^{\alpha}$ = 20.2 (18.0, 25.5), I (variance)$^{\iota}$ = 0.190 (0.009), P = 0.015*
vii. M (IQR)$^{\alpha}$ = 29.0 (25.7, 32.3), I (variance)$^{\iota}$ = 0.269 (0.009), P = 0.001*
viii. M (IQR)$^{\alpha}$ = 34.5 (31.9, 40.5), I (variance)$^{\iota}$ = 0.262 (0.009), P = 0.001*
ix. M (IQR)$^{\alpha}$ = 41.6 (38.5, 43.5), I (variance)$^{\iota}$ = 0.195 (0.009), P = 0.011*
x. M (IQR)$^{\alpha}$ = 45.9 (43.4, 45.0), I (variance)$^{\iota}$ = 0.308 (0.009), P < 0.001*
xi. M (IQR)$^{\alpha}$ = 51.6 (49.1, 53.6), I (variance)$^{\iota}$ = 0.302 (0.009), P < 0.001*

Figure 4.3: Choropleth maps of the US showing the prevalence (%) of a rheumatic disorder diagnosis** in US residents during their lifetime by a medical doctor or healthcare worker, by state and age category$^{\varepsilon}$, according to the Behavioural Risk Factor Surveillance System (BRFSS), across years 2001 (A), 2005 (B), 2009 (C), 2013 (D), and 2017 (E).

Legends per year contain the M (IQR)$^{\alpha}$ (median (interquartile range)) prevalence across all states, the I (variance)$^{\iota}$ (Global Moran's I (variance)) spatial correlation, and the corresponding P-value (*significant), for each year in question.

$^{\varepsilon}$Age categories correspond to roman numerals, where: i. 18 to 24, ii. 25 to 29, iii. 30 to 34, iv. 35 to 39, v. 40 to 44, vi. 45 to 49, vii. 50 to 54, viii. 55 to 59, ix. 60 to 64, x. 65 to 69, and xi. 70 and above

**Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

4.1.3 State-specific prevalence of rheumatic disorder diagnosis by sex

Rheumatic disorders are reported to be more common in females (Kvien *et al.*, 2006; Barnabe *et al.*, 2012; Maynard *et al.*, 2020), thus I conducted a state-based analysis by sex. The prevalence of rheumatic disorder diagnoses in US residents was taken as the proportion of people who answered "Yes" to the question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?" The prevalence was calculated in for each state in years, where state-specific data was available, namely: 2001, 2003, 2005, 2007, 2009, and 2011 to 2018. After the prevalence for each state was obtained, a Global Moran's I was done to assess whether there was a spatial correlation. This analysis was done in males and females separately.

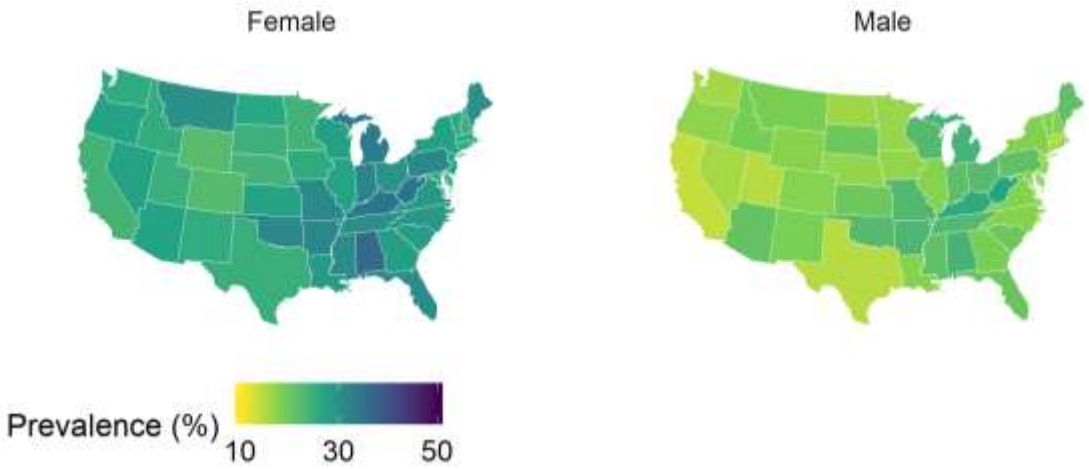
The median (interquartile range) prevalence by sex, Global Moran's I statistics, and the five states at the upper and lower prevalence limit, respectively, are available in Tables XV and XVI, Appendix K, for all years analysed. Annual state-specific prevalences by sex, for each year analysed, are available in Tables XXIX and XXX, Appendix K. Choropleth maps for every four years of analyses from 2001 (2001, 2005, 2009, 2013, and 2017) are available within this chapter, while the remaining years (2003, 2007, 2011, 2012, 2014, 2015, 2016, and 2018) are available on GitHub (https://github.com/AnneIoannides/BRFSS_Musculoskeletal-Pain/tree/master/Figures).

The confidence intervals for state prevalence in both sexes were wider in years 2001, 2003, 2005, 2007 and 2009 due to previous weighting methods, which were improved after 2011. Furthermore, I have omitted the US Virgin Islands and Guam from the lower limit state/region list reports due to the inconsistent sampling across years. Hawaii and Alaska are not visible on my maps as these maps are of mainland US, however these states' specific prevalence data are found in the tables in the appendices.

In males, there was a weak positive spatial correlation between state proximity and doctor-diagnosed rheumatic disorder in all years analysed ($0.163 \leq$ Global Moran's $I \leq 0.276$, $P < 0.05$), suggesting a similarity in the prevalence of doctor-diagnosed rheumatic conditions between states closer to in geographical distance to each other. The median rheumatic disorder diagnosis prevalence was between 17.5% and 23.4% for all years analysed, but between 20.7% and 22.7%

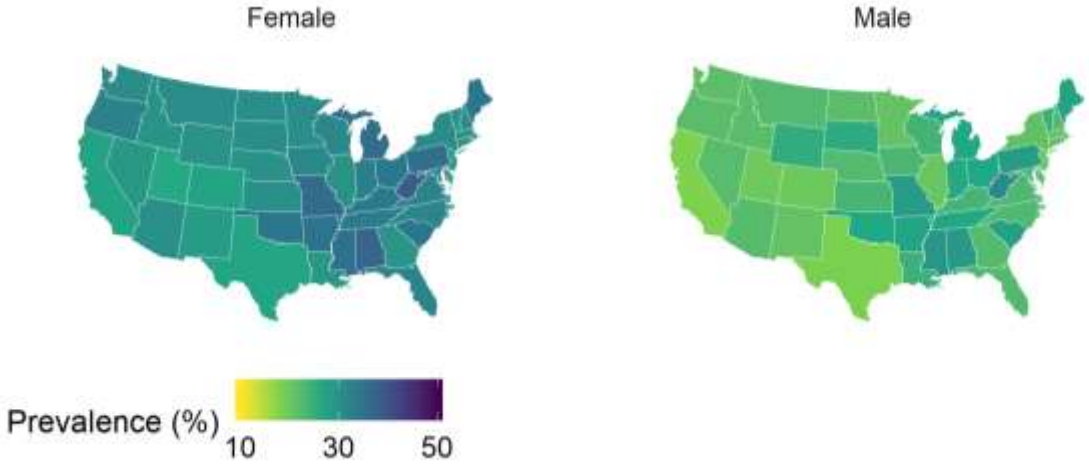
from 2011 until 2018. States most frequently at the upper limit of rheumatic disorder diagnosis prevalences included West Virginia, Alabama, Kentucky, Michigan, Arkansas, Michigan, and Maine. Conversely, states/territories frequently at the lower limit included Hawaii, California, Utah, Texas, the District of Columbia, and Puerto Rico (Figure 4.4).

In females, there was a weak positive spatial correlation between states across all years of analysis ($0.238 \leq$ Global Moran's $I \leq 0.375$, $P < 0.05$), suggesting that the states geographically closer to each other had similar proportions of women that have been diagnosed with a rheumatic condition. The median prevalence of doctor-diagnosed rheumatic conditions in women was between 26.7% and 31.1% across all years analysed, and between 28.0% and 30.3% from 2011 until 2018. States that appeared at the upper prevalence limit most frequently included West Virginia, Alabama, Kentucky, Arkansas, and Michigan. The states/territories most frequently occurring at the lower prevalence limit included Hawaii, California, Utah, Minnesota, and the District of Columbia (Figure 4.4).



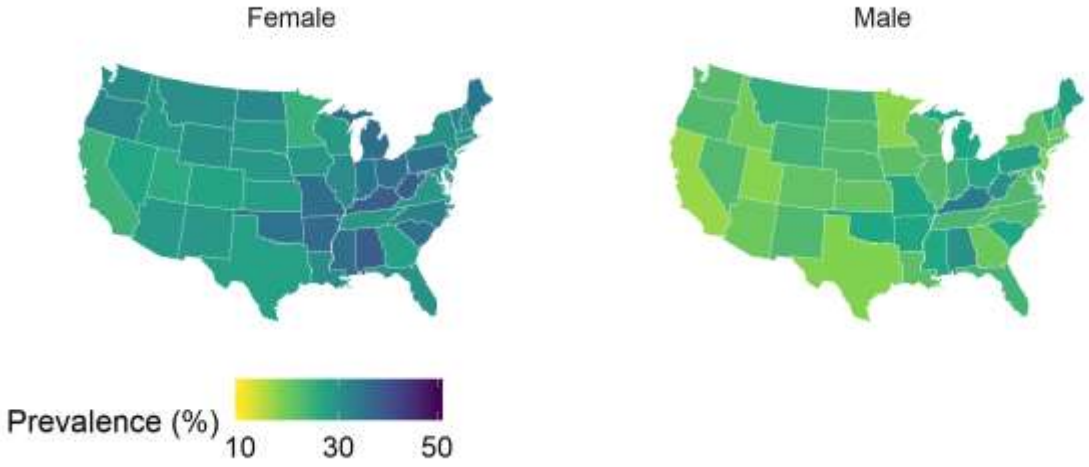
A: 2001

Females: M (IQR)[α] = 26.7 (24.7, 29.8), I (variance)[ι] = 0.359 (0.009), P < 0.001*
Males: M (IQR)[α] = 17.5 (16.3, 21.1), I (variance)[ι] = 0.276 (0.010), P = 0.001*



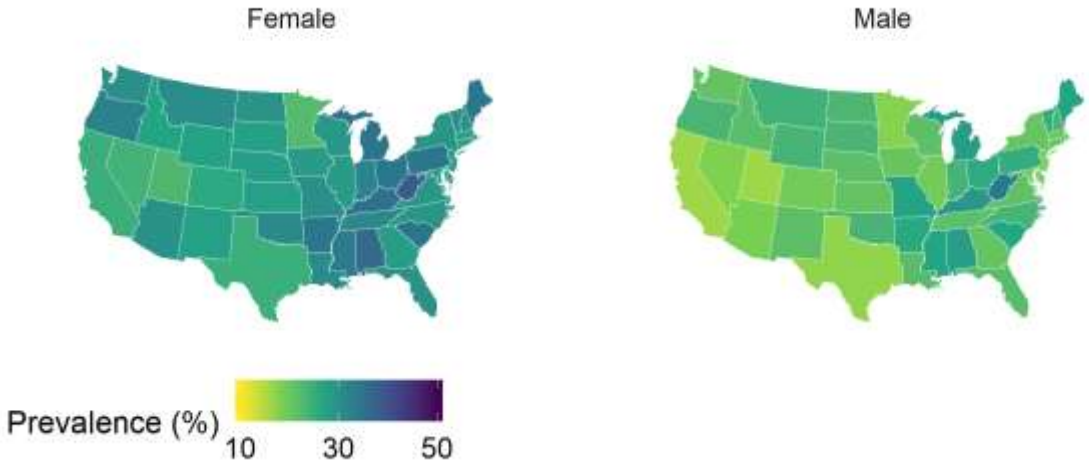
B: 2005

Females: M (IQR)[α] = 30.6 (29.3, 33.1), I (variance)[ι] = 0.252 (0.010), P = 0.003*
Males: M (IQR)[α] = 22.7 (21.0, 25.4), I (variance)[ι] = 0.188 (0.009), P = 0.016*



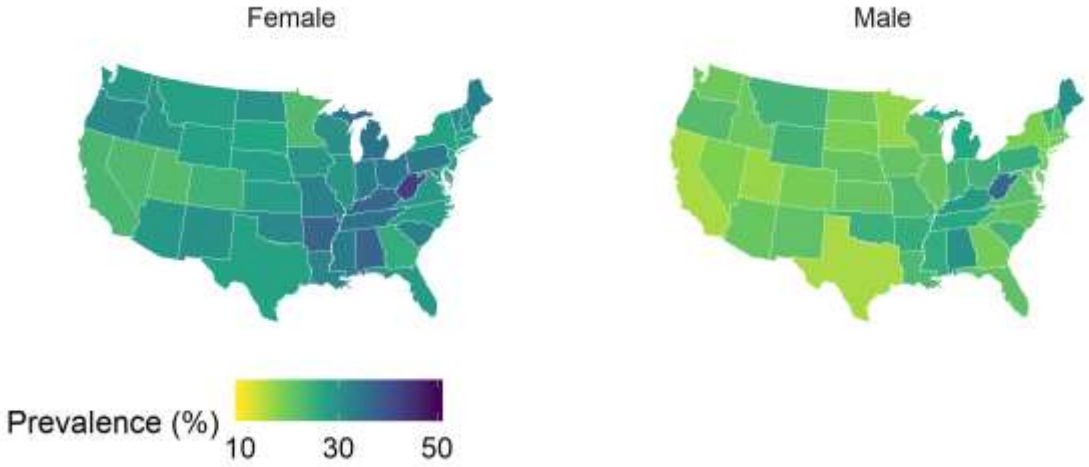
C: 2009

Females: M (IQR)[α] = 29.7 (27.4, 33.7), I (variance)[ι] = 0.238 (0.010), P = 0.004*
Males: M (IQR)[α] = 22.5 (20.0, 24.7), I (variance)[ι] = 0.163 (0.009), P = 0.029*



D: 2013

Females: M (IQR)[α] = 29.0 (27.2, 30.9), I (variance)[ι] = 0.267 (0.009), P = 0.002*
Males: M (IQR)[α] = 21.6 (19.6, 23.8), I (variance)[ι] = 0.241 (0.009), P = 0.007*



E: 2017

Females: M (IQR)[α] = 28.4 (26.9, 31.6), I (variance)[ι] = 0.286 (0.009), P < 0.001*
Males: M (IQR)[α] = 20.7 (18.7, 23.8), I (variance)[ι] = 0.190 (0.009), P = 0.013*

Figure 4.4: Choropleth maps of the US showing the prevalence (%) of a rheumatic disorder diagnosis** in US residents during their lifetime by a medical doctor or healthcare worker, by state and sex, according to the Behavioural Risk Factor Surveillance System (BRFSS), across years 2001 (A), 2005 (B), 2009 (C), 2013 (D), and 2017 (E).

Legends per year contain the M (IQR)[α] (median (interquartile range)) prevalence across all states, the I (variance)[ι] (Global Moran's I (variance)) spatial correlation, and the corresponding P-value (*significant), for each year in question.

**Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

4.2 National Health Interview Survey (NHIS)

Joint symptoms

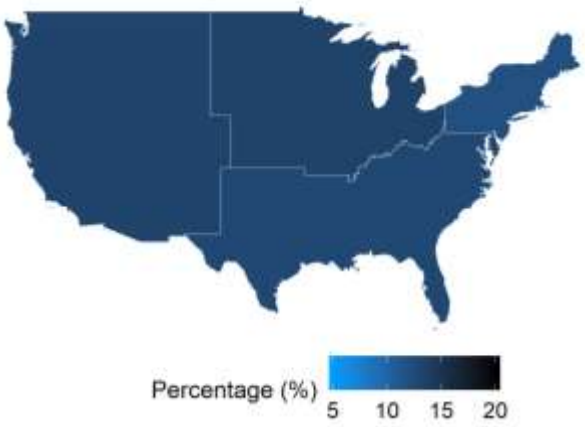
The National Health Interview Survey (NHIS)'s spatial data provided for US regions, namely: Midwest, Northeast, South, and West. A US map containing the US states and corresponding regions can be found at the front of this thesis. The prevalence of US residents who reported joint pain was taken as the proportion of people who answered "Yes" to the question, "The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?", with appropriate design weights applied. The prevalence of joint symptoms in US residents was calculated per US region, and calculated from years 2002 through 2018, with the exception of 2004, where no stratum data was available to create a design object. To illustrate these data, I made choropleth maps by US region in order to show the prevalence of joint symptoms within the previous 30 days for each year of analysis. Maps for every four years (2005, 2009, 2013, and 2017) are shown in this chapter, while the remaining maps for all other years are available on GitHub (https://github.com/AnneIoannides/NHIS_Musculoskeletal-Pain/tree/master/JS%20Figures). I also conducted annual logistic regressions to establish whether joint symptoms were associated with living in a particular region, where the Midwest was the reference region.

I also created choropleth maps of the US age and sex demographic distributions in order to interpret my results against any confounding regional demographic distributions for each year (Figure 4.5.1 to 4.5.12), as both older age and female sex have been shown to associate with various types of painful arthropathies (Kvien *et al.*, 2006; Barnabe *et al.*, 2012; González-Chica *et al.*, 2018; Park, Mendy and Vieira, 2018; Maynard *et al.*, 2020). I have shown these distributions for years 1997, 2001, 2005, 2009, 2013, and 2017 in this chapter, while all other years are also available on GitHub (https://github.com/AnneIoannides/NHIS_Musculoskeletal-Pain/tree/master/Geo-demographic%20distribution%20images). Years 1997 and 2001 are shown here as they will be required for interpretation in Section 2 (low back pain).

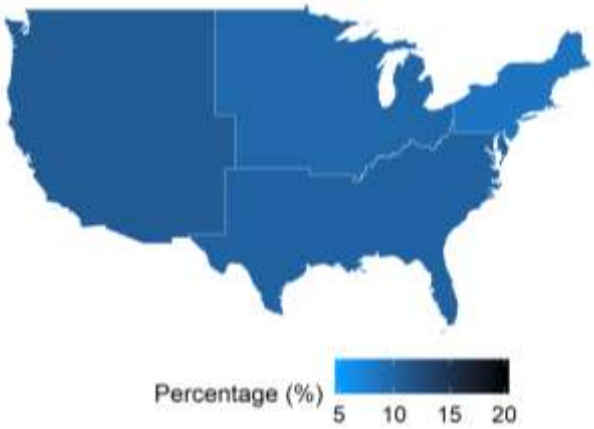
The proportions of various age and sex groups per region are not always entirely consistent across time, likely due to sampling. From these maps, I established that the Northeast has a lower

proportion of younger adults, and an increased proportion of older adults. The Midwest and West also have a higher proportion of younger people residing there compared to other regions. The country has a tendency to be younger in its western regions and older in its eastern regions. Furthermore, there are more females in the Northeast and South compared to the West (Figure 4.5.1 to Figure 4.5.12).

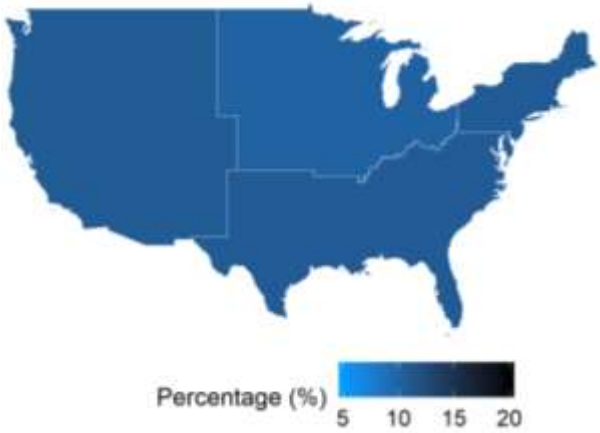
Age 18 to 24 years



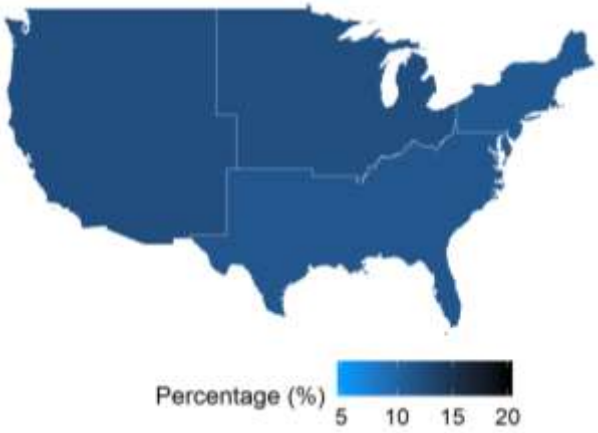
Age 25 to 29 years



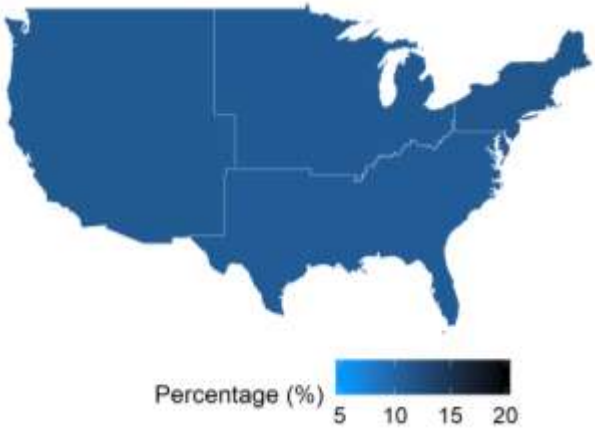
Age 30 to 34 years



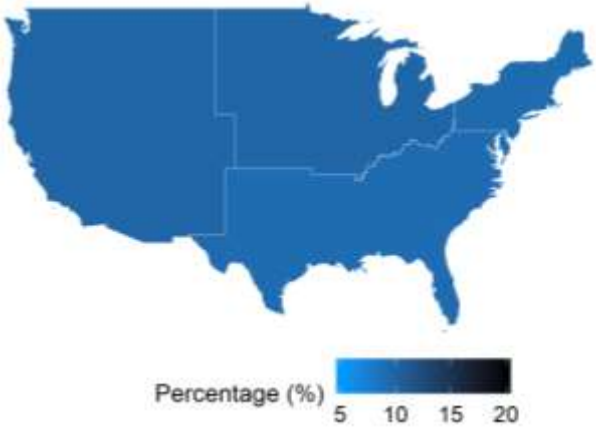
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



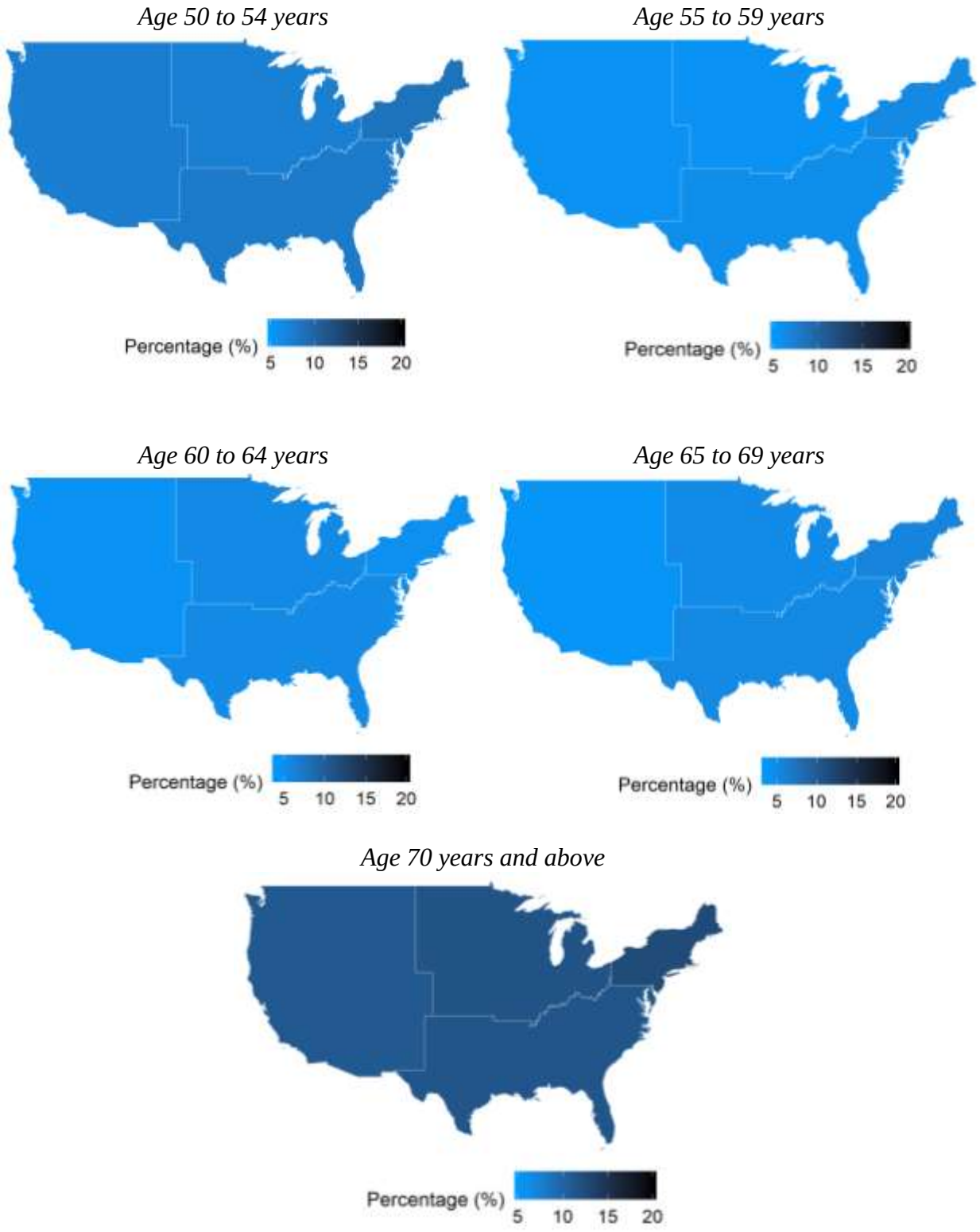


Figure 4.5.1: Distribution of various age groups across the US by region in 1997, according to the NHIS weighted sample

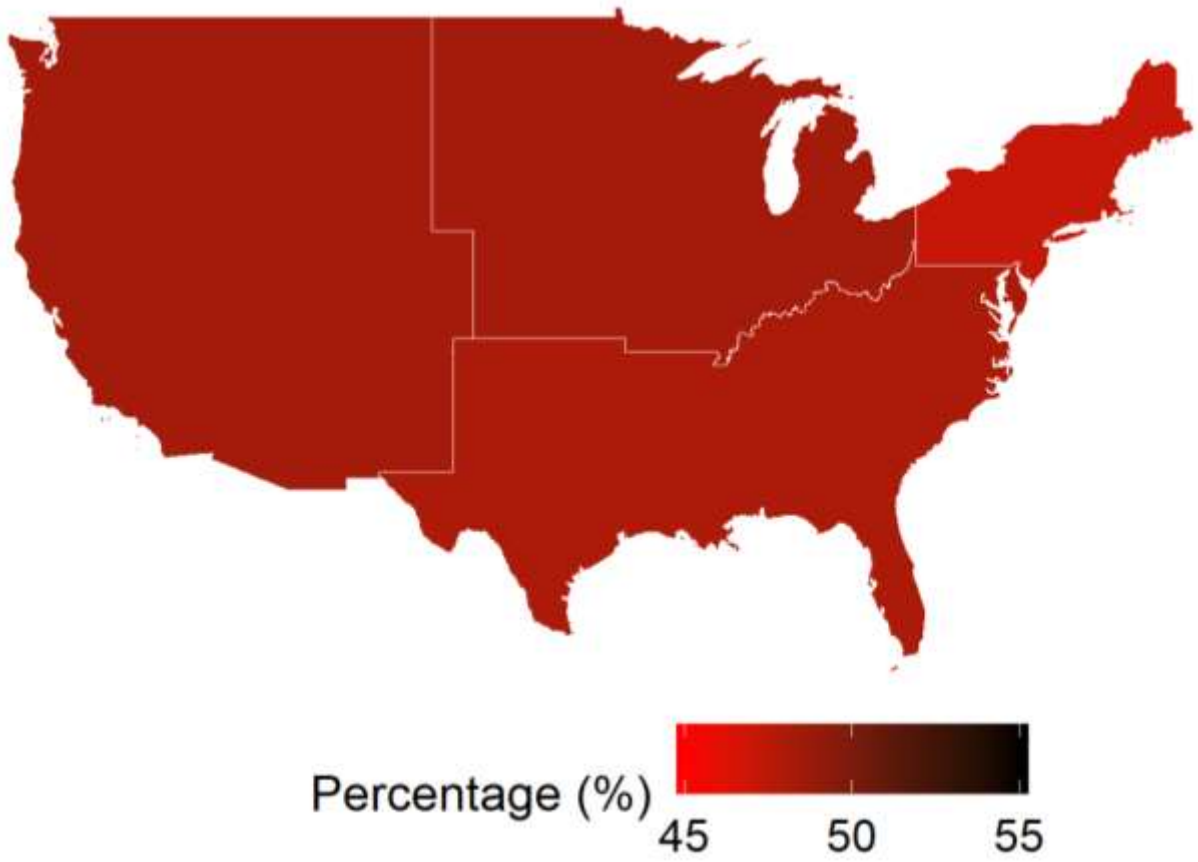
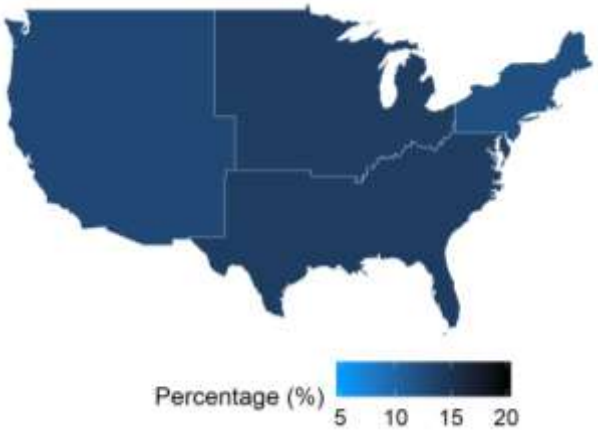
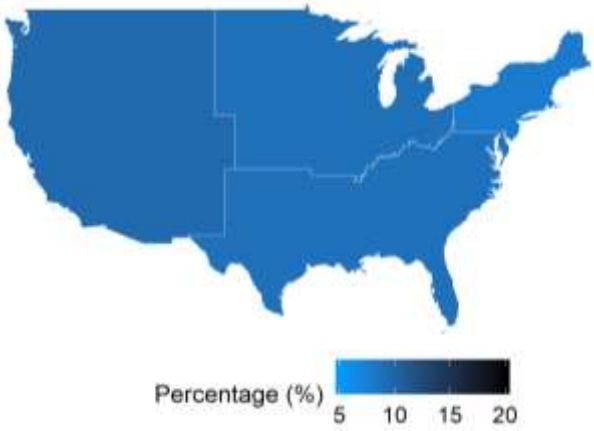


Figure 4.5.2: Distribution of males across the US by region in 1997, according to the NHIS weighted sample

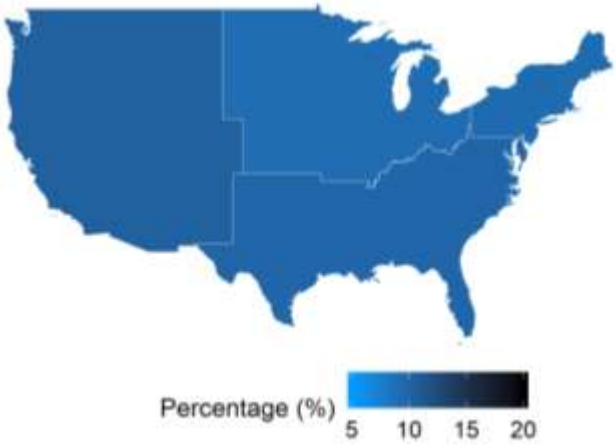
Age 18 to 24 years



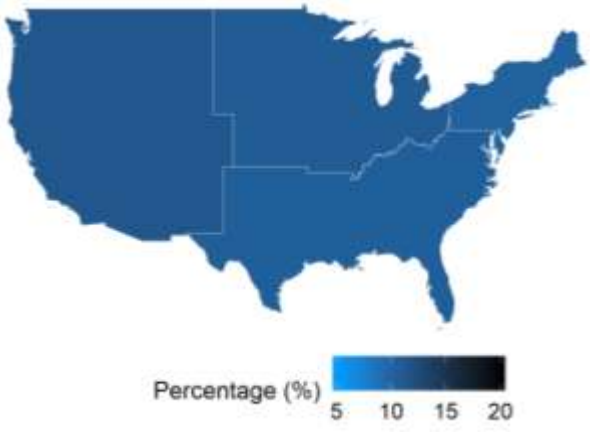
Age 25 to 29 years



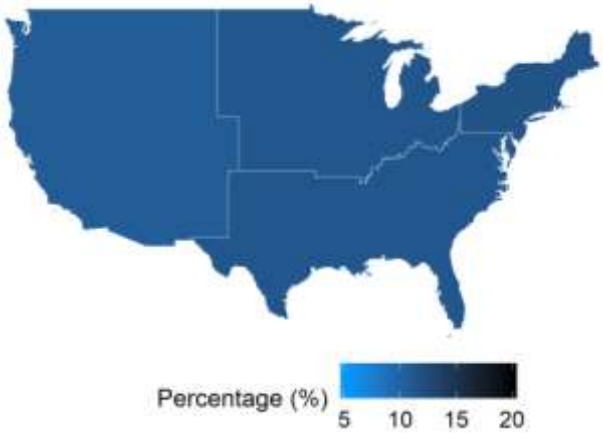
Age 30 to 34 years



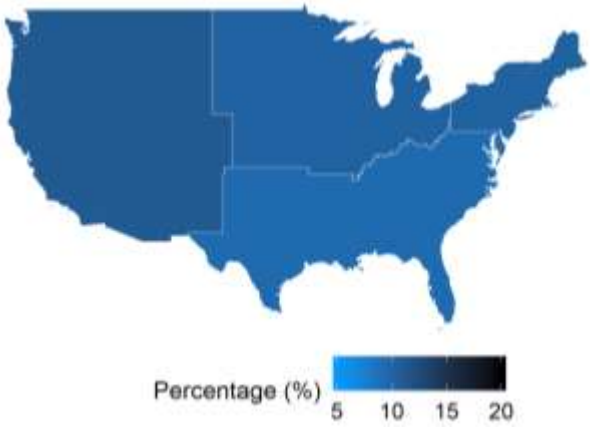
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



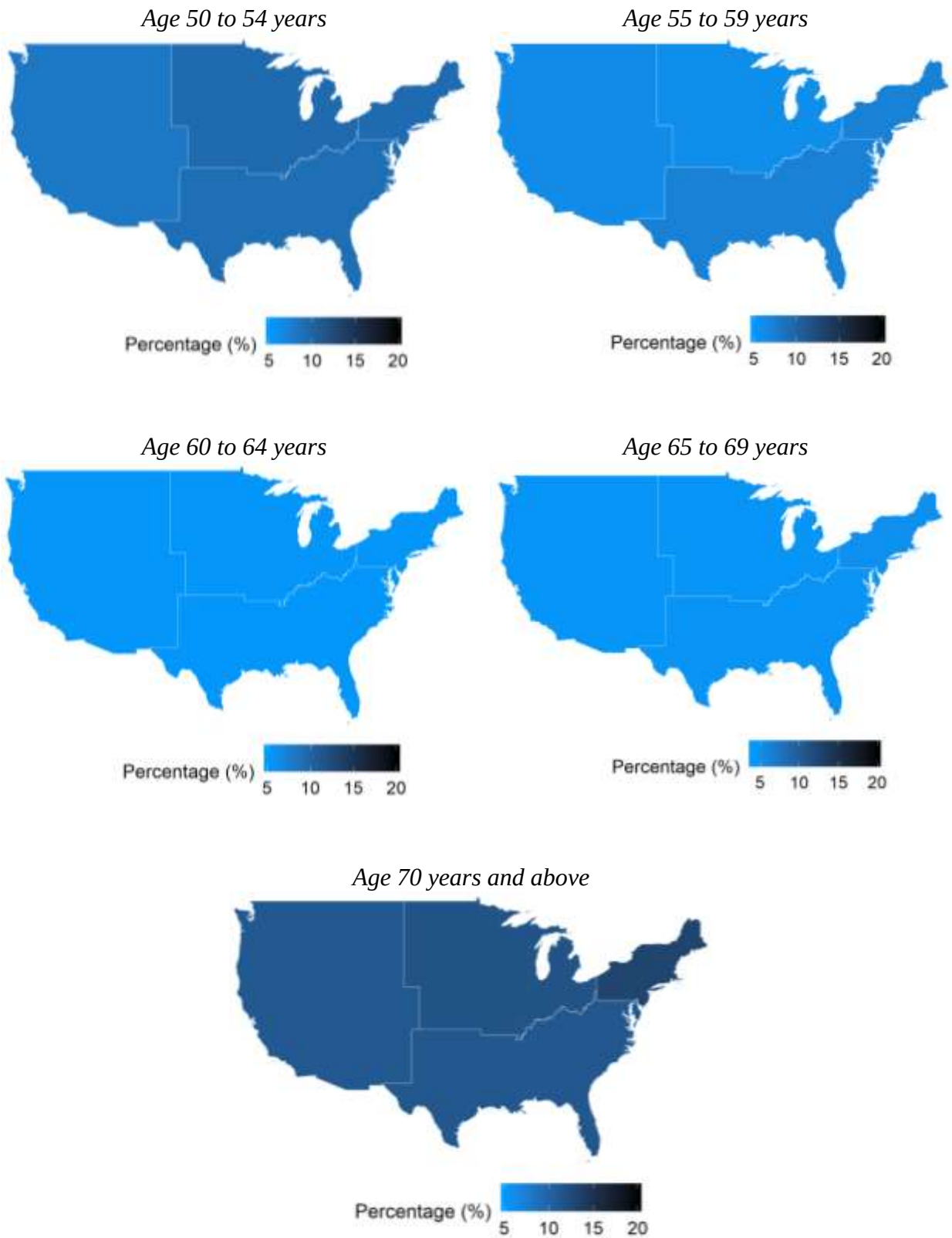


Figure 4.5.3: Distribution of various age groups across the US by region in 2001, according to the NHIS weighted sample

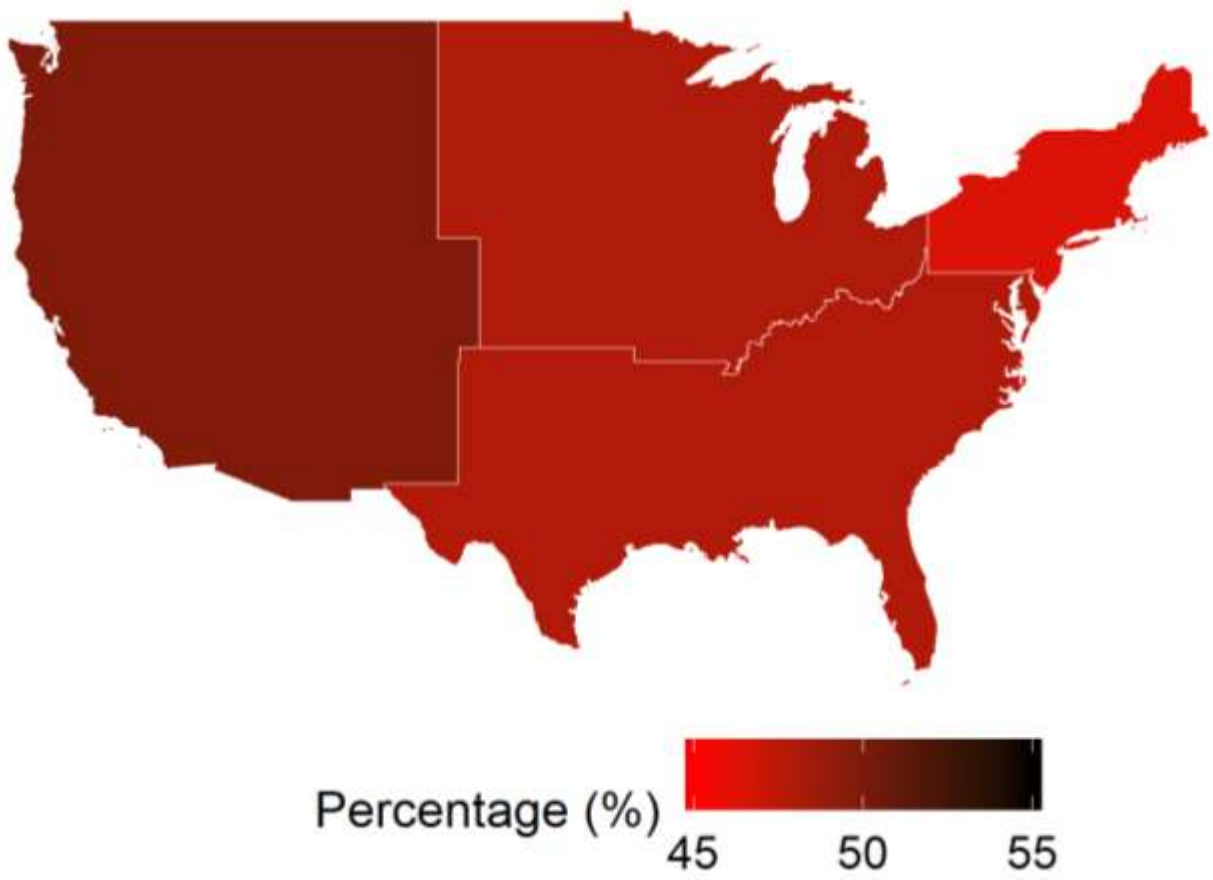
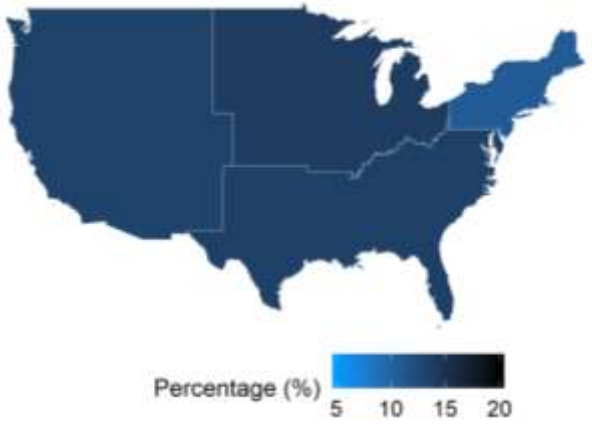
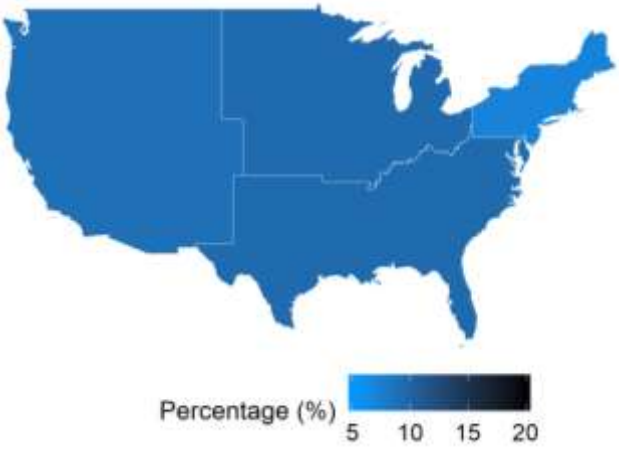


Figure 4.5.4: Distribution of males across the US by region in 2001, according to the NHIS weighted sample

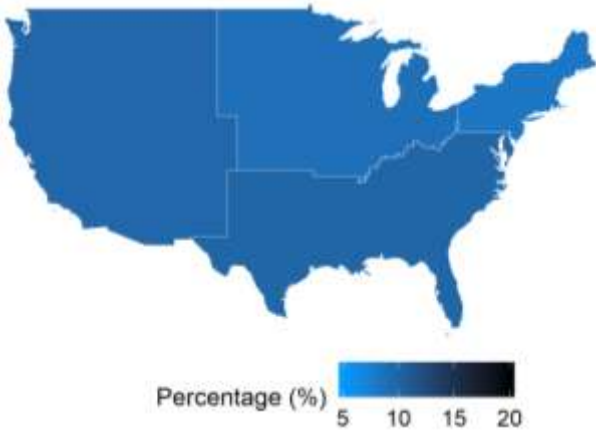
Age 18 to 24 years



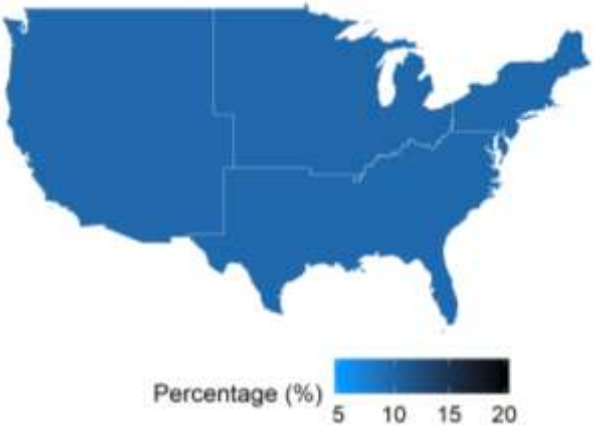
Age 25 to 29 years



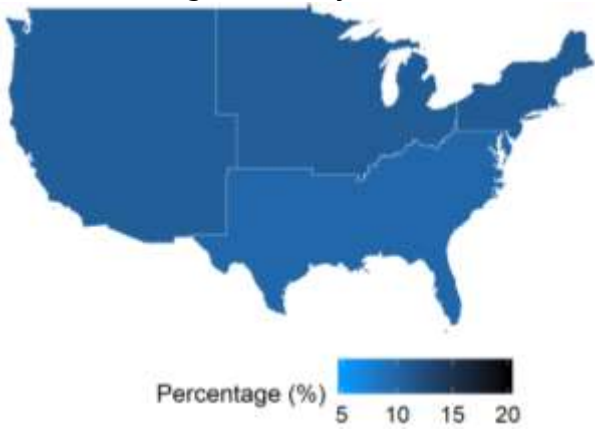
Age 30 to 34 years



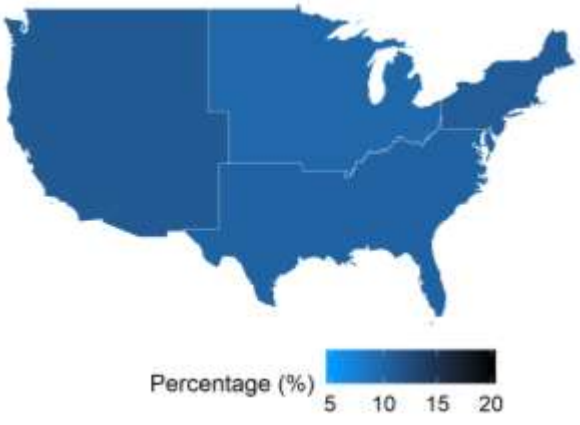
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



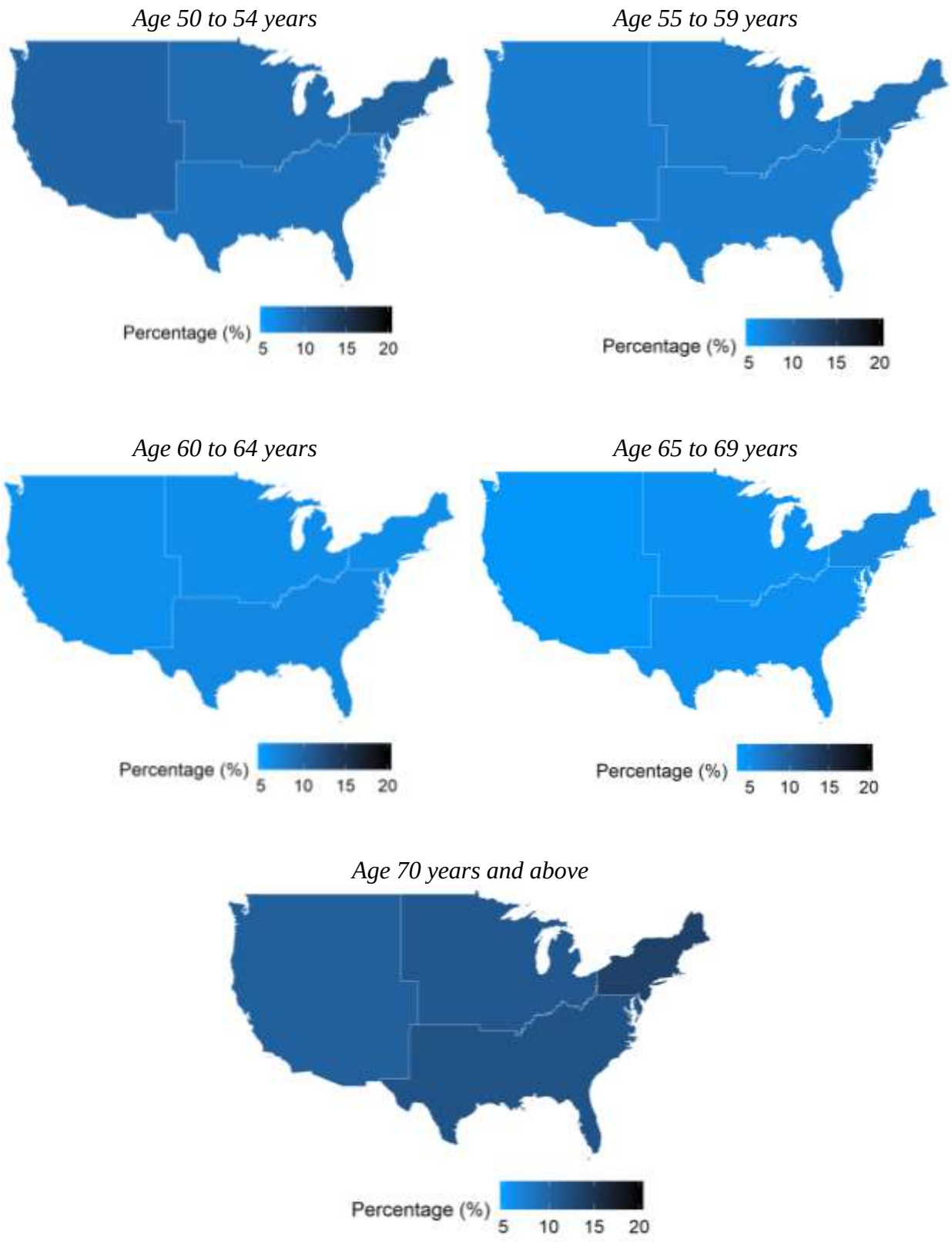


Figure 4.5.5: Distribution of various age groups across the US by region in 2005, according to the NHIS weighted sample

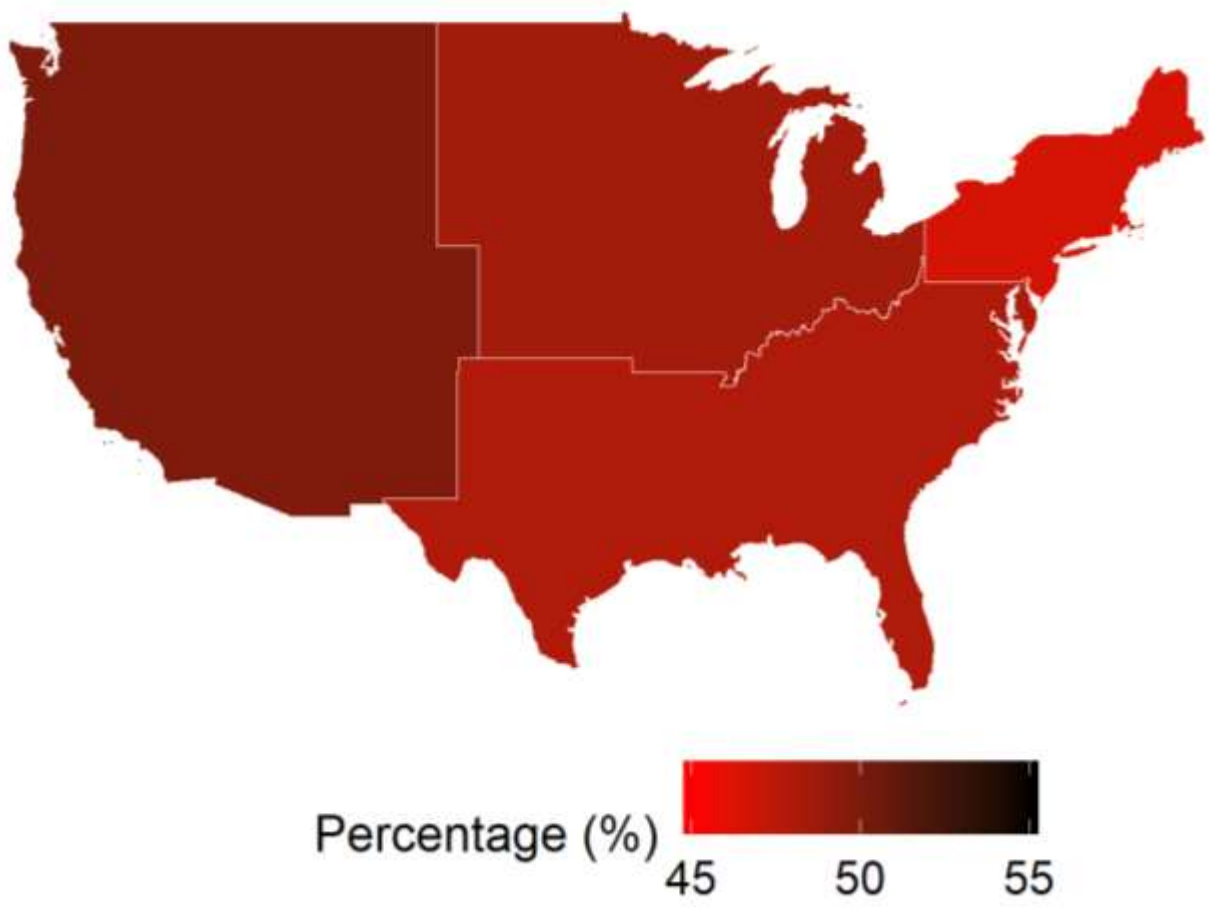
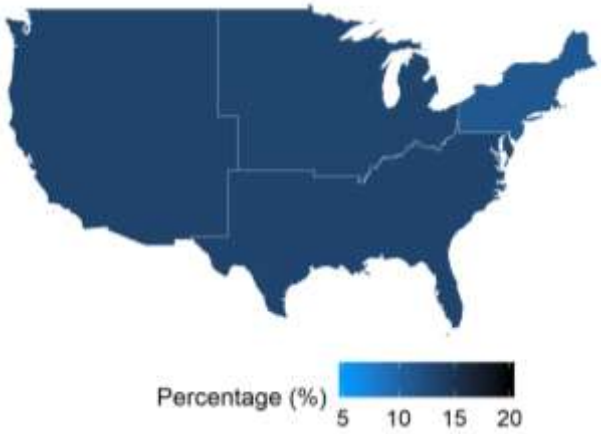
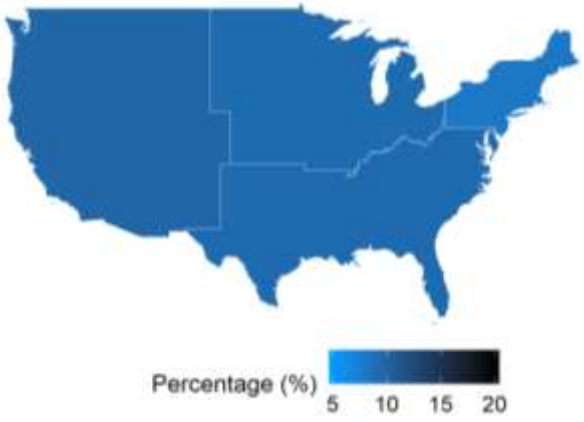


Figure 4.5.6: Distribution of males across the US by region in 2005, according to the NHIS weighted sample

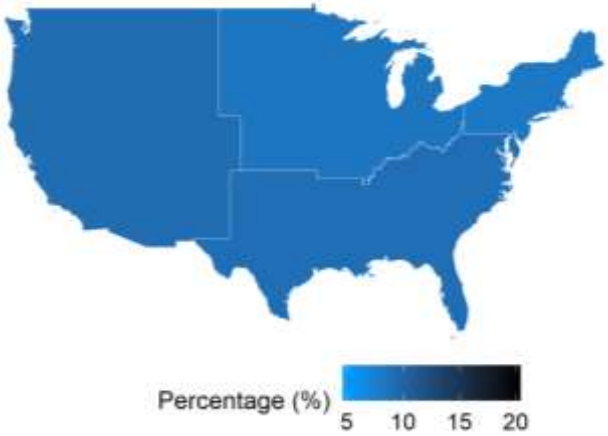
Age 18 to 24 years



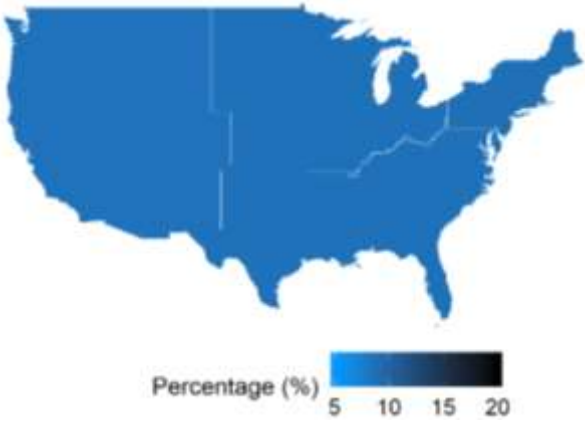
Age 25 to 29 years



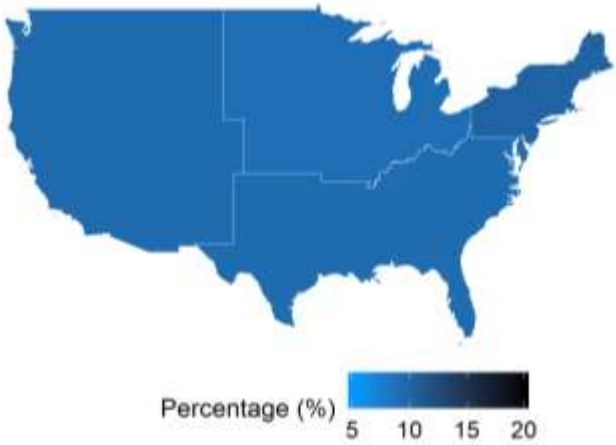
Age 30 to 34 years



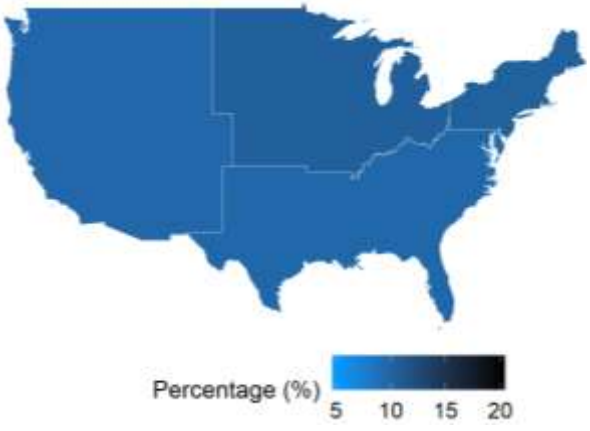
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



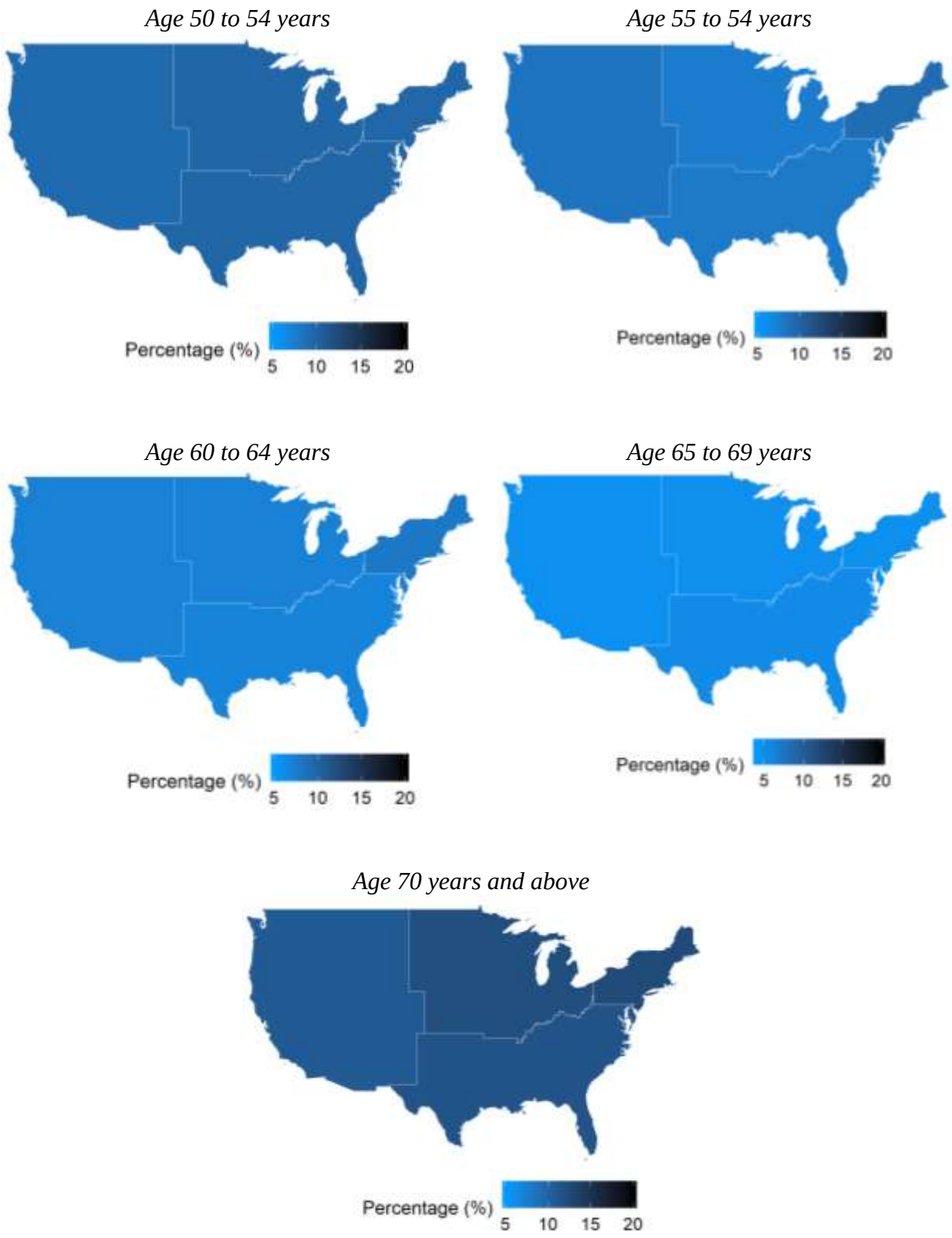


Figure 4.5.7: Distribution of various age groups across the US by region in 2009, according to the NHIS weighted sample

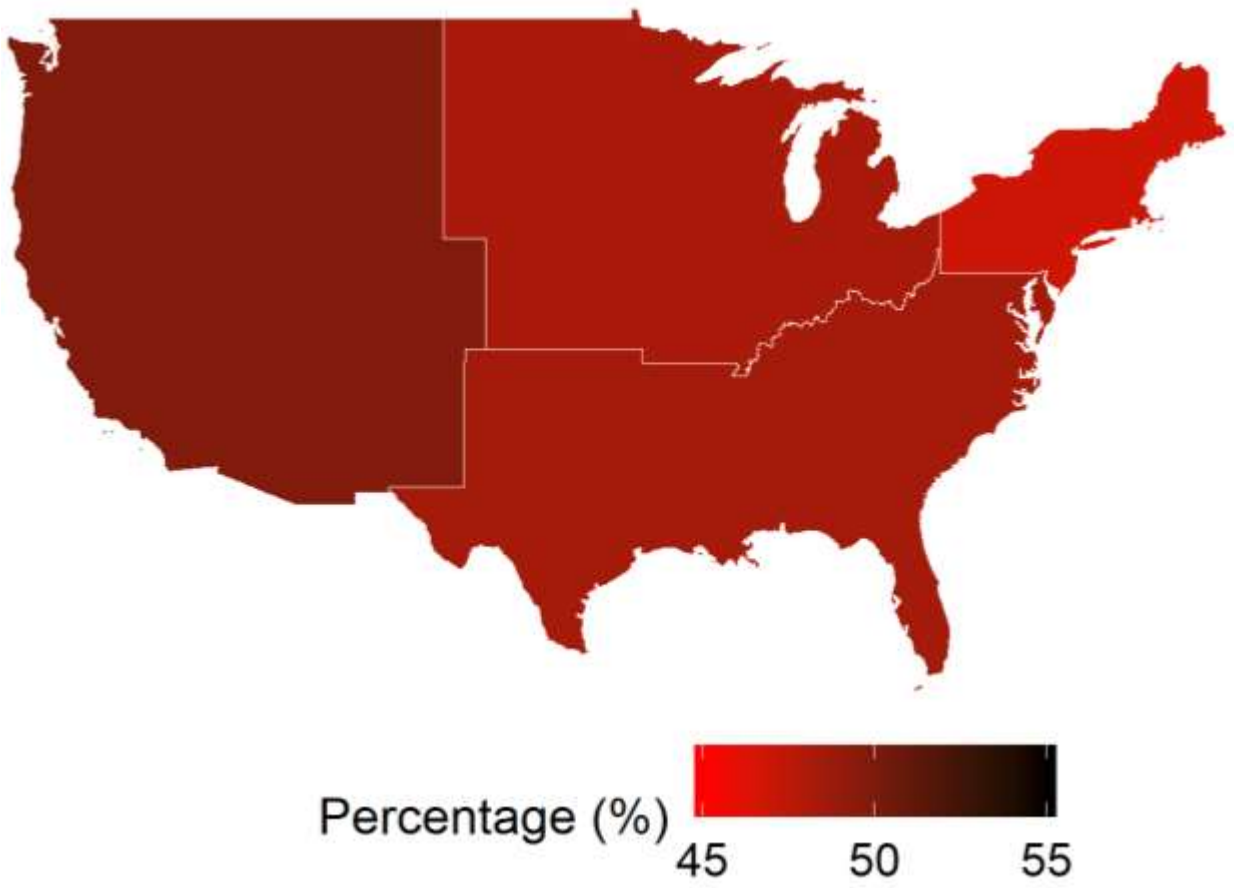
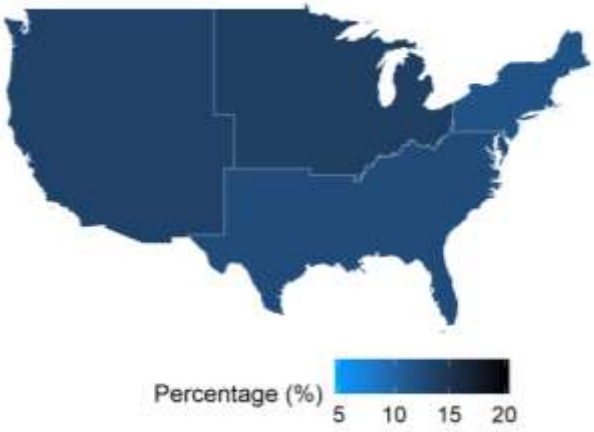
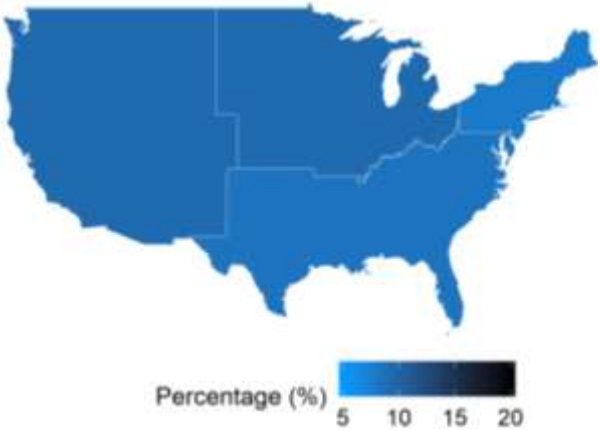


Figure 4.5.8: Distribution of males across the US by region in 2009, according to the NHIS weighted sample

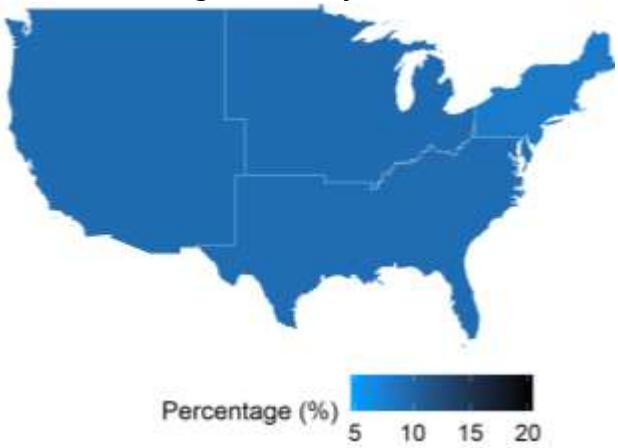
Age 18 to 24 years



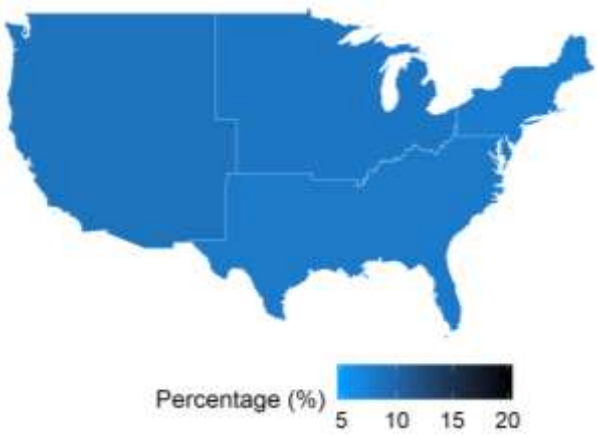
Age 25 to 29 years



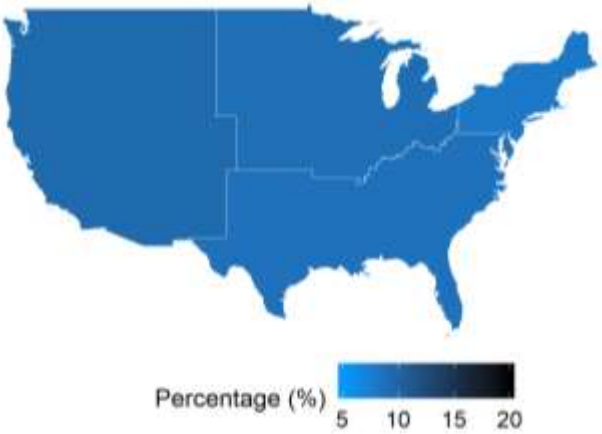
Age 30 to 34 years



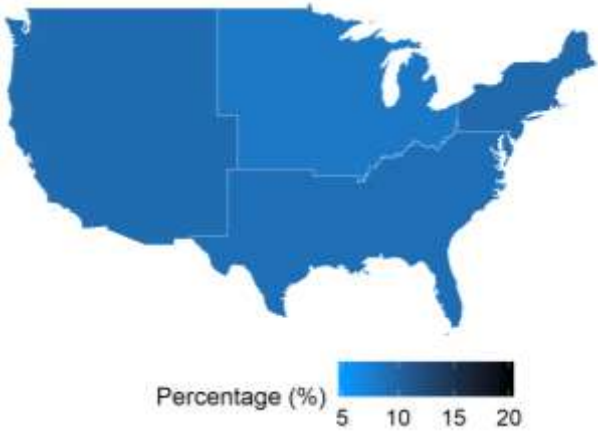
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



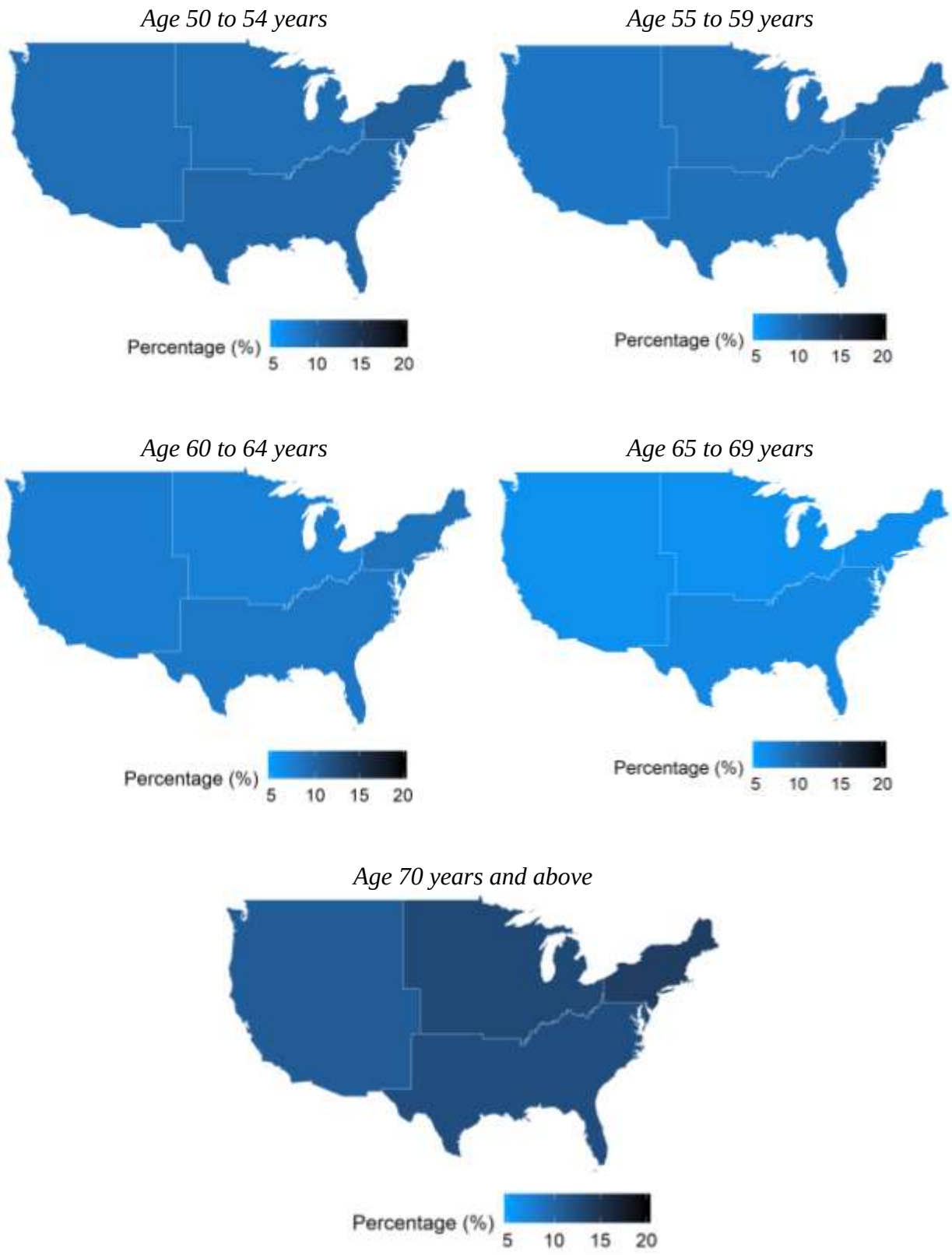


Figure 4.5.9: Distribution of various age groups across the US by region in 2013, according to the NHIS weighted sample

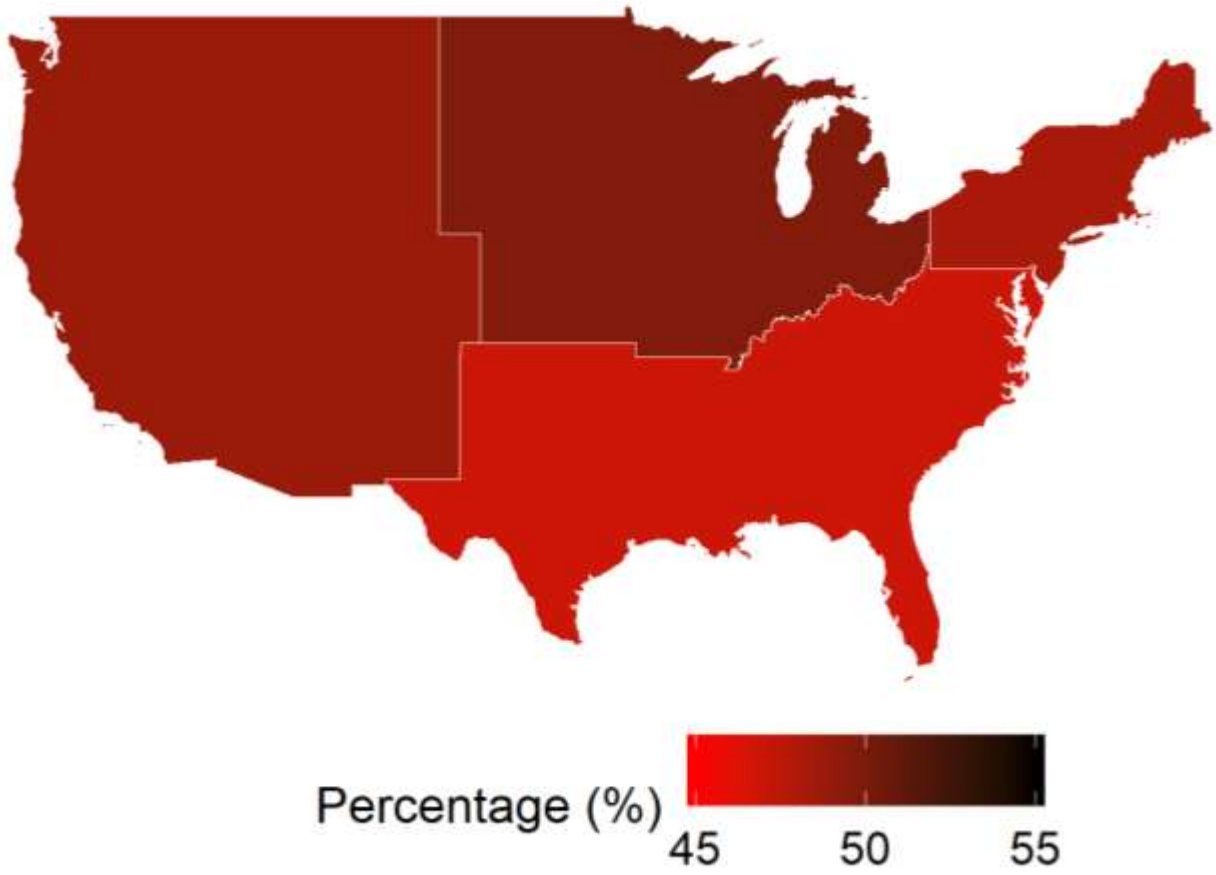
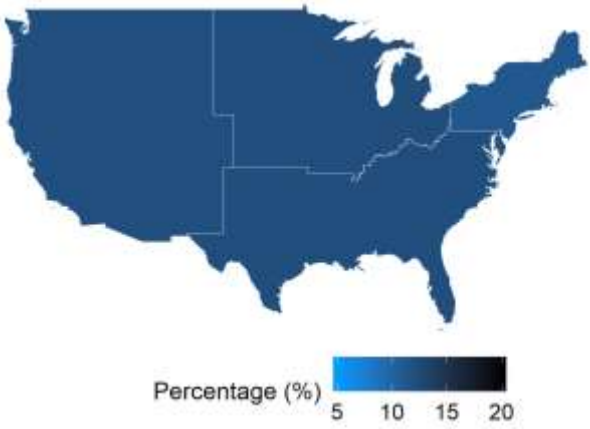
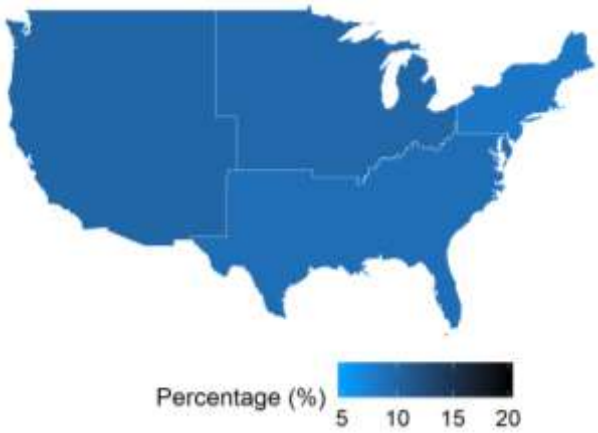


Figure 4.5.10: Distribution of males across the US by region in 2013, according to the NHIS weighted sample

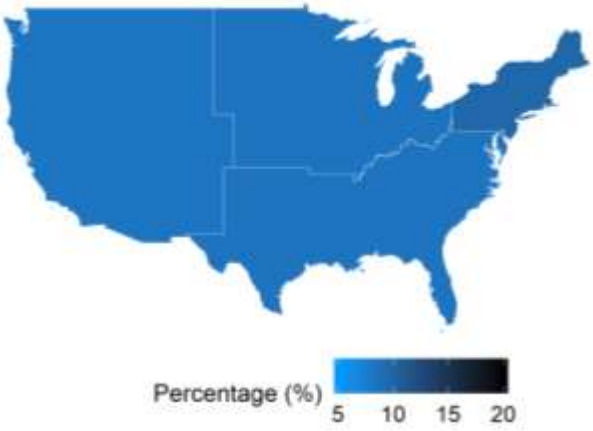
Age 18 to 24 years



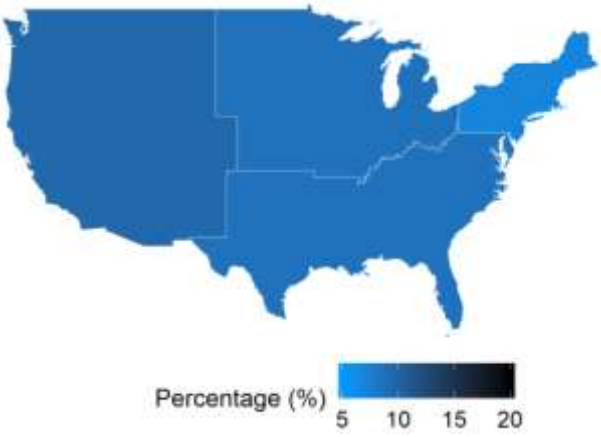
Age 25 to 29 years



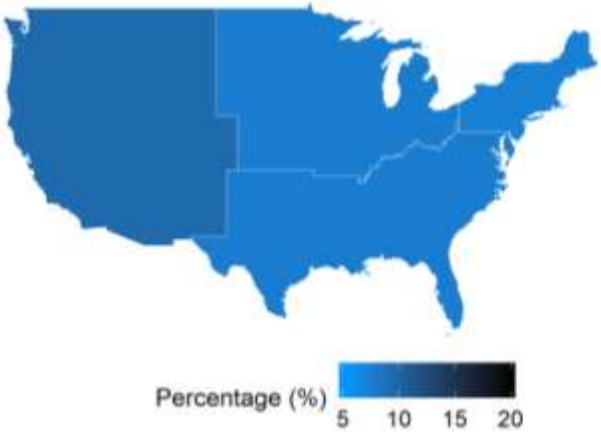
Age 30 to 34 years



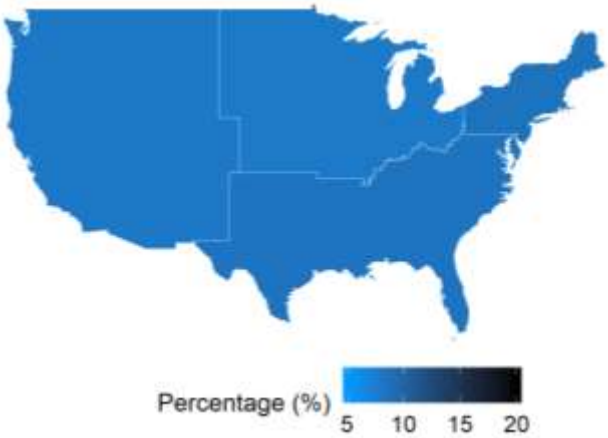
Age 35 to 39 years



Age 40 to 44 years



Age 45 to 49 years



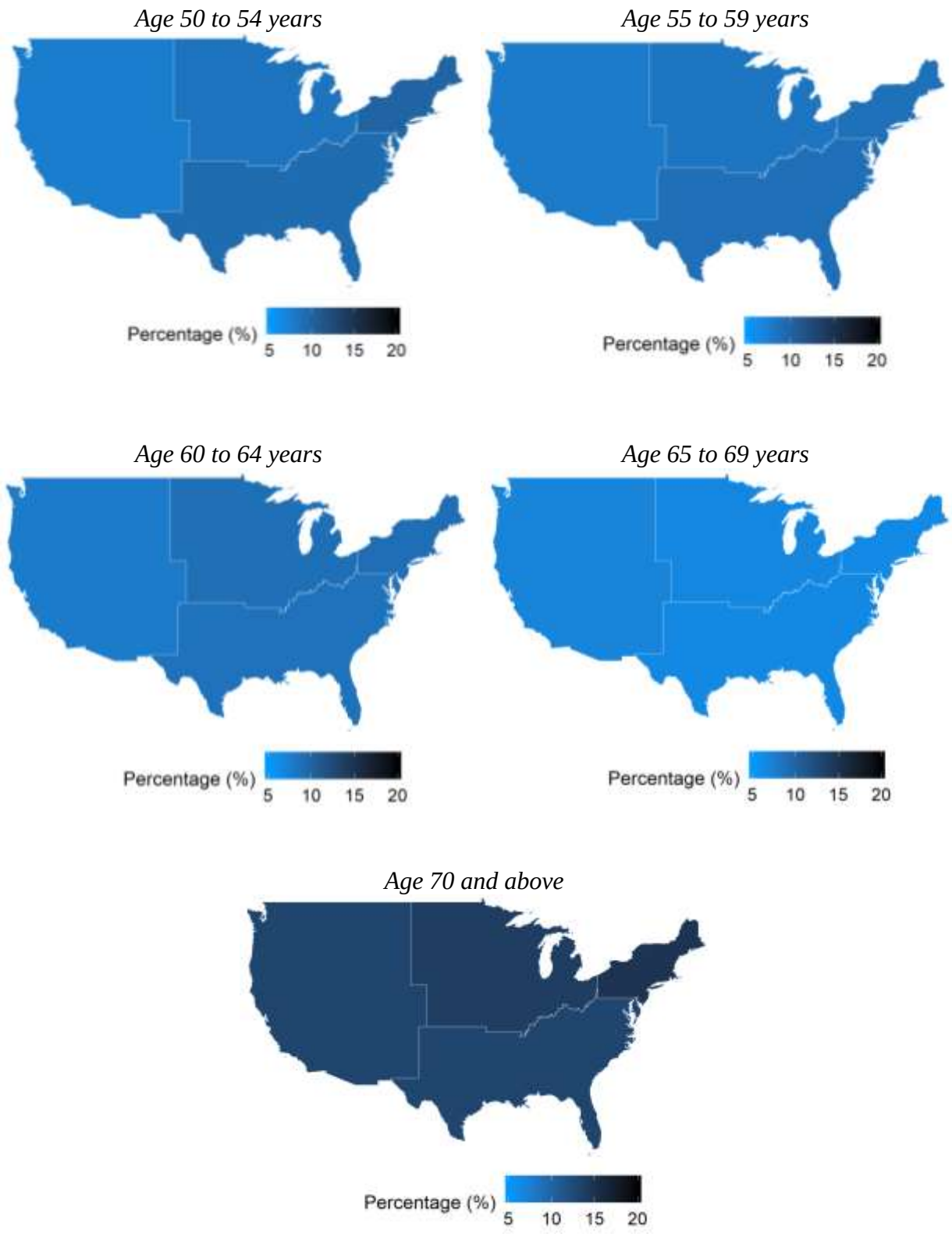


Figure 4.5.11: Distribution of various age groups across the US by region in 2017, according to the NHIS weighted sample

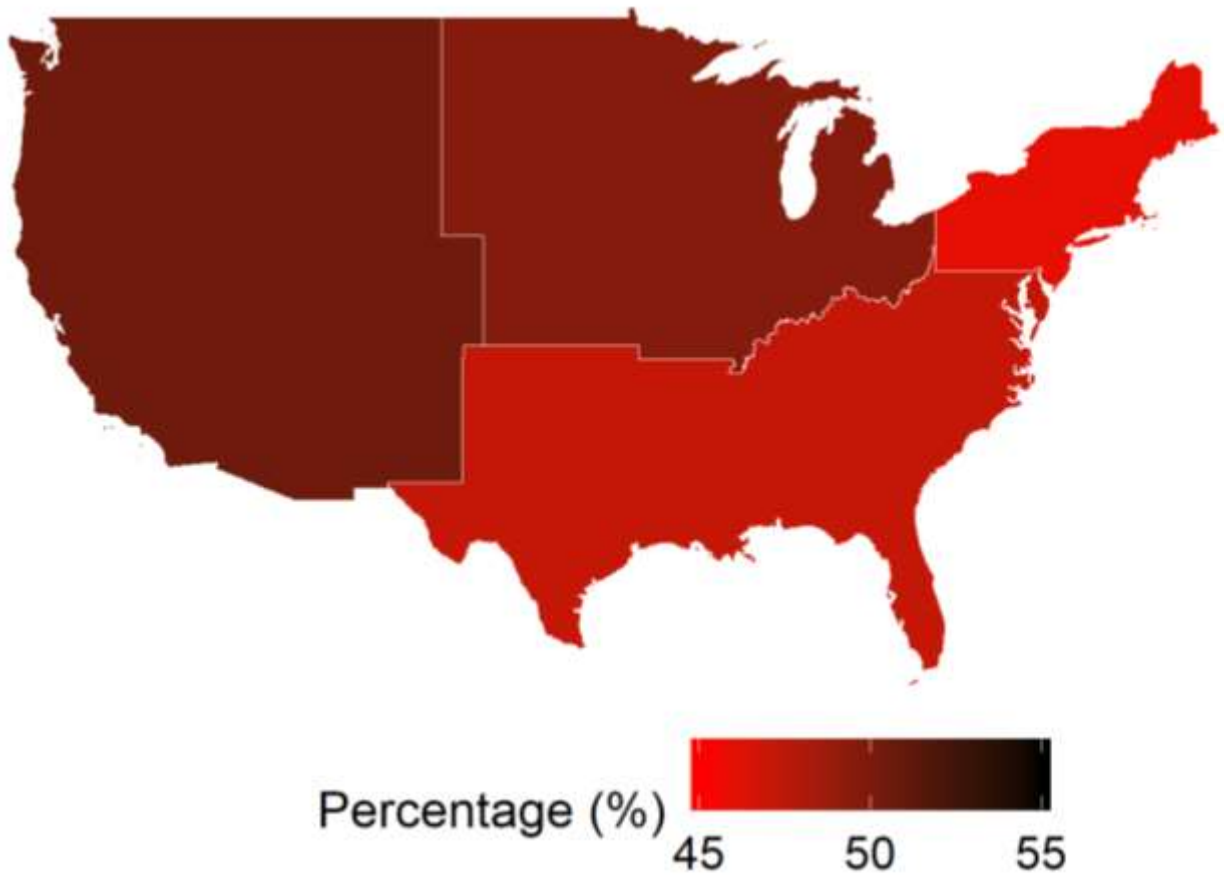
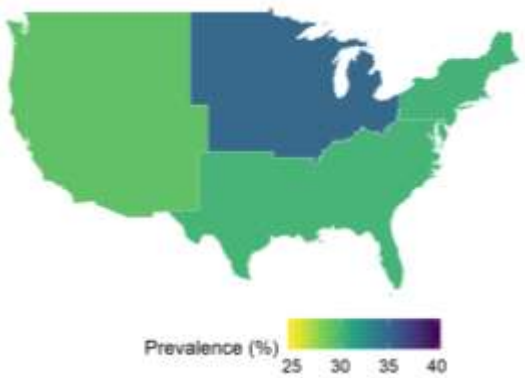


Figure 4.5.12: Distribution of males across the US by region in 2017, according to the NHIS weighted sample

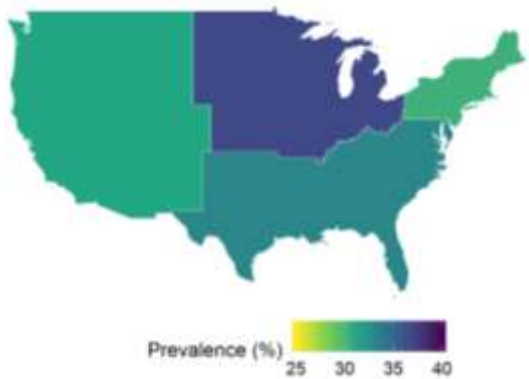
4.2.1 Region-specific prevalence of joint symptoms for US residents

Regional joint symptoms were fairly uniform in the Northeast, South, and West. Midwestern residents reported significantly more joint symptoms compared to residents from the Northeast, South, and West, across all years (Figure 4.6). A table of prevalence data for each region, in each year analysed, can be found in Table I, Appendix L.



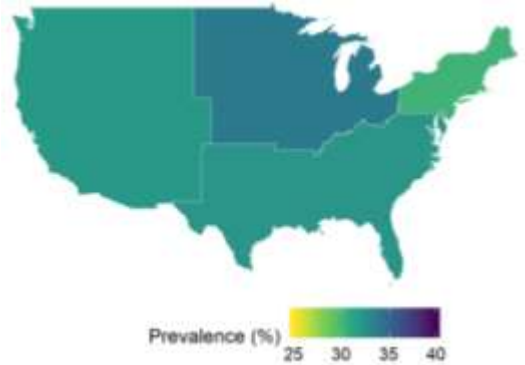
A: 2005 - *WP $^{\varepsilon}$ (95% CI); OR (95% CI); p-value*

M: 34.9 (33.7, 36.1); 0.198 (0.172, 0.226)
N: 30.2 (28.8, 31.6); 0.721 (0.659, 0.789); < 0.001*
S: 30.1 (29.2, 31.1); 0.782 (0.726, 0.843); < 0.001*
W: 29.2 (28.0, 30.4); 0.754 (0.693, 0.822); < 0.001*



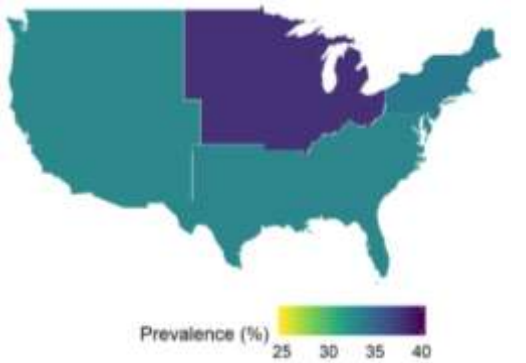
B: 2009 - *WP $^{\varepsilon}$ (95% CI); OR (95% CI); p-value*

M: 36.7 (35.3, 38.2); 0.206 (0.176, 0.240)
N: 30.4 (28.6, 32.1); 0.703 (0.631, 0.783); < 0.001*
S: 33.0 (31.9, 34.2); 0.845 (0.775, 0.922); < 0.001*
W: 31.1 (29.6, 32.6); 0.776 (0.703, 0.857); < 0.001*



C: 2013 - *WP $^{\varepsilon}$ (95% CI); OR (95% CI); p-value*

M: 33.8 (32.4, 35.2); 0.165 (0.141, 0.192)
N: 30.3 (28.7, 31.9); 0.774 (0.698, 0.858); < 0.001*
S: 32.2 (31.1, 33.2); 0.891 (0.820, 0.968); 0.006*
W: 31.9 (30.7, 33.1); 0.927 (0.848, 1.01); 0.095



D: 2017 - *WP $^{\varepsilon}$ (95% CI); OR (95% CI); p-value*

M: 38.0 (36.6, 39.4); 0.197 (0.169, 0.230)
N: 33.9 (32.1, 35.7); 0.791 (0.713, 0.878); < 0.001*
S: 33.1 (32.0, 35.2); 0.852 (0.782, 0.859); < 0.001*
W: 33.0 (31.5, 34.5); 0.868 (0.788, 0.956); 0.004*

Figure 4.6: Choropleth maps of the US showing the prevalence (%) of joint symptoms (pain, aching, or stiffness) in US residents within the previous 30 days, according to the NHIS, in 2005 (A), 2009 (B), 2013 (C), and 2017 (D)

Legends per year contain the first letter of each region (where M is the Midwest, N is the Northeast, S is the South, and W is the West), WP$^{\varepsilon}$ (95% CI) (weighted prevalence per region (95% confidence interval)), OR (95% CI) (odds ratio (95% confidence interval)), and corresponding P-value (*significant), for each year in question

4.2.2 Region-specific prevalence of joint symptoms by age

Given that painful arthropathies have previously been associated with older age (González-Chica *et al.*, 2018; Park, Mendy and Vieira, 2018), I calculated the regional prevalence of US residents who reported joint symptoms within the previous 30 days, after applying appropriate design weights, in eleven age groups. Age groups were: 18 to 24 years, 25 to 29 years, 30 to 34 years, 35 to 39 years, 40 to 44 years, 45 to 49 years, 50 to 54 years, 55 to 59 years, 60 to 64 years, 65 to 69 years, and 70 years and above. I also conducted annual sex-adjusted logistic regressions, where the comparator group was Midwestern residents for the age group in question, to see whether there was an association between regional residence and joint symptoms in specific age groups. A table of weighted statistics [prevalence (95% confidence interval), odds ratio (95% confidence interval) and p-value] by age for each region, in each year analysed, can be found in Appendix L (Tables II to XII).

Overall, Midwestern residents frequently, although often in random years of analysis, reported significantly more joint symptoms compared to the other regions, particularly the Northeast. However, there were some age groups (namely ages 30 to 34 years, 35 to 39 years, 40 to 44 years, 50 to 54 years, and 60 to 64 years) where this trend occurred less frequently in the most recent five years. Furthermore, in younger age groups, although Midwestern residents reported significantly more joint symptoms compared to the other regions, these other regions with the significantly fewer joint symptoms were often random across time. In older age groups, however, this steadied, and the Northeast was the region with significantly fewer joint symptoms, despite the Northeastern population slightly being older (Figure 4.7), according to the age proportion maps (Figure 4.5.1 to 4.5.12).

In earlier years of analysis (2002 until 2010), Midwestern 18- to 24-year-olds reported significantly more joint symptoms compared to those living in other regions, particularly the South and Northeast. However, from 2011, the trend is mixed. In some years (2012 and 2014), Midwestern residents reported significantly more joint symptoms compared to other regions, while in all other years not. The only region that remained significantly lower in joint symptom reports across time compared to the Midwest was the South (Figure 4.7).

In those aged 25 to 29 years, Midwestern residents frequently (although not every year of analysis) reported significantly more joint symptoms compared to other regions, particularly in the Northeast and South (Figure 4.7). Midwestern residents reported significantly more joint symptoms in 2002, 2003, 2005, 2006, 2009, 2011, 2012, 2014, 2017, and 2018. Although Midwestern residents reported significantly more joint symptoms compared to Western residents in earlier years, Midwestern residence joint symptom prevalences have not been significantly different to that of Western residence joint symptom prevalences since 2006.

In those aged 30 to 34 years, Midwestern residents frequently (although not every year of analysis) reported significantly more joint symptoms compared to other regions, particularly in the Northeast. Midwestern residents reported significantly more joint symptoms specifically in 2003, 2005, 2006, 2008 to 2010, and 2012, but not so thereafter (Figure 4.7).

In those aged 35 to 39 years, Midwestern residents frequently (2003, 2005, 2009 to 2012, 2014, and 2016 to 2018) reported significantly more joint symptoms compared to other regions, but only compared to one or two random regions per year (Figure 4.7).

In the 40- to 44-year-old group, Midwestern residents reported significantly more joint symptoms compared to Northeastern and Western residents, but only for seven years of the total 15 years analysed (2002, 2005, 2006, 2009 to 2011, and 2017). Furthermore, in the latest six years' worth of analyses, only 2017 saw Midwestern 40- to 44-year-olds reporting significantly more joint symptoms compared to Western residents only, likely due to sampling (Figure 4.7).

In those aged 45 to 49 years, Midwestern residents did report significantly more joint symptoms compared to the other regions on occasion, although the other regions were random, and never more than one region at a time. However, this age group had the fewest number of regional differences: only five of the 15 years (2005, 2006, 2012, 2014, and 2018), and in a random pattern (Figure 4.7).

In those aged 50 to 54 years, Midwestern residents frequently (2003, 2005, 2007 to 2011, 2016, and 2017) reported significantly more joint symptoms compared to other regions, particularly the Northeast. However, the latest six years' worth of results did not have Midwestern residents reporting significantly more joint symptoms, with the exception of only one year, where

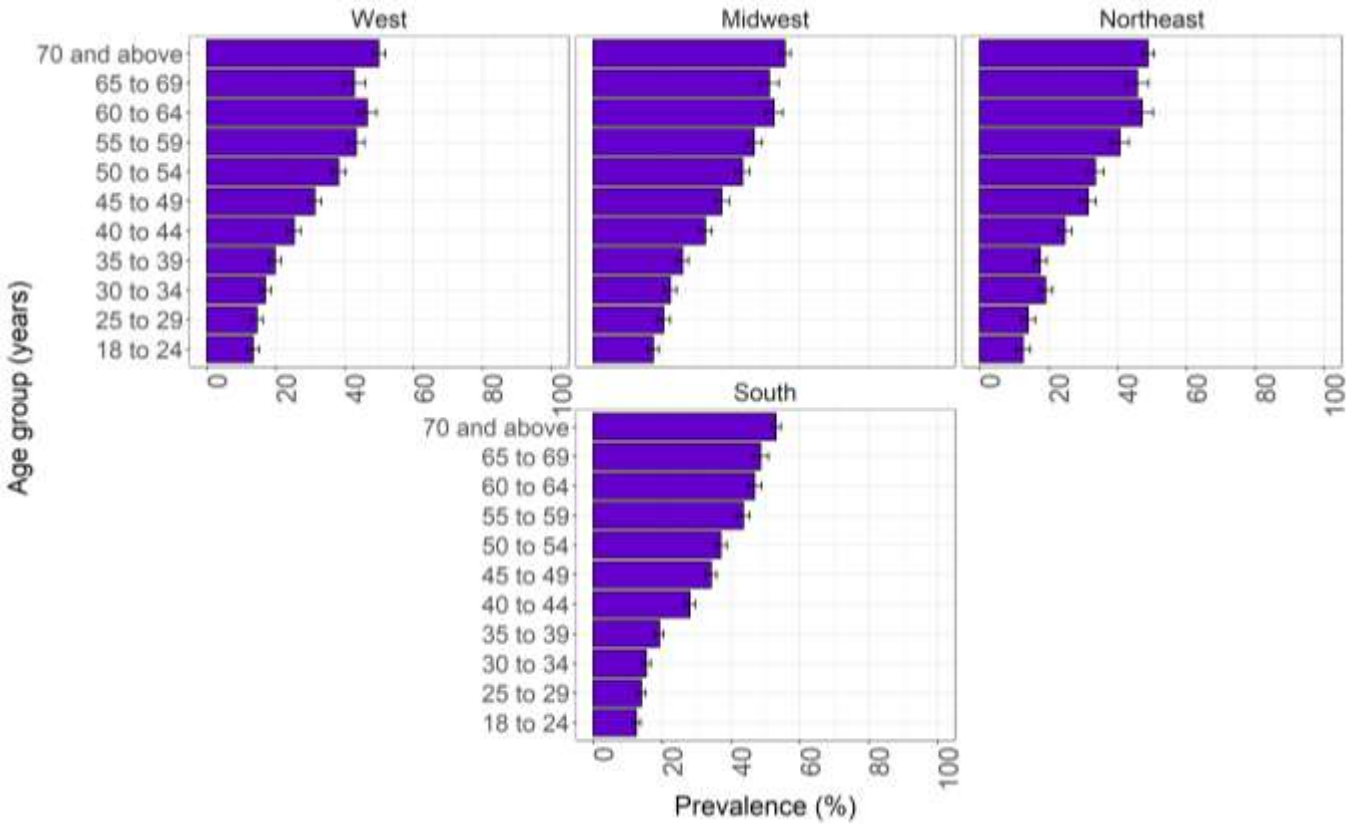
Midwestern 50- to 54-year-olds reported significantly more joint symptoms than Western 50-to 54-year-olds, likely as a result of sampling (Figure 4.7).

In those aged 55 to 59 years, Midwestern residents more frequently (compared to other age groups) reported significantly more joint symptoms compared to other regions, specifically the Northeast (Figure 4.7). Midwestern residents reported significantly more joint symptoms compared to other regions in 2002, 2003, 2006, 2008 to 2011, 2013, 2015, 2017, and 2018.

In those aged 60 to 64 years, Midwestern residents frequently reported significantly more joint symptoms most often compared to the Northeast (however, also compared to the South in some years), in years 2003, 2006, 2010 to 2014, and 2016 (Figure 4.7).

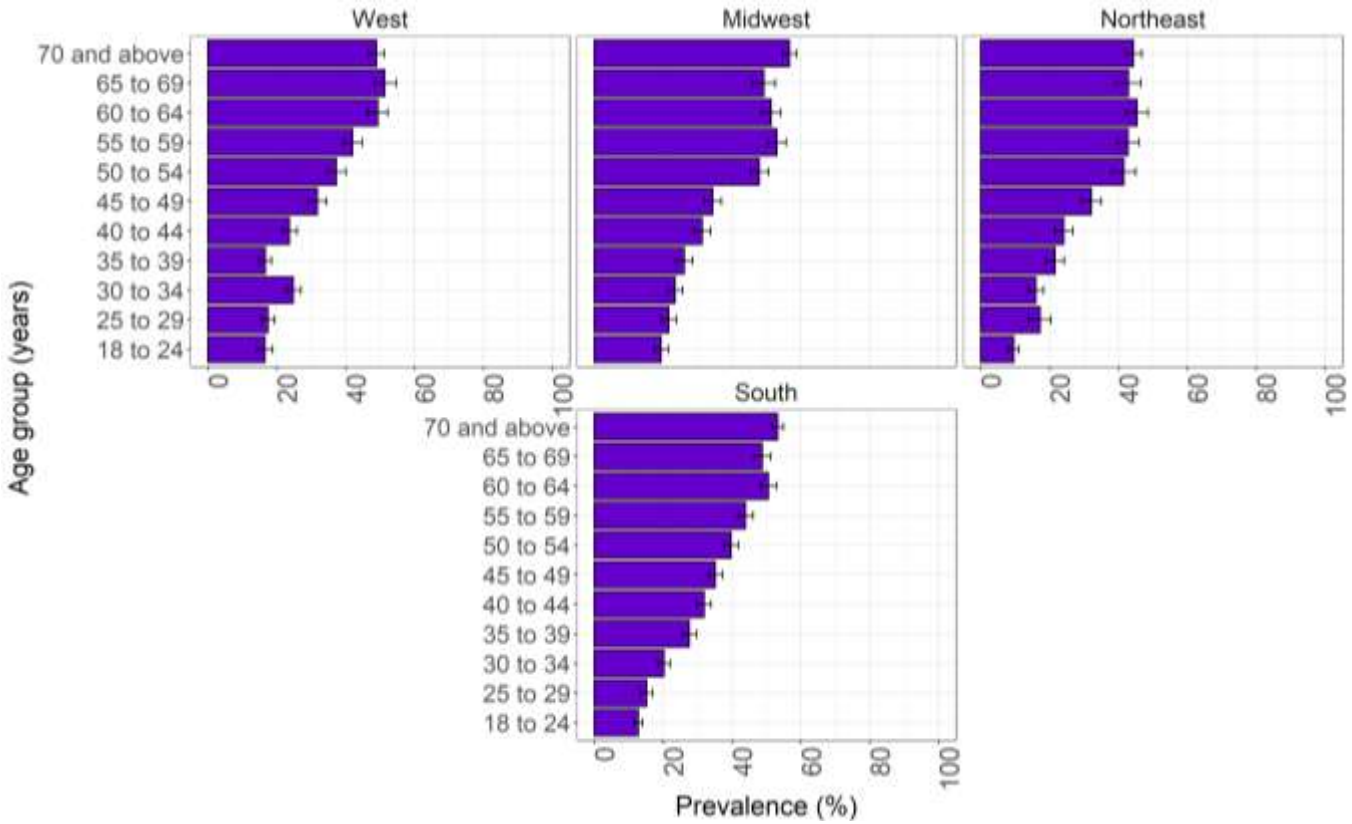
In those aged 65 to 69 years, Midwestern residents reported significantly more joint symptoms compared to Northeastern and Western regional residents (2003, 2010, 2012, and 2014 to 2016), but far less so in earlier years of analysis (Figure 4.7).

In those 70 years old and above, the pattern of joint symptoms was largely random. In most years, Midwestern residents reported significantly more joint symptoms compared to other regions. Although the Northeastern residents frequently had significantly fewer joint symptoms compared to the Midwest, the South and the West also had significantly fewer joint symptoms on occasion. There was also no particular timeframe trend, as the years where the Midwest did not have significantly more joint symptoms appeared randomly (2002, 2003, 2005, 2006, 2009, 2010, and 2014 to 2018) (Figure 4.7).



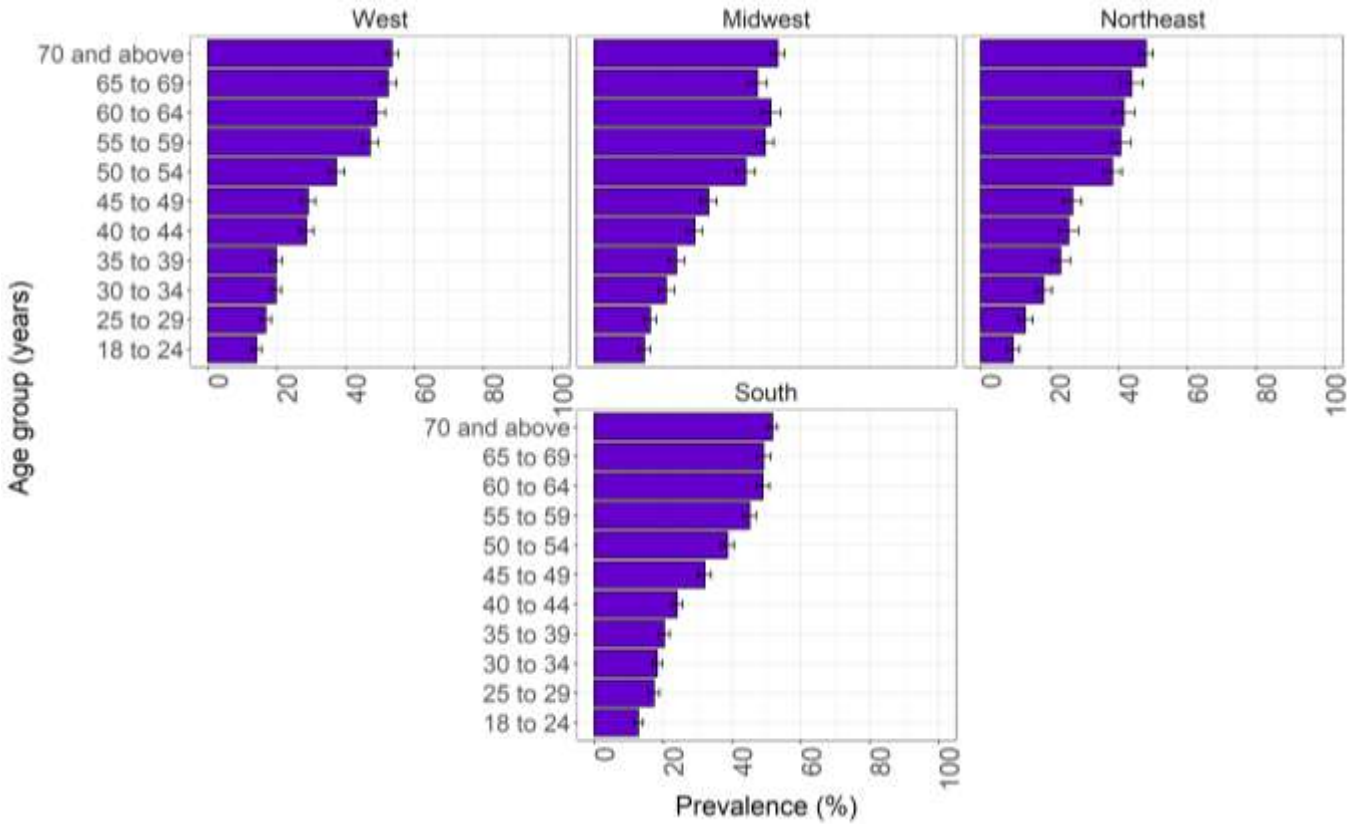
A: 2005 – *OR (95% CI), p-value*

Age 18 to 24	M: 0.226 (0.176, 0.290)	N: 0.684 (0.444, 1.05); 0.084	S: 0.679 (0.500, 0.923); 0.013*	W: 0.737 (0.508, 1.07); 0.109
Age 25 to 29	M: 0.222 (0.171, 0.288)	N: 0.658 (0.152, 1.20); 0.046*	S: 0.641 (0.456, 0.884); 0.007*	W: 0.672 (0.471, 0.957); 0.028*
Age 30 to 34	M: 0.276 (0.220, 0.347)	N: 0.821 (0.582, 1.16); 0.262	S: 0.634 (0.478, 0.841); 0.002*	W: 0.713 (0.523, 0.971); 0.032*
Age 35 to 39	M: 0.350 (0.286, 0.429)	N: 0.611 (0.449, 0.831); 0.002*	S: 0.667 (0.528, 0.867); 0.002*	W: 0.702 (0.525, 0.937); 0.017*
Age 40 to 44	M: 0.477 (0.394, 0.577)	N: 0.682 (0.518, 0.898); 0.006*	S: 0.810 (0.643, 1.02); 0.073	W: 0.704 (0.542, 0.915); 0.009*
Age 45 to 49	M: 0.627 (0.515, 0.764)	N: 0.768 (0.583, 1.01); 0.060	S: 0.873 (0.693, 1.10); 0.247	W: 0.765 (0.591, 0.990); 0.042*
Age 50 to 54	M: 0.889 (0.735, 1.07)	N: 0.665 (0.504, 0.878); 0.004*	S: 0.763 (0.608, 0.958); 0.020*	W: 0.814 (0.634, 1.05); 0.107
Age 55 to 59	M: 1.01 (0.826, 1.22)	N: 0.793 (0.599, 1.05); 0.104	S: 0.885 (0.699, 1.12); 0.308	W: 0.886 (0.677, 1.16); 0.376
Age 60 to 64	M: 1.39 (1.12, 1.72)	N: 0.819 (0.595, 1.13); 0.222	S: 0.796 (0.614, 1.03); 0.084	W: 0.797 (0.595, 1.07); 0.129
Age 65 to 69	M: 1.18 (0.930, 1.49)	N: 0.814 (0.583, 1.14); 0.228	S: 0.912 (0.687,1.21); 0.525	W: 0.721 (0.514, 1.01); 0.059
Age ≥ 70	M: 1.46 (1.26, 1.68)	N: 0.761 (0.622, 0.931); 0.008*	S: 0.897 (0.753, 1.07); 0.223	W: 0.795 (0.646, 0.978); 0.030*



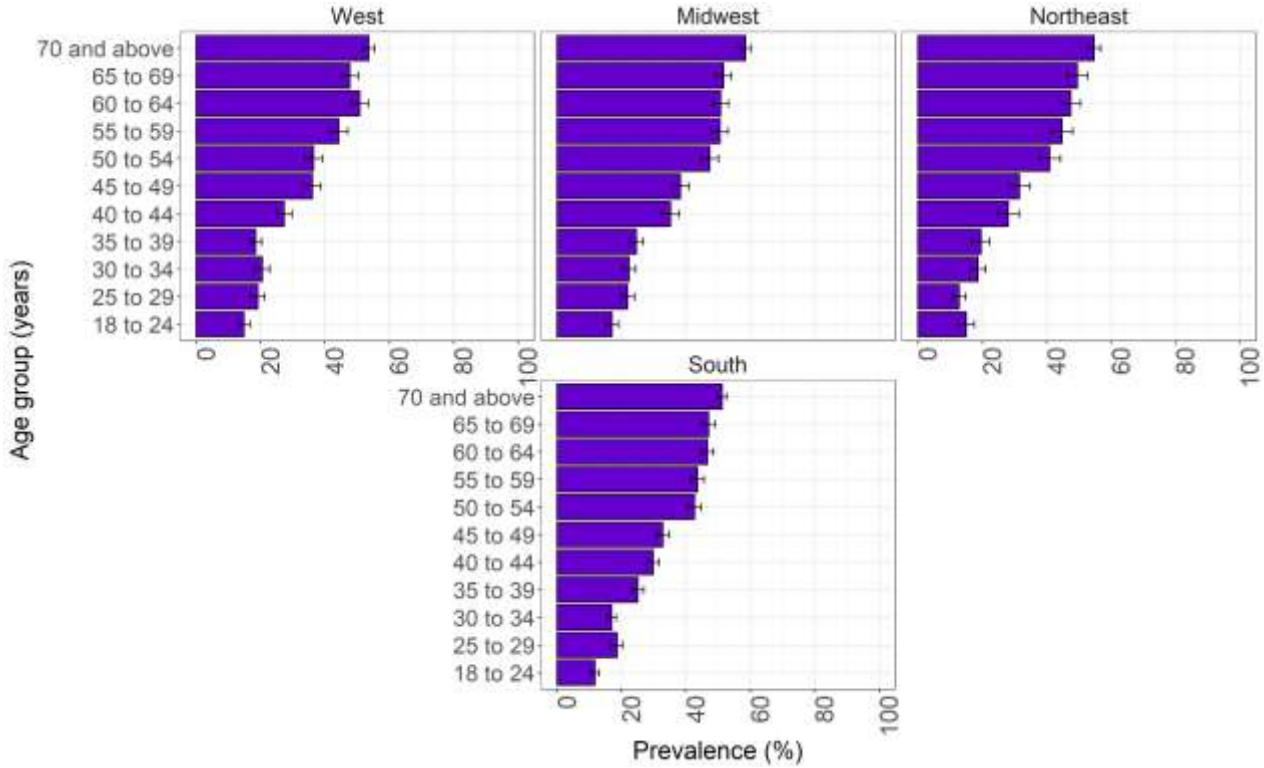
B: 2009 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.217 (0.162, 0.290)	N: 0.436 (0.276, 0.689); < 0.001*	S: 0.607 (0.429, 0.858); 0.005*	W: 0.821 (0.543, 1.24); 0.349
Age 25 to 29	M: 0.237 (0.178, 0.315)	N: 0.757 (0.459, 1.25); 0.275	S: 0.652 (0.485, 0.929); 0.018*	W: 0.761 (0.530, 1.09); 0.140
Age 30 to 34	M: 0.256 (0.196, 0.334)	N: 0.628 (0.419, 0.939); 0.024*	S: 0.817 (0.591, 1.13); 0.221	W: 1.08 (0.771, 1.51); 0.663
Age 35 to 39	M: 0.360 (0.272, 0.477)	N: 0.780 (0.523, 1.16); 0.224	S: 1.08 (0.783, 1.494); 0.637	W: 0.567 (0.356, 0.813); 0.002*
Age 40 to 44	M: 0.465 (0.361, 0.599)	N: 0.696 (0.489, 0.992); 0.045*	S: 1.02 (0.762, 1.38); 0.875	W: 0.681 (0.490, 0.945); 0.022*
Age 45 to 49	M: 0.502 (0.394, 0.638)	N: 0.913 (0.651, 1.28); 0.595	S: 1.04 (0.788, 1.37); 0.786	W: 0.891 (0.644, 1.23); 0.488
Age 50 to 54	M: 0.987 (0.791, 1.23)	N: 0.771 (0.546, 1.09); 0.141	S: 0.716 (0.551, 0.931); 0.013*	W: 0.646 (0.477, 0.873); 0.005*
Age 55 to 59	M: 1.38 (1.09, 1.73)	N: 0.659 (0.475, 0.913); 0.012*	S: 0.703 (0.533, 0.926); 0.012*	W: 0.635 (0.468, 0.860); 0.003*
Age 60 to 64	M: 1.32 (1.04, 1.67)	N: 0.795 (0.570, 1.11); 0.178	S: 0.973 (0.737, 1.29); 0.850	W:0.939 (0.685, 1.29); 0.695
Age 65 to 69	M: 1.22 (0.915, 1.64)	N: 0.753 (0.510, 1.11); 0.154	S: 0.944 (0.680, 1.31); 0.731	W: 1.06 (0.736, 1.54); 0.743
Age ≥ 70	M: 1.58 (1.33, 1.87)	N: 0.603 (0.471, 0.772); < 0.001*	S: 0.865 (0.704, 1.06); 0.170	W: 0.740 (0.584, 0.940); 0.013*



C: 2013 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.190 (0.139, 0.260)	N: 0.603 (0.356, 1.02); 0.061	S: 0.859 (0.589, 1.25); 0.432	W: 0.983 (0.677, 1.43); 0.927
Age 25 to 29	M: 0.177 (0.132, 0.237)	N: 0.777 (0.491, 1.23); 0.283	S: 1.09 (0.775, 1.54); 0.614	W: 1.05 (0.739, 1.50); 0.777
Age 30 to 34	M: 0.253 (0.193, 0.332)	N: 0.849 (0.558, 1.29); 0.445	S: 0.850 (0.609, 1.19); 0.338	W: 0.937 (0.667, 1.32); 0.708
Age 35 to 39	M: 0.298 (0.228, 0.389)	N: 0.968 (0.659, 1.42); 0.867	S: 0.819 (0.602, 1.11); 0.205	W: 0.793 (0.576, 1.09); 0.155
Age 40 to 44	M: 0.433 (0.341, 0.549)	N: 0.832 (0.579, 1.20); 0.320	S: 0.768 (0.587, 1.00); 0.054	W: 0.972 (0.727, 1.30); 0.850
Age 45 to 49	M: 0.556 (0.441, 0.702)	N: 0.732 (0.522, 1.03); 0.070	S: 0.940 (0.716, 1.23); 0.658	W: 0.817 (0.609, 1.10); 0.177
Age 50 to 54	M: 0.946 (0.753, 1.19)	N: 0.777 (0.568, 1.06); 0.115	S: 0.796 (0.613, 1.03); 0.087	W: 0.761 (0.572, 1.01); 0.061
Age 55 to 59	M: 1.14 (0.921, 1.42)	N: 0.687 (0.507, 0.931); 0.016*	S: 0.820 (0.639, 1.05); 0.120	W: 0.892 (0.679, 1.17); 0.410
Age 60 to 64	M: 1.33 (1.06, 1.69)	N: 0.699 (0.481, 0.930); 0.017*	S: 0.885 (0.679, 1.15); 0.363	W: 0.904 (0.677, 1.21); 0.492
Age 65 to 69	M: 1.03 (0.815, 1.31)	N: 0.852 (0.605, 1.20); 0.358	S: 1.07 (0.817, 1.41); 0.613	W: 1.21 (0.904, 1.63); 0.199
Age ≥ 70	M: 1.32 (1.13, 1.55)	N: 0.818 (0.655, 1.02); 0.077	S: 0.942 (0.780, 1.14); 0.540	W: 1.00 (0.812, 1.23); 0.991



D: 2017 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.234 (0.173, 0.317)	N: 0.840 (0.525, 1.34); 0.486	S: 0.650 (0.451, 0.938); 0.021*	W: 0.838 (0.566, 1.24); 0.378
Age 25 to 29	M: 0.286 (0.219, 0.375)	N: 0.519 (0.332, 0.810); 0.003*	S: 0.813 (0.587, 1.12); 0.211	W: 0.843 (0.583, 1.22); 0.366
Age 30 to 34	M: 0.279 (0.216, 0.361)	N: 0.796 (0.540, 1.17); 0.251	S: 0.708 (0.520, 0.965); 0.029*	W: 0.892 (0.617, 1.29); 0.542
Age 35 to 39	M: 0.353 (0.272, 0.458)	N: 0.743 (0.488, 1.13); 0.166	S: 1.03 (0.759, 1.39); 0.861	W: 0.693 (0.495, 0.970); 0.033*
Age 40 to 44	M: 0.532 (0.411, 0.689)	N: 0.719 (0.479, 1.08); 0.112	S: 0.781 (0.578, 1.05); 0.107	W: 0.690 (0.492, 0.966); 0.031*
Age 45 to 49	M: 0.691 (0.538, 0.887)	N: 0.736 (0.505, 1.07); 0.112	S: 0.767 (0.575, 1.02); 0.072	W: 0.902 (0.653, 1.25); 0.532
Age 50 to 54	M: 1.06 (0.838, 1.34)	N: 0.747 (0.529, 1.06); 0.098	S: 0.813 (0.617, 1.07); 0.144	W: 0.645 (0.472, 0.883); 0.006*
Age 55 to 59	M: 1.23 (0.983, 1.53)	N: 0.788 (0.566, 1.10); 0.159	S: 0.747 (0.577, 0.967); 0.027*	W: 0.786 (0.583, 1.06); 0.114
Age 60 to 64	M: 1.28 (1.03, 1.59)	N: 0.877 (0.643, 1.20); 0.407	S: 0.833 (0.650, 1.07); 0.151	W: 0.989 (0.742, 1.32); 0.940
Age 65 to 69	M: 1.36 (1.10, 1.68)	N: 0.886 (0.646, 1.22); 0.453	S: 0.809 (0.629, 1.04); 0.100	W: 0.851 (0.642, 1.13); 0.262
Age ≥ 70	M: 1.62 (1.40, 1.87)	N: 0.843 (0.684, 1.04); 0.110	S: 0.741 (0.624, 0.881); < 0.001*	W: 0.816 (0.669, 0.995); 0.044*

Figure 4.7: Geofacet plots of the prevalence (%) (standard error) of joint symptoms (pain, aching, or stiffness) in US residents within the previous 30 days, by age category according to the National Health Interview Survey (NHIS), across years 2005 (A), 2009 (B), 2013 (C), and 2017 (D)

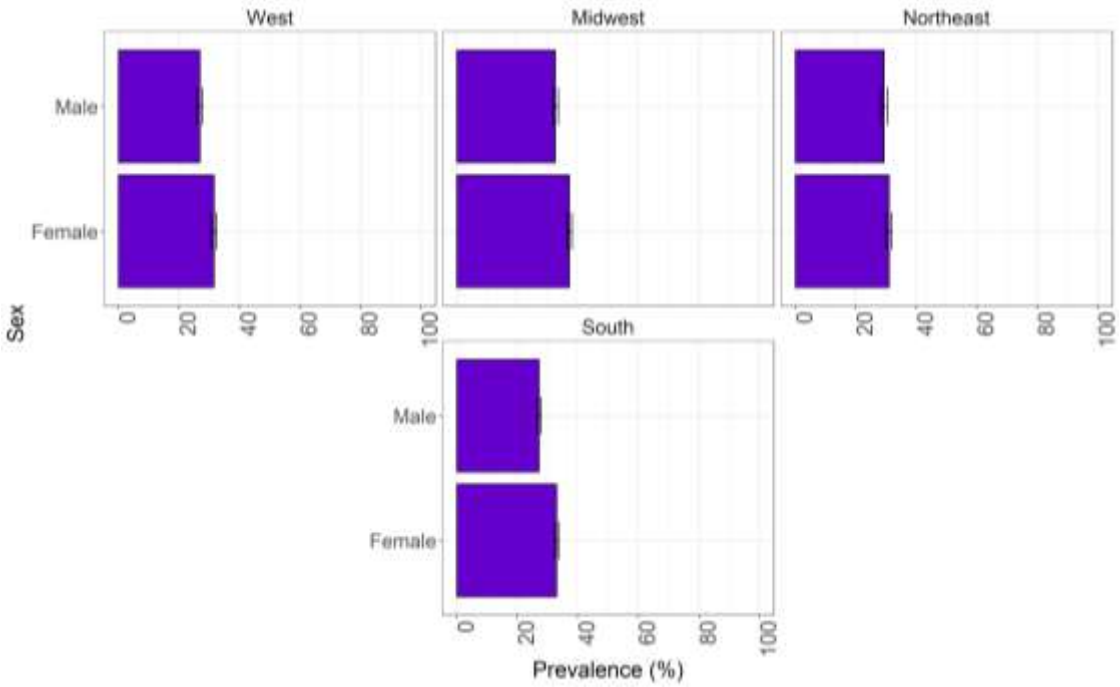
Legends per year contain the first letter of each region (where M is the Midwest, N is the Northeast, S is the South, and W is the West), OR (95% CI) (odds ratio (95% confidence interval)), and corresponding P-value (*significant), for each year in question

4.2.3 Region-specific prevalence of joint symptoms by sex

Various painful arthropathies have previously been associated with sex, where females tend to report more painful arthropathies compared to males (Kvien *et al.*, 2006; Barnabe *et al.*, 2012; Maynard *et al.*, 2020). I, therefore, calculated the prevalence of US residents who reported joint symptoms within the previous 30 days, after applying appropriate design weights, in males and females; in order to observe whether these sex-specific differences in prevalence statistics were consistent across all US regions. Thereafter, I also did annual age-adjusted logistic regressions, where the comparator group was Midwestern residents for the sex in question, to establish whether regional residence was associated with joint symptoms, in each sex individually. A table of weighted statistics [prevalence (95% confidence interval), odds ratio (95% confidence interval), and p-value] by sex for each region, in each year analysed, can be found in Appendix L (Tables XIII and XIV). Overall, Midwestern residents had significantly more joint symptom reports compared to all other regions in both sexes, consistently across time.

Across all years, Midwestern males reported significantly more joint symptoms compared to Northeastern and Southern males. Furthermore, with only five years' worth of exceptions (2007, 2009, 2012, 2013 and 2018), Midwestern males also reported significantly more joint symptoms compared to Western males (Figure 4.8).

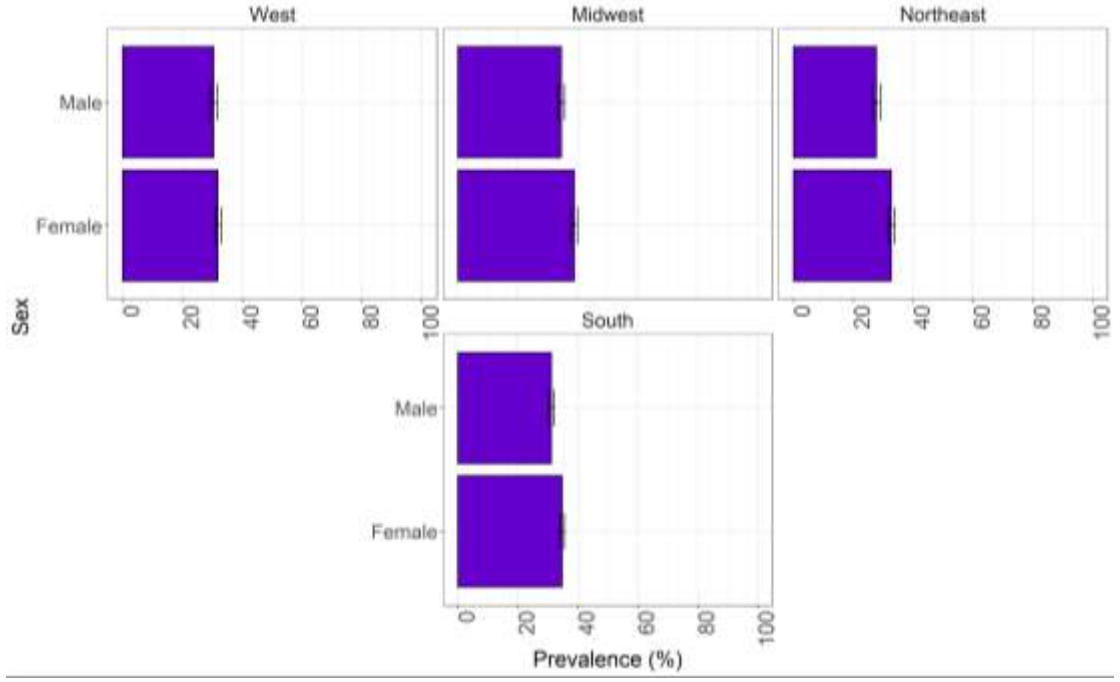
In females, Midwestern residents reported significantly more joint symptoms compared to Northeastern residents in every year, except 2007. Furthermore, Midwestern females reported significantly more joint symptoms compared to Southern females (except for 2007, 2008, 2013 and 2016). Likewise, Midwestern females reported significantly more joint symptoms than Western females (except for 2007, 2012 and 2013) (Figure 4.8).



A: 2005 - *OR (95% CI), p-value*

Male M: 0.185 (0.150, 0.227); N: 0.759 (0.660, 0.872), < 0.001*; S: 0.754 (0.673, 0.844), < 0.001*; W: 0.743 (0.653, 0.846), < 0.001*

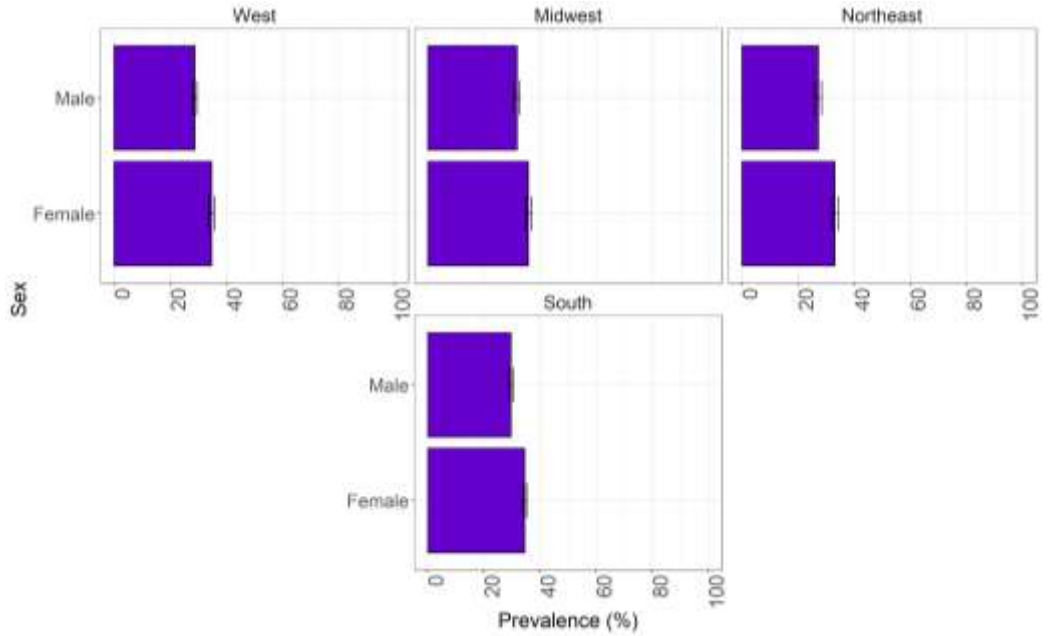
Female M: 0.210 (0.176, 0.252); N: 0.697 (0.620, 0.785), < 0.001*; S: 0.810 (0.734, 0.895), < 0.001*; W: 0.773 (0.689, 0.867), < 0.001*



B: 2009 - *OR (95% CI), p-value*

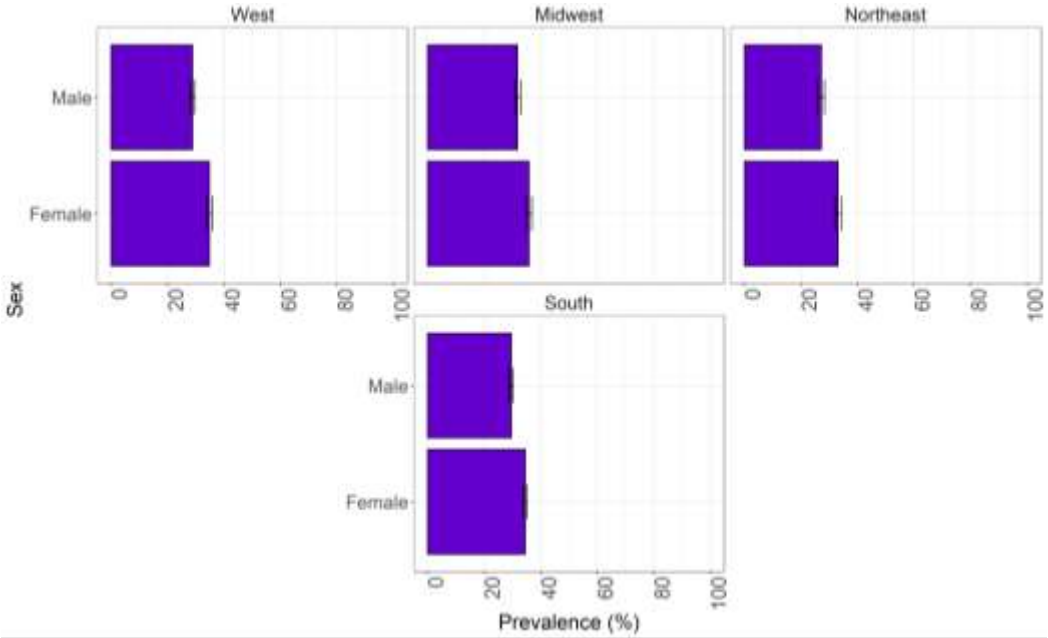
Male M: 0.221 (0.176, 0.277); N: 0.670 (0.594, 0.825), < 0.001*; S: 0.863 (0.758, 0.982), 0.026*; W: 0.841 (0.726, 0.973), 0.020*

Female M: 0.190 (0.154, 0.234); N: 0.702 (0.608, 0.811), < 0.001*; S: 0.828 (0.735, 0.932, 0.002*; W: 0.717 (0.627, 0.821), < 0.001*



C: 2013 - *OR (95% CI), p-value*

Male	M: 0.151 (0.121, 0.189); N: 0.736 (0.632, 0.857), < 0.001*; S: 0.860 (0.759, 0.975), 0.018*; W: 0.776 (0.680, 0.886), 0.080
Female	M: 0.180 (0.146, 0.221); N: 0.805 (0.699, 0.927), 0.003*; S: 0.911 (0.816, 1.02); W: 0.961 (0.852, 1.08), 0.518



D: 2017 - *OR (95% CI), p-value*

Male	M: 0.178 (0.143, 0.222); N: 0.750 (0.612, 0.876), < 0.001*; S: 0.735 (0.651, 0.830), < 0.001*; W: 0.780 (0.681, 0.894), 0.002*
Female	M: 0.218 (0.176, 0.270); N: 0.816 (0.710, 0.939), 0.004*; S: 0.832 (0.744, 0.930), 0.001*; W: 0.834 (0.734, 0.947), 0.005*

Figure 4.8: Geofacet plots of the prevalence (%) (standard error) of joint symptoms (pain, aching, or stiffness) in US residents within the previous 30 days, by sex, according to the NHIS, in 2005 (A), 2009 (B), 2013 (C), and 2017 (D)

Legends per year contain the first letter of each region (where M is the Midwest, N is the Northeast, S is the South, and W is the West), OR (95% CI) (odds ratio (95% confidence interval)), and corresponding P-value (*significant), for each year in question

SECTION 1 DISCUSSION

Geospatial trends of painful arthropathies using the BRFSS and NHIS surveys

Summary of findings

Using the Behavioural Risk Factor Surveillance System (BRFSS), I calculated the weighted prevalence of rheumatic disorder diagnoses per state. I then assigned the prevalence measurements to their state geographical zone and conducted a Global Moran's I to assess whether there was a spatial correlation between state rheumatic disorder diagnosis prevalence. Overall, a median of around one in four people have a diagnosed rheumatic disorder across all US states. Furthermore, there was a weak positive spatial correlation between diagnosed rheumatic disorders and state, meaning that states closer together tend to have similar prevalence measurements.

I then repeated these analyses for various age groups [age range (in years) 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. In the youngest adult age groups (adults up to their late thirties), diagnosed rheumatic disorder prevalence is generally low across the US, and there was little (weak positive correlation in some years, but not so in others) to no spatial correlation between state prevalence estimates. In middle-aged adults (from their early forties until their late fifties), there was a weak to moderate spatial correlation between diagnosed rheumatic disorders and state, where states closer together had similar prevalence measurements. As the general population aged, the prevalence of rheumatic disorder diagnosis was high across all US states (although there is still a range of values between states), and there was some weak spatial correlation, but it was not as uniform and consistent in comparison with middle-aged adults.

I repeated the prevalence calculations and Global Moran's I on males and females by state. In males, there was a weak positive spatial correlation between state and rheumatic disorder diagnosis, where states closer together had similar prevalence estimates. The same result was true for females, although the prevalence of diagnosed rheumatic conditions was higher in females across states.

States with high prevalence estimates of diagnosed rheumatic conditions are largely consistent in the overall population groups, and within demographic sub–groups, as well as across time, such that the same states frequently appeared at the upper and lower limits of prevalences, irrespective of the demographic group in question. West Virginia, in particular, had very high prevalence measurements of diagnosed rheumatic conditions compared to other states. This was true in every demographic group and every year of analysis. Other states consistently high in diagnosed rheumatic conditions included Alabama, Kentucky, Maine, Tennessee, Mississippi, Arkansas and Michigan. Michigan is an outlier by geography, given that it is found in the northeastern Midwest. The remaining states with high prevalence measurements are mostly close together, often bordering each other in the eastern and southeastern area of the US, namely in Appalachia and the Mississippi Valley.

States with low prevalence estimates of diagnosed rheumatic disorders are also generally consistent across demographic groups, with the exception of an odd state, which varied over time, appearing in a particular demographic group (the details of these odd states can be found in Appendix K, Tables I to XVI). Although certain states/territories consistently appear at the lower limit (Hawaii, California, Arizona, Texas, Minnesota, Utah, the District of Columbia, and Puerto Rico), other states make random appearances more frequently compared to random state appearances at the upper limit. As one would expect, the consistency of states is far less in younger age groups (as only a small percentage of young people have a rheumatic condition diagnosis). Texas notably appeared at the lower prevalence limit for males, but not females; and Minnesota was at the lower limit specifically in older age groups.

Thereafter, using the National Health Interview Survey (NHIS), I calculated the weighted prevalence of people who reported having experienced joint symptoms in the 30 days prior to participating in the survey interview, per US region. I then conducted logistic regressions to ascertain whether a particular region was associated with having joint symptoms. Overall, residing in the Midwest was associated with increased joint symptom reports compared to residing in the Northeast, South or West.

I repeated these analyses for the various age groups [age ranges (in years) 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. Across age groups, the prevalence of joint symptoms increased across all regions in older people,

but was generally higher in the Midwest. Furthermore, Midwestern residents sometimes had significantly higher reports of joint symptoms compared to other three regions, although not always consistently. Raised prevalences in the Midwest were not always consistent across all the age groups. If there was a significant difference between regions, it was often the Northeast that was significantly lower in joint symptom reports than the Midwest. I repeated these analyses on the sexes, and the Midwest generally had significantly higher joint symptom prevalences compared to other regions in both sexes, aligning with the result from the general population.

Geospatial trends of prevalence of painful arthropathies in the US

A geospatial analysis of rheumatic conditions of this magnitude and over this amount of time has not previously been conducted. The BRFSS does have a Geographic Information System (GIS) mapping facility online where spatial data on multiple disease outcomes are available to users for download (the SMART facility). Furthermore, the BRFSS spatial data with reference to doctor-diagnosed arthritis has been published in the CDC's *Morbidity and mortality weekly report surveillance summaries* in multiple years, but in separate reports. The median state-based arthritis prevalence in 2014 was also 24% (Barbour *et al.*, 2016b), as was the case with my own findings in that around a quarter of US residents had a doctor-diagnosed rheumatic condition. Furthermore, as is the case for my findings, state data are not consistent, and present a range of different prevalences, between 15.8% and 38.6% (Barbour *et al.*, 2016b). What is shown by my research however, is the consistency across time of these prevalence statistics. Research from later years also indicated a state-specific range of arthritis diagnoses (Boring *et al.*, 2017). Furthermore, other reports from the surveillance summaries across multiple years have all concluded that there is a geospatial range of prevalences of multiple diseases and conditions across US states, including doctor-diagnosed arthritis (Chowdhury *et al*., 2010; Gamble *et al.*, 2017; Barbour *et al.*, 2018).

In light of the range of state-specific prevalences of painful rheumatic disorders, the states frequently found in the upper quartiles of arthritis prevalence include West Virginia, Alabama, Arkansas, Michigan, Missouri, Tennessee and Kentucky, both in my research and research reported by others (CDC, 2007; Barbour *et al.*, 2016b; 2018; Gamble *et al.*, 2017; Guglielmo *et al.*, 2019). The Mississippi Valley and Appalachian areas have been identified as arthritis

hotspots (CDC, 2007; Guglielmo *et al.*, 2019). The Mississippi Valley is also a hotspot in my own research, overlapping with my findings on high prevalences in Missouri, Arkansas, Kentucky, and Tennessee, which are found along the Mississippi Valley region. Likewise, Appalachia is also a hotspot for rheumatic disorder diagnoses, aligning with my findings of high prevalences in Alabama, Kentucky, Mississippi, Pennsylvania, Tennessee, and West Virginia, all of which make up parts of the Appalachian region. Notably, previous research established that elevated prevalence of rheumatoid arthritis is increased by the inhalation of pollutants, particularly silica, and osteoarthritis may be the result of heavy labour in the labour-intensive forms of work located in these regions (Blanc *et al*., 2018; Schmajuk *et al.*, 2019). Appalachia is well-established as a coal mining area of the USA, and research has linked the elevated prevalence of arthritis in the coal mining counties of the USA (specifically Appalachia) to the inhaled mineral dust and work-related coal exposure of the mining industry (Blanc *et al*., 2018; Schmajuk *et al.*, 2019). An alternative hypothesis regarding the increased prevalence of arthritis diagnoses in the Appalachian region is related to socioeconomic status. Unemployment rates in the majority of Appalachia are higher than the national average, while per capita income, average earnings, per capita investments, and education levels are lower than national averages (Herath and Brown, 2013). While the socioeconomic correlation with arthritis could well be playing a role, so too does the general health status of the population: the region reports higher rates of serious disease and mortality compared to national averages, and 44% of the population is obese (Herath and Brown, 2013). Socioeconomic factors (Herath and Brown, 2013) as well as obesity (Herath and Brown, 2013; Barbour *et al.*, 2018) are associated with higher prevalence estimates of arthritis.

States and regions at the lower quartile of arthritis prevalence included Hawaii and the District of Columbia (CDC, 2007; Guglielmo *et al.*, 2019). Furthermore, the CDC's surveillance summaries on the 2014 and 2015 confirm my findings of low arthritis prevalences in California, Minnesota, and Texas (Barbour *et al.*, 2016b; 2018; Gamble *et al.*, 2017). The value in knowing which states have low arthritis prevalence estimates lies in ascertaining whether there are differences in disease states, demographics, lifestyle habits, health policies, or state health funding in these states compared to states with high prevalences of rheumatic disorders. In this way, patterns on demographics, lifestyle habits, health policies and funding (all of which affect health-related

outcomes) of states low in rheumatic disorders may be used as a starting block for intervention programmes.

The diversity of prevalence measurements for various diseases in various states means that different states should prioritise health outcomes that are applicable to their state within their health policies and budgets. Arthritis is the leading cause of disability in US adult residents (CDC, 2007). Given the rippling costs associated with arthritis, including the direct healthcare costs as well as indirect costs such as lost productivity at work, early exit from work, disability grants, and reduced health-related quality of life (Barbour *et al.*, 2014; Storheim and Zwart, 2014; Salmon *et al.*, 2016; Hsieh *et al.*, 2020), and other comorbidities and unhealthy lifestyle habits, spatial analysis is essential to knowing how and where to apply funding and policies. Indeed, research suggests that states with increased estimates of arthritis also had more arthritis-attributable activity limitations and joint pain, physically and mentally unhealthy days, obesity, and less physical activity (CDC, 2007; Boring *et al.*, 2017; Barbour *et al.*, 2018). Furthermore, research has shown that, in middle-aged and older adults, the prevalence of falls and fall injuries is high in adults with arthritis (Gaino *et al.*, 2019) in all states (Barbour *et al.*, 2014). In particular, states with one or more falls in the past 12 months included Kentucky, Mississippi, Alabama, and Missouri, all of which have high prevalences of a rheumatic disorder diagnoses (Barbour *et al.*, 2014). All of the above are harmful to health and wellbeing, and costly to individuals and societies. Therefore, states with increased prevalence of arthritis could well have a decrease in the overall wellbeing of its residents, based on the negative effects of the aforementioned aspects of health, and how they negatively affect overall health-related quality of life. Positive outcomes have been obtained from intervention programmes, including community-based physical activity workshops as well as encouraging the population to consume healthier food and smoke less (Kelley *et al.*, 2011). Specifically, and crucially, these community-based programmes have shown much promise within the context of pain relief (Kelley *et al.*, 2011). Therefore, the range of prevalence estimates across states is crucial to identifying how to implement funding and interventions.

Spatial disparities in disease outcomes (including arthritis) is not unique to the USA. Other countries that have conducted spatial trend-based research, and found significant spatial disparities include Turkey (İnanır *et al.*, 2013), Mexico (Moreno-Montoya *et al.*, 2015),

Canada(Cañizares *et al.*, 2008), Finland (Kaipiainen-Seppänen, Aho and Nikkarinen, 2001), South Africa (Kamerman *et al*., 2020) and the United Kingdom (Hawley *et al.*, 2020). Furthermore, geographical trend disparities have also been found on a global scale, where spatial trends have been established specifically for arthritis (Rudan *et al.*, 2015). Ethnic and cultural differences have been cited as potential reasons for regional disparities in arthritis prevalences (Moreno-Montoya *et al.*, 2015), however, socio-economic factors are also mentioned independently of, but also linked to, ethnic or cultural origin (Rudan *et al.*, 2015). Environmental effects have also been cited as a reason for spatial disparities. Temperature extremes, lower altitude, increased water vapour pressure, southwestern residence (specific to Turkish geography), and distance to the sea have all been reported to have significant impacts on rheumatoid arthritis (İnanır *et al.*, 2013). The Turkish model however did not account for human influence (for example, anthropometric, demographic, socioeconomic, and pollution-related factors). The potential effect of environmental conditions therefore remains a potentially important approach to geospatial disparities in painful arthropathies, including in the US context where the size and diversity of the landscape could also be contributing to disease outcomes in the population. The potential effect of climatic conditions suggests that changes may even start to be seen in the prevalence and burden of rheumatic disorders and symptoms thereof with the progression of climate change. Macroscopically, there is also a country-based disparity in arthritis prevalence (Rudan *et al.*, 2015), and North America and Northern Europe have significantly higher arthritis (specifically, rheumatoid arthritis) compared to Southern Europe and developing countries (Alamanos, Voulgari and Drosos, 2006). As a country with high painful arthropathy statistics, it is important for the US to address the corresponding burden, which could potentially be streamlined by having an understanding of geographical distribution of painful arthropathies.

Geospatial trends of prevalence of painful arthropathies in the US by age and sex

Whilst CDC surveillance reports have given context on geospatial trends within the context of health and health-related behaviours, it does not give us information on the prevalence of arthritis in various demographics and the spatial trends thereof. The geospatial analyses of demographic (age and sex) divisions may be the most novel offering of this thesis, as, to my

knowledge, no other literature this extensive about the spatial and time trends in rheumatic disorders, and joint symptoms (particularly in the context of age and sex), exists. It is known that older men from around 50 years of age in Appalachia are more affected by coal mine work-related arthritis (Blanc *et al*., 2018; Schmajuk *et al.*, 2019). Likewise, research done on women has found that those women living in the Midwest have previously had an increased risk of rheumatoid arthritis compared to states in the Northeast (Costenbader *et al.*, 2008). Indeed, the demographic spatial trends is an area of suggested future research. Future research should continue to look at arthritis in different demographic groups within the context of geography. For example, arthritis diagnoses tend to increase with age, therefore states with slightly older populations may have a higher burden of arthritis compared to states with younger populations.

In the case of my research, the prevalence of rheumatic symptoms was higher in states where the population was older (for example, West Virginia, Arkansas, Tennessee, and Kentucky), and lower in states where the population was younger (for example, Utah and Texas). While it is true that, after being broken down into various age and sex groups, the same states and regions emerged as hotspots for arthritis and joint symptoms, there is little doubt that an older population will increase rheumatic symptom-related burdens on individuals, health systems, and society. Thus, states and regions with higher proportions of the elderly and rheumatic disorders will push up state and regional prevalences, as is the case with West Virginia, Kentucky, Arkansas, and Tennessee. Another aspect of age-related arthritis research should aim to establish whether, within a geospatial context, certain demographic groups (by sex and perhaps race/ethnicity) are developing arthritis at a younger age compared to other demographic groups. Establishing these trends will also assist in refining intervention programmes, and make them more applicable to the groups needing the intervention.

Limitations and section conclusion

My analysis was not without limitations. Although other geospatial research on arthritis is limited (and virtually non-existent for the demographic specifics), what research is available has shown that the spatial differences are not only at the inter-state level, but also at the inter-county level. In particular, Arizona, New Mexico, Nevada, and Colorado have distinct and stark inter-county differences within the respective states (Boring *et al.*, 2017; Barbour *et al.*, 2018),

suggesting that – even within states – there may be further and more intricate differences in various areas. However, these data are not within the scope of this thesis, but ideally should be addressed by the health authorities within each state, as the intra-state disparities would be detrimental to the health system resources within that state. Furthermore, some research has suggested that there may be a rural/urban trend, where rural residence predicted higher arthritis prevalence in US adults older than 45 years old (Lutfiyya *et al.*, 2013). Therefore, county level analyses should be looked at across time and demographic groups. My state-based analysis, based on the BRFSS, found an arthritis hot spot in Appalachia (including states West Virginia, Kentucky, Tennessee, Arkansas, Mississippi, Alabama, Michigan and Pennsylvania). However, Appalachia crosses US regional boundaries, therefore making a regional analysis more limited. Given that the NHIS interview asked about "joint symptoms", as opposed to a diagnosed rheumatic condition (BRFSS), it is unfortunate that I do not have the same geospatial rigour (state-based prevalence data and not only regional data) in order to compare the surveys; particularly as the missing link may align with healthcare seeking behaviour or access to healthcare. The BRFSS weighting methods have been refined over time, and have improved since 2011, making data pre- and post-2011 impossible to compare. Finally, only one data point per state was available in order to calculate the Global Moran's I, as the only means of obtaining appropriately weighted data for the Global Moran's I analysis was to use overall weighted prevalences. It would, of course, have been better to have been able to use the whole weighted dataset, which was not possible due to not being able to conduct spatial correlation analyses on design objects.

Despite evidence to suggest that geospatial distributions of rheumatic diseases vary, geospatial research on rheumatic disorders is very limited, and the demographic trends thereof entirely novel. Thus, the geospatial work in this thesis offers a novel outlook on the current spatial trends, as well as the trajectories of spatial trends, due to the extensive timeframe analysed. The cost of painful arthropathies is high, both to the individual and society. States with higher prevalence rates could face greater socioeconomic burdens due to lowered workplace productivity, as well as due to other effects on overall health outcomes. To compound this burden, not all demographic groups experience the same burden of rheumatic disorders. States with different demographic compositions should also consider the way in which painful arthropathy prevalences are linked to the demographic composition of the state. Designing health policies

that are more direct and refined in their approach geographically may offer some reprieve to the burden. In light of this, the geospatial findings of this thesis could hopefully assist greatly in offering direction to the refining of federal and state governmental healthcare decisions, and consequently help those who are struggling with painful arthropathies.

SECTION 2: GEOSPATIAL TRENDS OF LOW BACK PAIN

Chapter One of this thesis highlighted the dearth of geospatial data on musculoskeletal pain, including low back pain. The Global Burden of Disease Study 2017 showed the prevalence of low back pain globally, where various countries had different prevalences of low back pain (Wu *et al.*, 2020). However, no research has assessed the potential differences of low back pain prevalence within and across the US. Although some CDC reports are available, these data are often a snapshot, and do not provide context on whether or not geospatial discrepancies of musculoskeletal pain prevalences stand the test of time.

Furthermore, low back pain has previously been associated with age (Maher, Underwood and Buchbinder, 2017) and sex (Wu *et al.*, 2020). Therefore, geospatial trends within these specific demographic groups may in fact exist, but is not being addressed by the current research available. Section 2 of this chapter thus aimed to address my second thesis objective: to establish the spatial trends in the prevalence of low back pain.

The National Health Interview Survey (NHIS) releases data on regional (Midwest, Northeast, South, and West) residence, as well as records data on age and sex. Furthermore, the NHIS surveys low back pain within the previous three months. Using NHIS data, I calculated the prevalence of low back pain across regions; as well as the prevalence of low back pain within age groups, and between sexes, by region.

4.3 National Health Interview Survey (NHIS)

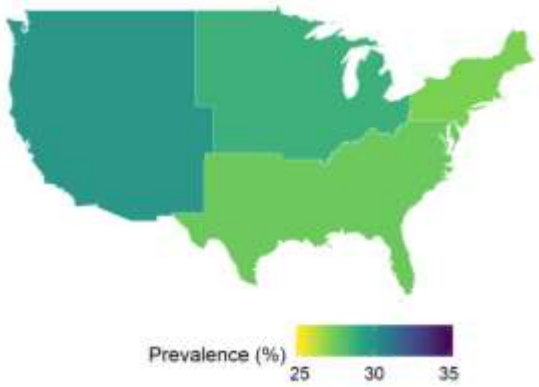
The National Health Interview Survey provided spatial data by US region, namely: Midwest, Northeast, South, and West. A US map containing the US states and corresponding regions can be found at the front of this thesis. The prevalence of US residents who reported having low back pain in the three months prior to taking the NHIS Sample Adult Questionnaire was calculated (after appropriate design weights were applied) as the proportion of people who answered “Yes” to the question, “DURING THE PAST THREE MONTHS, did you have low back pain?”. Overall prevalences were calculated across years 1997 until 2018, with the exception of 2004, where stratum data was unavailable to compose a design object. To illustrate these data, I made

choropleth maps by US region on order to show the prevalence of low back pain within the previous three months for each year of analysis. Maps for every four years (1997, 2001, 2005, 2009, 2013, and 2017) are shown in this chapter, while the remaining maps for all other years are available in GitHub (https://github.com/AnneIoannides/NHIS_Musculoskeletal-Pain/tree/master/LBP%20Figures). After prevalence was obtained, annual logistic regressions were done to establish whether regional residence was associated with low back pain, where the Midwest was the comparator group.

Regional maps of the US comprised of age and sex distributions in order to establish whether certain states have potential confounding population demographics are available in Figure 4.5.1 to Figure 4.5.12, (Section 1 (Painful Arthropathies), subsection 2 – NHIS (Joint Symptoms)), and on GitHub (https://github.com/AnneIoannides/NHIS_Musculoskeletal-Pain/tree/master/Geo-demographic%20distribution%20images). As a reminder, the proportions of various age and sex groups per region were not always entirely consistent across time. I established that the Northeast had a lower proportion amount of younger adults, and an increased proportion of older adults. The Midwest and West also had a higher proportion of younger people residing there compared to other regions. The country has a tendency to be younger in its western regions and older in its eastern regions. Furthermore, there are more females in the Northeast and South compared to the West (Figure 4.5.1 to Figure 4.5.12).

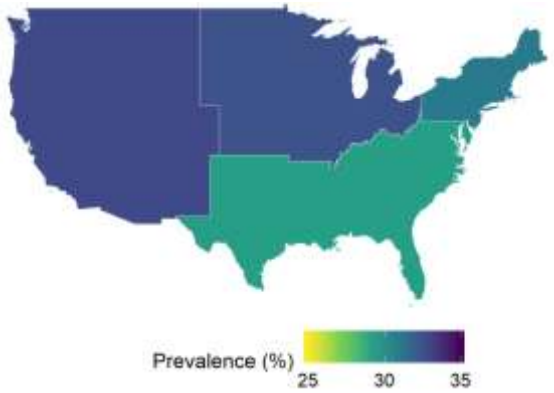
4.3.1 Region-specific prevalence of low back pain for US residents

The overall prevalence of low back pain did not show strong region-based trends. Midwestern residents reported significantly more low back pain compared to residents of the Northeast (1997, 2000, 2012, 2013, 2014, and 2016), and South (1999 to 2007, and 2014), but never more than the West. Furthermore, the prevalence of low back pain did not remain highest or lowest in any particular region over time (in the way that occurred with Midwestern residents and joint symptoms). Some regions have a small number of years where the prevalence is ranked lowest or highest (for example, the South had the lowest low back pain prevalence from 1998 until 2008, but thereafter was less consistent; likewise, the Midwest and West interchangeably had the highest prevalences of low back pain) (Figure 4.9). A table of weighted prevalence (95% confidence interval), odds ratio (95% confidence interval) and p-value for each region, in each year analysed, can be found in Appendix M, Table I.



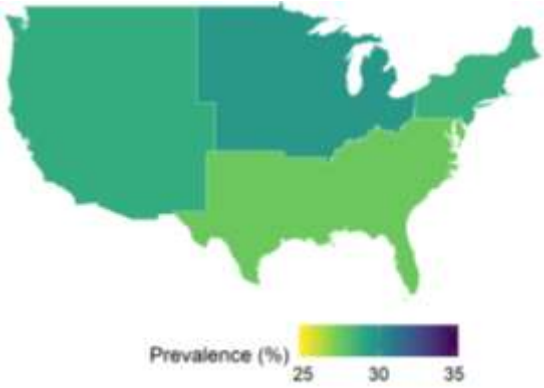
A: 1997 - *WP [ε] (95% CI); OR (95% CI); p-value*

M: 28.6 (27.5, 29.7); 0.288 (0.260, 0.319)
N: 27.1 (25.9, 28.2); 0.916 (0.846, 0.992); 0.031*
S: 27.4 (26.6, 28.3), 0.942 (0.879, 1.01), 0.086
W: 29.7 (28.5, 30.9), 1.06 (0.979, 1.14), 0.153



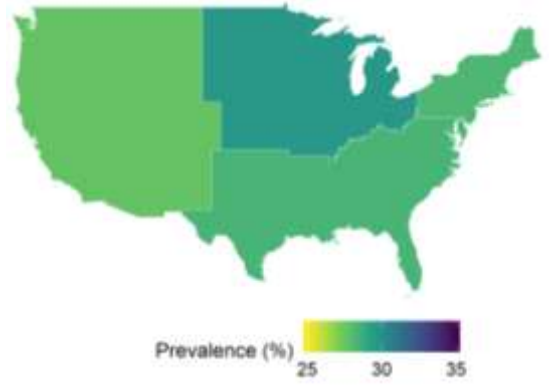
B: 2001 - *WP [ε] (95% CI); OR (95% CI); p-value*

M: 32.4 (31.2), 0.370 (0.334, 0.409)
N: 30.9 (29.6, 32.2), 0.923 (0.849, 1.00), 0.056
S: 29.4 (28.5, 30.3), 0.868 (0.808, 0.931) < 0.001*
W: 32.8 (31.5, 34.1), 1.01 (0.926, 1.10), 0.644



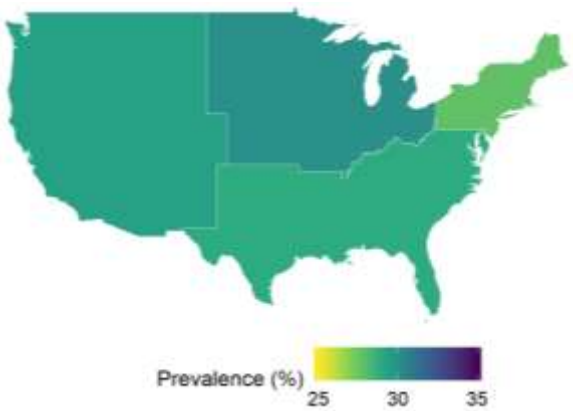
C: 2005 - *WP [ε] (95% CI); OR (95% CI); p-value*

M: 29.7 (28.5, 30.9), 0.273 (0.243, 0.306)
N: 28.7 (27.3, 30.1), 0.925 (0.846, 1.01), 0.083
S: 27.5 (26.5, 28.4), 0.896 (0.832, 0.964), 0.003*
W: 28.8 (27.5, 30.3), 0.957 (0.881, 1.04), 0.308



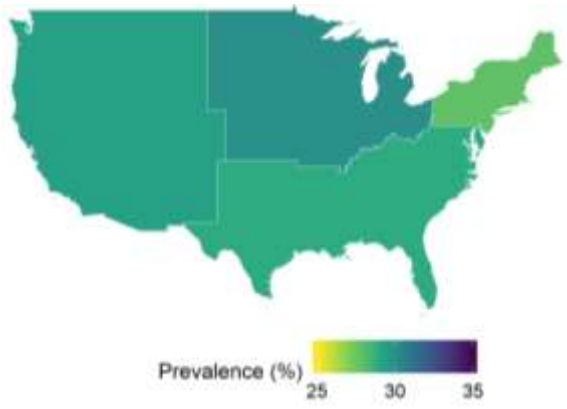
D: 2009 - *WP [ε] (95% CI); OR (95% CI); p-value*

M: 29.7 (28.3, 31.1), 0.233 (0.203, 0.268)
N: 28.3 (26.6, 29.9), 0.916 (0.823, 1.02), 0.106
S: 28.4 (27.3, 29.5), 0.943 (0.864, 1.03), 0.195
W: 27.7 (26.3, 29.1), 0.913 (0.828, 1.01), 0.068



E: 2013 - *WP [ε] (95% CI); OR (95% CI); p-value*

M: 30.0 (28.6, 31.4), 0.232 (0.202, 0.267)
N: 27.8 (26.2, 29.4), 0.867 (0.781, 0.962), 0.007*
S: 28.9 (27.9, 29.9), 0.929 (0.854, 1.01), 0.085
W: 29.3 (28.1, 30.5), 0.966 (0.883, 1.06), 0.448



F: 2017 - *WP [ε] (95% CI); OR (95% CI); p-value*

M: 28.5 (27.2, 29.8), 0.201 (0.174, 0.233)
N: 28.4 (26.7, 30.1), 0.979 (0.880, 1.09), 0.704
S: 28.8 (27.7, 29.9), 1.01 (0.932, 1.10), 0.754
W: 28.8 (27.4, 30.2), 1.02 (0.929, 1.12), 0.673

Figure 4.9: Choropleth maps of the US showing the regional prevalence (%) of low back pain in US residents within the previous three months, according to the NHIS[α], in 1997 (A), 2001 (B), 2005 (C), 2009 (D), 2013 (E) and 2017 (F)

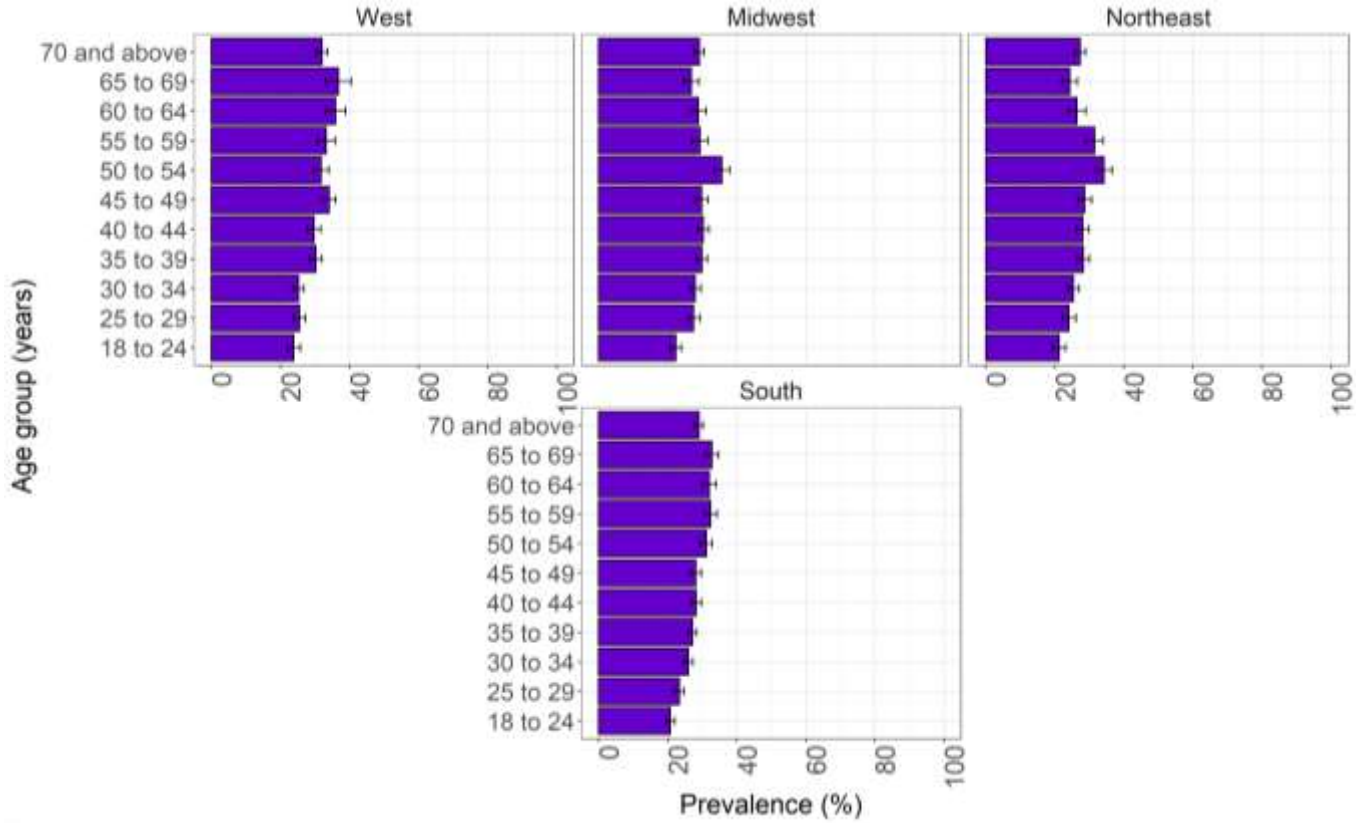
Legends per year contain the first letter of each region (where M is the Midwest, N is the Northeast, S is the South, and W is the West), WP[ε] (95% CI) (weighted prevalence per region (95% confidence interval)), OR (95% CI) (odds ratio (95% confidence interval)), and corresponding P-value (*significant), for each year in question

[α]NHIS Sample Adult Questionnaire

4.3.2 Region-specific prevalence of low back pain by age

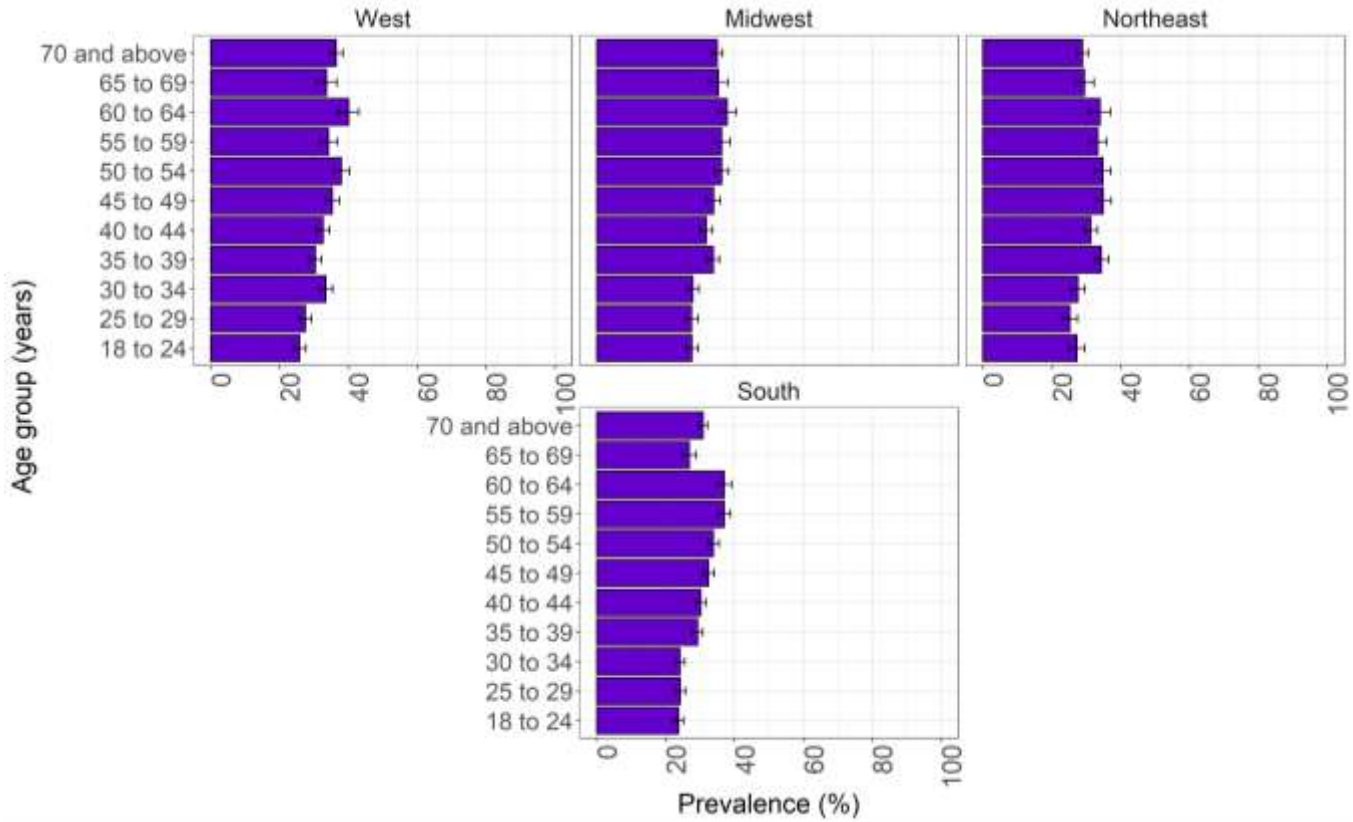
Low back pain has been previously associated with older age (Maher, Underwood and Buchbinder, 2017). Therefore, I repeated my regional analysis by age groups, namely: age 18 to 24 years, 25 to 29 years, 30 to 34 years, 35 to 39 years, 40 to 44 years, 45 to 49 years, 50 to 54 years, 55 to 59 years, 60 to 64 years, 65 to 69 years, and 70 years and above. I calculated the prevalence of US residents who reported low back pain within the previous three months, after applying appropriate design weights. I also did annual sex-adjusted logistic regressions to establish whether regional residence was associated with low back pain in each age group, where the comparator group was Midwestern residents for the age group in question.

Regional residence produced very little to no association with low back pain reports in the various age groups. In the youngest age category, the Midwest sometimes had significantly more low back pain reported compared to the Northeast and South, but this then dwindles and becomes randomised in older age groups. When one region had significantly more low back pain reported compared to other regions, it was likely due to sampling, as it occurred in random years and with random regions (Figure 4.10). A table of weighted prevalence data for each region, by age group, in each year analysed, can be found in Appendix M, Tables II to XII.



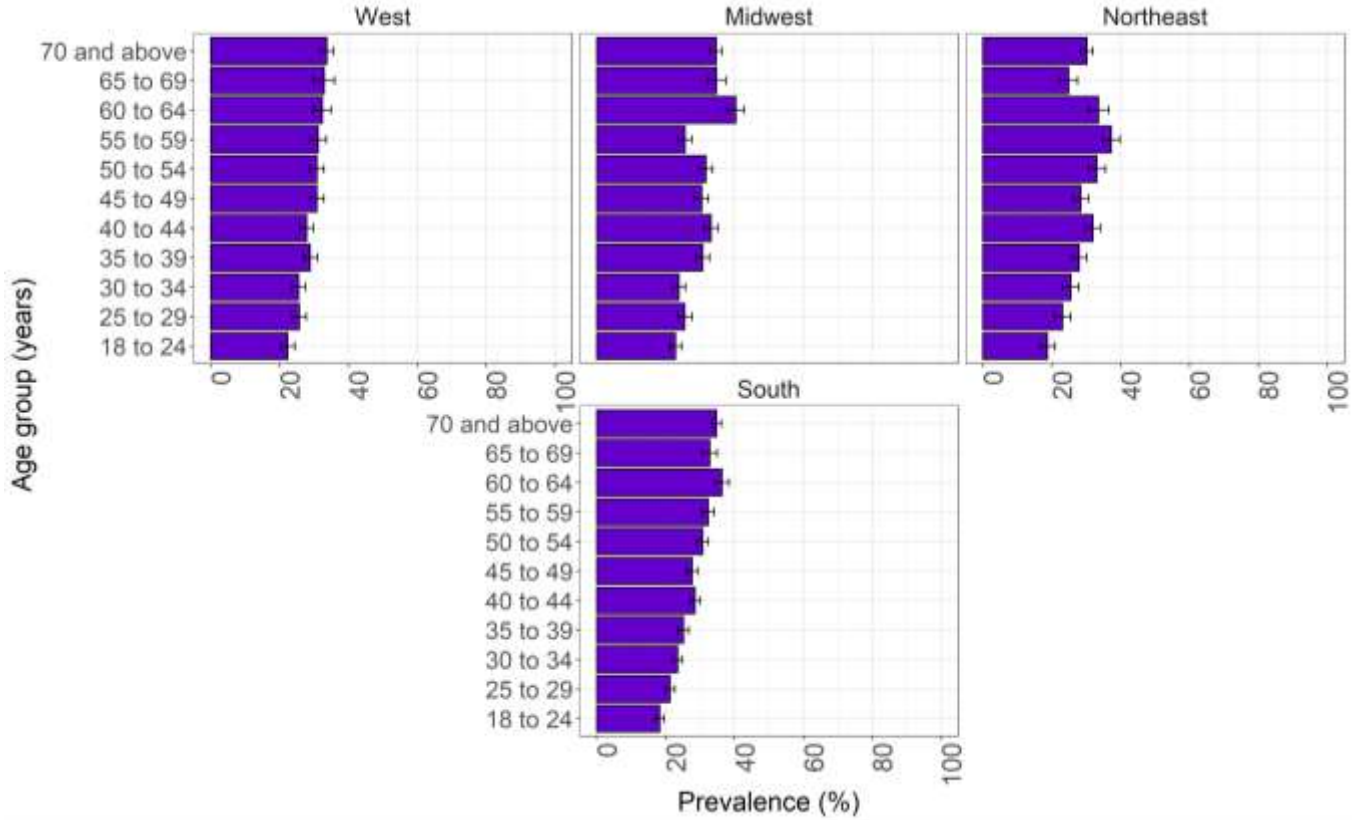
A: 1997 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.334 (0.276, 0.405)	N: 0.994 (0.711, 1.25); 0.693	S: 0.926 (0.728, 1.18); 0.530	W: 1.10 (0.834, 1.45); 0.506
Age 25 to 29	M: 0.439 (0.364, 0.529)	N: 0.828 (0.628, 1.09); 0.181	S: 0.801 (0.637, 1.01); 0.059	W: 0.901 (0.702, 1.16); 0.414
Age 30 to 34	M: 0.381 (0.319, 0.454)	N: 0.873 (0.688, 1.11); 0.265	S: 0.904 (0.731, 1.12); 0.352	W: 0.869 (0.688, 1.10); 0.236
Age 35 to 39	M: 0.425 (0.361, 0.499)	N: 0.923 (0.737, 1.16); 0.487	S: 0.895 (0.720, 1.06); 0.179	W: 1.02 (0.820, 1.27); 0.865
Age 40 to 44	M: 0.452 (0.381, 0.538)	N: 0.897 (0.710, 1.14); 0.367	S: 0.906 (0.736, 1.12); 0.353	W: 0.977 (0.771, 1.24); 0.845
Age 45 to 49	M: 0.465 (0.386, 0.561)	N: 0.943 (0.727, 1.22); 0.662	S: 0.923 (0.734, 1.16); 0.495	W: 1.22 (0.952, 1.47); 0.116
Age 50 to 54	M: 0.597 (0.484, 0.736)	N: 0.930 (0.701, 1.23); 0.615	S: 0.815 (0.637, 1.04); 0.105	W: 0.842 (0.637, 1.11); 0.227
Age 55 to 59	M: 0.402 (0.318, 0.507)	N: 1.11 (0.809, 1.52); 0.524	S: 1.15 (0.876, 1.52); 0.308	W: 1.20 (0.877, 1.64); 0.254
Age 60 to 64	M: 0.438 (0.346, 0.555)	N: 0.891 (0.634, 1.25); 0.504	S: 1.16 (0.879, 1.54); 0.290	W: 1.37 (0.988, 1.91); 0.059
Age 65 to 69	M: 0.935 (0.309, 0.504)	N: 0.864 (0.620, 1.20); 0.388	S: 1.32 (0.996, 1.75); 0.054	W: 1.56 (1.07, 2.28); 0.020*
Age ≥ 70	M: 0.464 (0.402, 0.535)	N: 0.912 (0.746, 1.12); 0.372	S: 0.998 (0.835, 1.19); 0.982	W: 1.16 (0.946, 1.42); 0.154



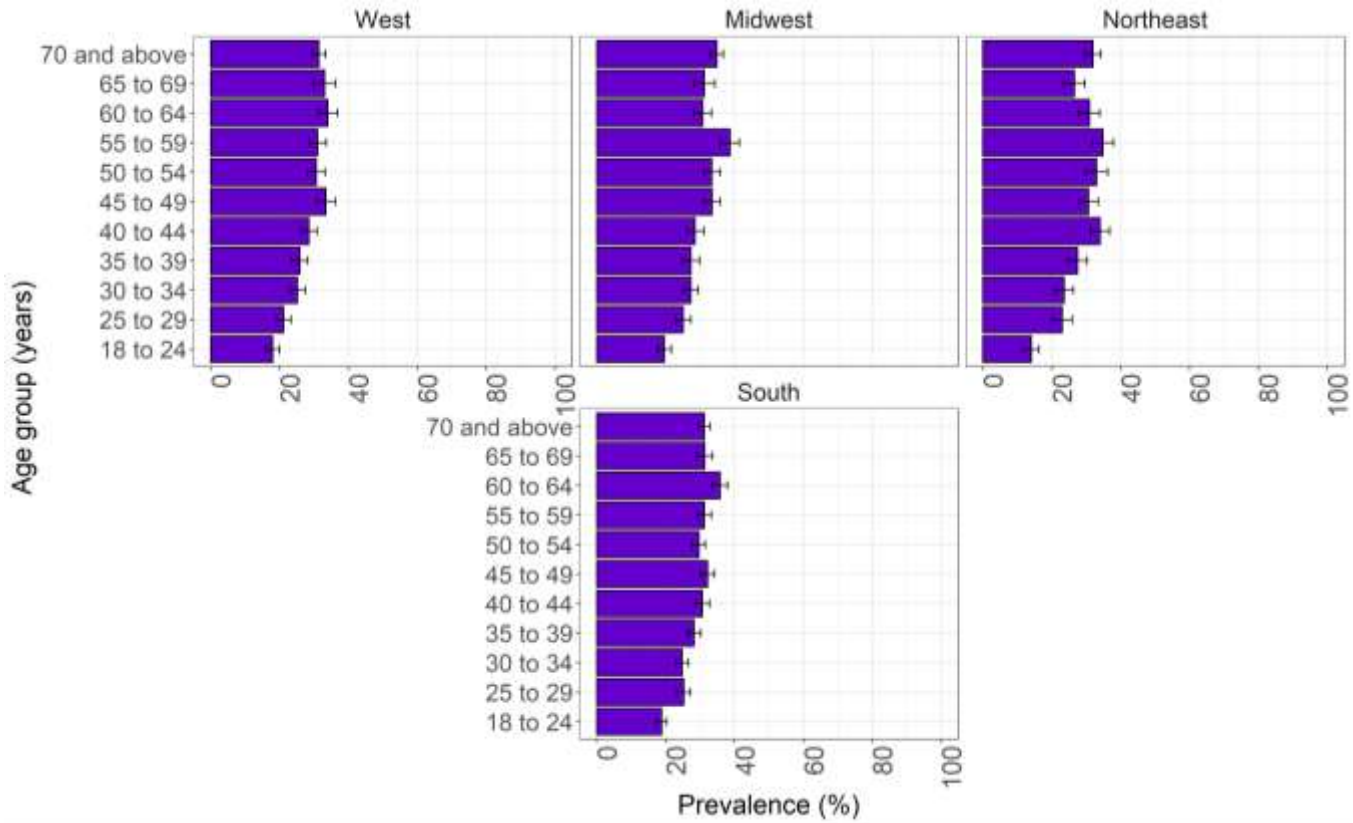
B: 2001 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.430 (0.355, 0.522)	N: 0.981 (0.738, 1.30); 0.895	S: 0.826 (0.655, 1.04); 0.109	W: 0.923 (0.710, 1.20); 0.548
Age 25 to 29	M: 0.455 (0.373, 0.556)	N: 0.880 (0.651, 1.19); 0.403	S: 0.829 (0.649, 1.06); 0.133	W: 0.992 (0.760, 1.30); 0.954
Age 30 to 34	M: 0.426 (0.353, 0.514)	N: 0.974 (0.744, 1.27); 0.845	S: 0.828 (0.657, 1.04); 0.105	W: 1.31 (1.02, 1.67); 0.033*
Age 35 to 39	M: 0.529 (0.445, 0630)	N: 1.03 (0.807, 1.31); 0.815	S: 0.813 (0.656, 1.01); 0.059	W: 0.861 (0.677, 1.09); 0.222
Age 40 to 44	M: 0.476 (0.397, 0.571)	N: 0.976 (0.765, 1.25); 0.845	S: 0.926 (0.747, 1.15); 0.482	W: 1.04 (0.817, 1.32); 0.755
Age 45 to 49	M: 0.482 (0.397, 0.584)	N: 1.05 (0.804, 1.37); 0.718	S: 0.939 (0.747, 1.18); 0.592	W: 1.07 (0.832, 1.37); 0.609
Age 50 to 54	M: 0.628 (0.518, 0.762)	N: 0.939 (0.719, 1.23); 0.643	S: 0.900 (0.717, 1.13); 0.363	W: 1.08 (0.827, 1.40); 0.581
Age 55 to 59	M: 0.608 (0.485, 0.764)	N: 0.873 (0.641, 1.19); 0.388	S: 1.03 (0.791, 1.34); 0.838	W: 0.909 (0.670, 1.23); 0.538
Age 60 to 64	M: 0.628 (0.496, 0.797)	N: 0.851 (0.603, 1.20); 0.356	S: 0.966 (0.728, 1.28); 0.809	W: 1.10 (0.798, 1.52); 0.553
Age 65 to 69	M: 0.580 (0.449, 0.749)	N: 0.766 (0.540, 1.09); 0.135	S: 0.673 (0.657, 1.32); 0.013*	W: 0.930 (0.657, 1.32); 0.685
Age ≥ 70	M: 0.603 (0.518, 0.702)	N: 0.755 (0.610, 0.936); 0.010*	S: 0.824 (0.684, 0.993); 0.042*	W: 1.07 (0.864, 1.33); 0.534



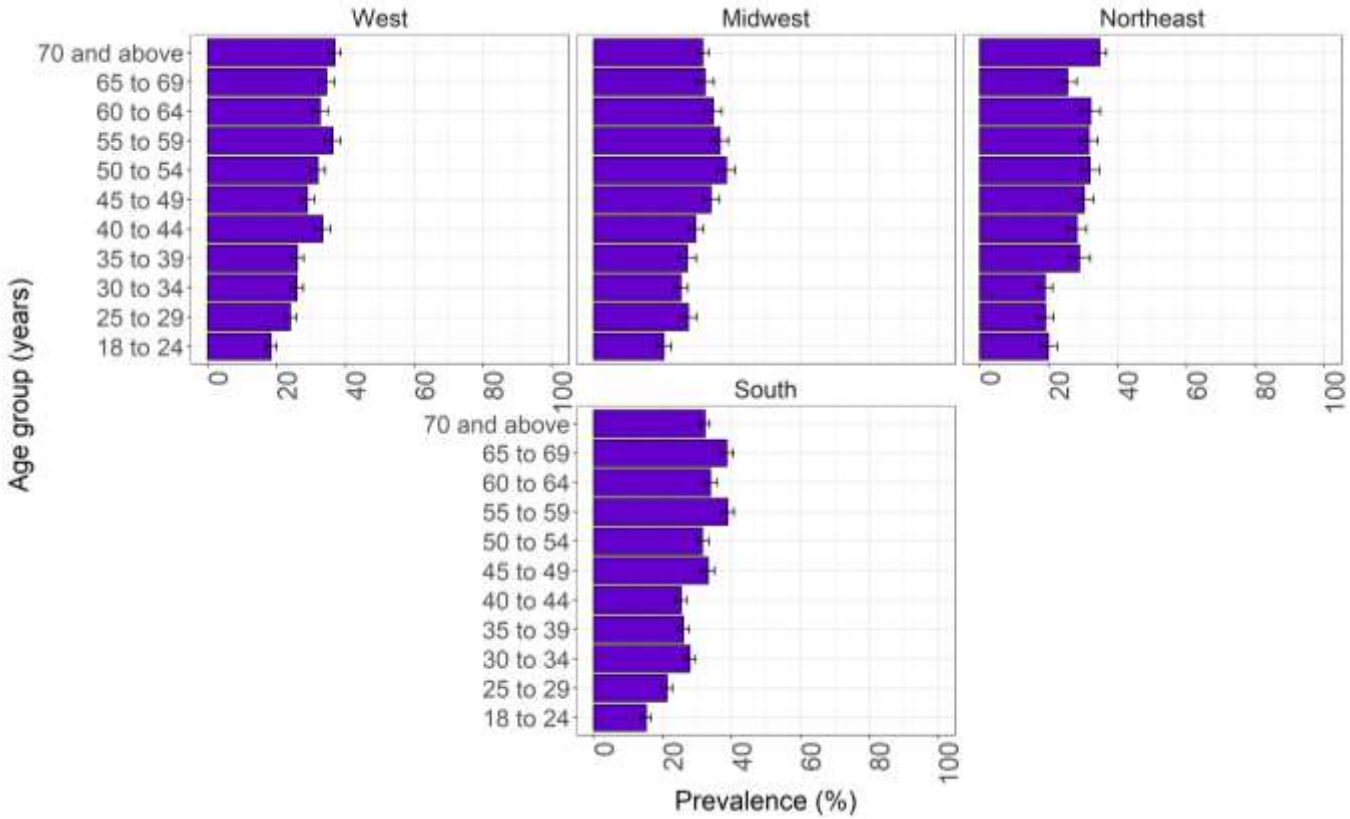
C: 2005 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.365 (0.296, 0.450)	N: 0.769 (0.454, 1.09); 0.136	S: 0.763 (0.589, 0.987); 0.040*	W: 0.989 (0.730, 1.34); 0.942
Age 25 to 29	M: 0.432 (0.344, 0.542)	N: 0.825 (0.853, 1.17); 0.280	S: 0.764 (0.851, 1.00); 0.054	W: 0.995 (0.738, 1.34); 0.974
Age 30 to 34	M: 0.350 (0.282, 0.433)	N: 1.08 (0.788, 1.48); 0.628	S: 0.975 (0.7556, 1.26); 0.848	W: 1.09 (0.822, 1.44); 0.558
Age 35 to 39	M: 0.433 (0.357, 0.526)	N: 0.874 (0.664, 1.15); 0.366	S: 0.754 (0.593, 0.960); 0.022*	W: 0.913 (0.701, 1.19); 0.498
Age 40 to 44	M: 0.494 (0.408, 0.598)	N: 0.944 (0.726, 1.23); 0.671	S: 0.804 (0.639, 1.01); 0.063	W: 0.776 (0.601, 1.00); 0.052
Age 45 to 49	M: 0.428 (0.350, 0.523)	N: 0.909 (0.684, 1.21); 0.509	S: 0.873 (0.687, 1.11); 0.269	W: 1.02 (0.786, 1.33); 0.876
Age 50 to 54	M: 0.502 (0.412, 0.613)	N: 1.07 (0.806, 1.43); 0.624	S: 0.955 (0.753, 1.21); 0.708	W: 0.968 (0.744, 1.26); 0.810
Age 55 to 59	M: 0.382 (0.307, 0.474)	N: 1.74 (1.30, 2.34); < 0.001*	S: 1.39 (1.08, 1.80); 0.011*	W: 1.33 (0.999, 1.78); 0.051
Age 60 to 64	M: 0.382 (0.307, 0.474)	N: 0.758 (0.543, 1.06); 0.103	S: 0.846 (0.646, 1.11); 0.227	W: 0.717 (0.527, 0.977); 0.035*
Age 65 to 69	M: 0.601 (0.468, 0.770)	N: 0.625 (0.436, 0.894); 0.010*	S: 0.922 (0.683, 1.25); 0.599	W: 0.932 (0.654, 1.33); 0.697
Age ≥ 70	M: 0.594 (0.511, 0.690)	N: 0.816 (0.656, 1.01); 0.066	S: 1.00 (0.835, 1.21); 0.966	W: 0.965 (0.776, 1.20); 0.751



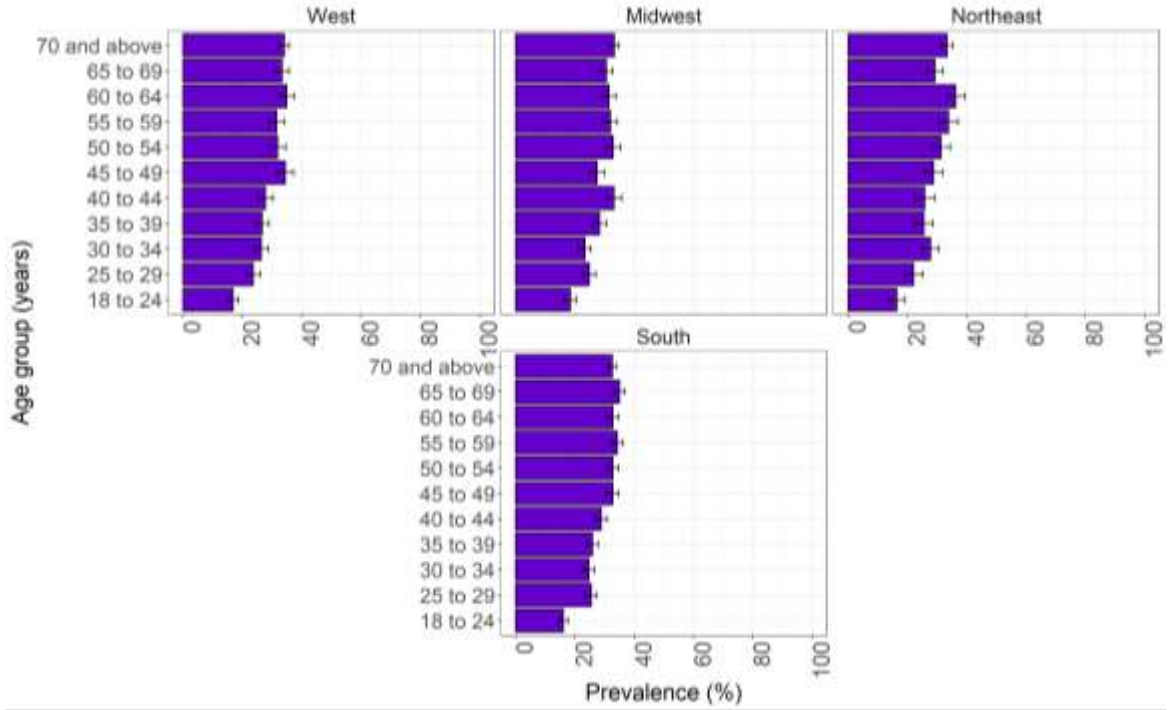
D: 2009 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.271 (0.206, 0.359)	N: 0.672 (0.432, 1.05); 0.079	S: 0.948 (0.689, 1.30); 0.744	W: 0.905 (0.636, 1.36); 0.581
Age 25 to 29	M: 0.428 (0.333, 0.551)	N: 0.876 (0.584, 1.31); 0.521	S: 0.993 (0.728, 1.36); 0.967	W: 0.808 (0.574, 1.14); 0.219
Age 30 to 34	M: 0.407 (0.321, 0.516)	N: 0.816 (0.565, 1.18); 0.275	S: 0.882 (0.658, 1.18); 0.403	W: 0.898 (0.654, 1.23); 0.504
Age 35 to 39	M: 0.454 (0.347, 0.592)	N: 1.03 (0.711, 1.49); 0.882	S: 1.06 (0.778, 1.44); 0.716	W: 0.962 (0.685, 1.35); 0.821
Age 40 to 44	M: 0.389 (0.301, 0.504)	N: 1.29 (0.920, 1.81); 0.139	S: 1.10 (0.811, 1.50); 0.536	W: 0.995 (0.715, 1.39); 0.976
Age 45 to 49	M: 0.529 (0.416, 0.672)	N: 0.873 (0.626, 1.22); 0.422	S: 0.940 (0.709, 1.25); 0.666	W: 1.00 (0.725, 1.38); 0.999
Age 50 to 54	M: 0.484 (0.385, 0.609)	N: 0.985 (0.691, 1.40); 0.932	S: 0.838 (0.637, 1.10); 0.206	W: 0.881 (0.645, 1.20); 0.425
Age 55 to 59	M: 0.708 (0.557, 0.899)	N: 0.487 (0.599, 1.20); 0.346	S: 0.726 (0.543, 0.971); 0.031*	W: 0.712 (0.516, 0.981); 0.038*
Age 60 to 64	M: 0.485 (0.376, 0.625)	N: 1.01 (0.708, 1.45); 0.947	S: 1.25 (0.933, 1.68); 0.134	W: 1.17 (0.840, 1.62); 0.357
Age 65 to 69	M: 0.548 (0.405, 0.743)	N: 0.779 (0.509, 1.19); 0.250	S: 0.973 (0.682, 1.39); 0.881	W: 1.07 (0.715, 1.59); 0.752
Age ≥ 70	M: 0.596 (0.501, 0.711)	N: 0.877 (0.675, 1.14); 0.328	S: 0.848 (0.681, 1.06); 0.141	W: 0.865 (0.679, 1.10); 0.244



E: 2013 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.337 (0.255, 0.447)	N: 0.955 (0.631, 1.45); 0.829	S: 0.687 (0.487, 0.969); 0.033*	W: 0.915 (0.645, 1.00); 0.050
Age 25 to 29	M: 0.402 (0.310, 0.521)	N: 0.618 (0.416, 0.920); 0.018*	S: 0.715 (0.526, 0.973); 0.033*	W: 0.835 (0.611, 1.14); 0.257
Age 30 to 34	M: 0.409 (0.325, 0.514)	N: 0.692 (0.482, 0.992); 0.045*	S: 1.12 (0.852, 1.46); 0.424	W: 1.02 (0.767, 1.36); 0.879
Age 35 to 39	M: 0.387 (0.291, 0.517)	N: 1.09 (0.738, 1.62); 0.656	S: 0.942 (0.686, 1.29); 0.709	W: 0.940 (0.682, 1.30); 0.704
Age 40 to 44	M: 0.436 (0.343, 0.554)	N: 0.931 (0.656, 1.32); 0.687	S: 0.807 (0.615, 1.06); 0.123	W: 1.19 (0.894, 1.60); 0.230
Age 45 to 49	M: 0.523 (0.414, 0.661)	N: 0.839 (0.596, 1.18); 0.317	S: 0.961 (0.731, 1.26); 0.777	W: 0.787 (0.585, 1.06); 0.113
Age 50 to 54	M: 0.680 (0.534, 0.864)	N: 0.746 (0.537, 1.04); 0.081	S: 0.736 (0.559, 0.969); 0.029*	W: 0.754 (0.560, 1.01); 0.061
Age 55 to 59	M: 0.545 (0.436, 0.683)	N: 0.803 (0.854, 1.10); 0.177	S: 1.11 (0.855, 1.43); 0.444	W: 0.992 (0.747, 1.32); 0.954
Age 60 to 64	M: 0.570 (0.448, 0.726)	N: 0.893 (0.633, 1.26); 0.519	S: 0.956 (0.726, 1.26); 0.748	W: 0.909 (0.671, 1.23); 0.539
Age 65 to 69	M: 0.516 (0.402, 0.663)	N: 0.710 (0.492, 1.02); 0.067	S: 1.32 (0.987, 1.76); 0.062	W: 1.10 (0.806, 1.50); 0.545
Age ≥ 70	M: 0.506 (0.428, 0.600)	N: 1.16 (0.918, 1.47); 0.215	S: 1.03 (0.843, 1.26); 0.767	W: 1.27 (1.02, 1.57); 0.035*



F: 2017 - *OR (95% CI), p-value*

Age 18 to 24	M: 0.299 (0.225, 0.396)	N: 0.822 (0.518, 1.31); 0.407	S: 0.859 (0.610, 1.21); 0.382	W: 0.878 (0.606, 1.27); 0.492
Age 25 to 29	M: 0.415 (0.321, 0.538)	N: 0.828 (0.539, 1.27); 0.388	S: 1.00 (0.734, 1.37); 0.984	W: 0.941 (0.672, 1.32); 0.723
Age 30 to 34	M: 0.344 (0.270, 0.440)	N: 1.28 (0.893, 1.83); 0.180	S: 1.08 (0.804, 1.45); 0.613	W: 1.20 (0.865, 1.67); 0.275
Age 35 to 39	M: 0.400 (0.311, 0.514)	N: 0.866 (0.580, 1.29); 0.481	S: 0.886 (0.661, 1.19); 0.416	W: 0.920 (0.669, 1.27); 0.610
Age 40 to 44	M: 0.568 (0.438, 0.738)	N: 0.683 (0.448, 1.04); 0.076	S: 0.813 (0.598, 1.11); 0.187	W: 0.779 (0.551, 1.10); 0.157
Age 45 to 49	M: 0.409 (0.314, 0.533)	N: 1.06 (0.727, 1.55); 0.759	S: 1.26 (0.937, 1.70); 0.125	W: 1.38 (0.987, 1.93); 0.059
Age 50 to 54	M: 0.512 (0.398, 0.657)	N: 0.926 (0.646, 1.32); 0.664	S: 0.992 (0.742, 1.33); 0.956	W: 0.959 (0.686, 1.34); 0.809
Age 55 to 59	M: 0.516 (0.409, 0.651)	N: 1.09 (0.764, 1.54); 0.647	S: 1.10 (0.844, 1.44); 0.472	W: 0.988 (0.723, 1.35); 0.938
Age 60 to 64	M: 0.486 (0.386, 0.612)	N: 1.24 (0.888, 1.72); 0.210	S: 1.06 (0.807, 1.38); 0.695	W: 1.16 (0.861, 1.57); 0.323
Age 65 to 69	M: 0.454 (0.363, 0.568)	N: 0.936 (0.669, 1.31); 0.698	S: 1.22 (0.939, 1.59); 0.136	W: 1.14 (0.845, 1.53); 0.395
Age ≥ 70	M: 0.544 (0.468, 0.632)	N: 0.993 (0.799, 1.24); 0.953	S: 0.967 (0.807, 1.16); 0.712	W: 1.04 (0.843, 1.27); 0.734

Figure 4.10: Geofacet plots of the prevalence (%) (standard error) of low back pain in US residents within the previous three months, by age category according to the National Health Interview Survey (NHIS)[α], across years 1997 (A), 2001 (B), 2005 (C) 2009 (D), 2013 (E) and 2017 (F)

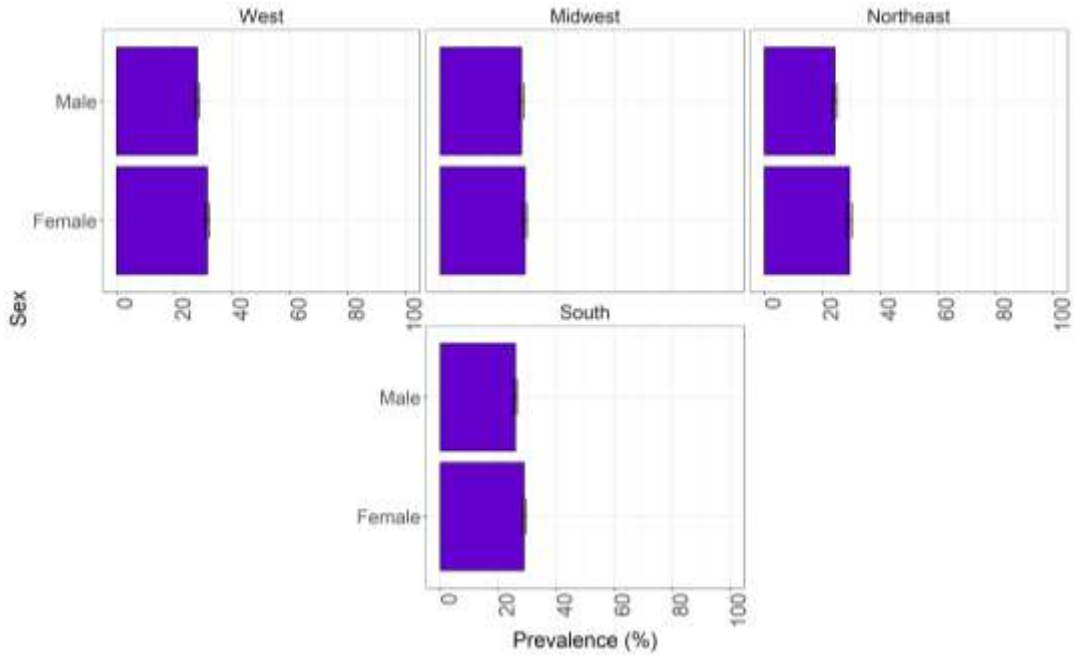
Legends per year contain the first letter of each region (where M is the Midwest, N is the Northeast, S is the South, and W is the West), OR (95% CI) (odds ratio (95% confidence interval)), and corresponding P-value (*significant), for each year in question

[α]NHIS Sample Adult Questionnaire

4.3.3 Region-specific prevalence of low back pain by sex

Low back pain has previously been associated with sex, where females reported more low back pain compared to males (Wu *et al*., 2020). Hence, I calculated the prevalence of US residents who reported low back pain within the previous three months, after applying appropriate design weights, in males and females, in order to observe whether there were sex-specific differences in prevalence statistics that were consistent across all US regions. Thereafter, I also did annual age-adjusted logistic regressions to establish whether regional residence predicted low back pain in either sex individually, where the comparator group was the Midwestern group for the sex concerned.

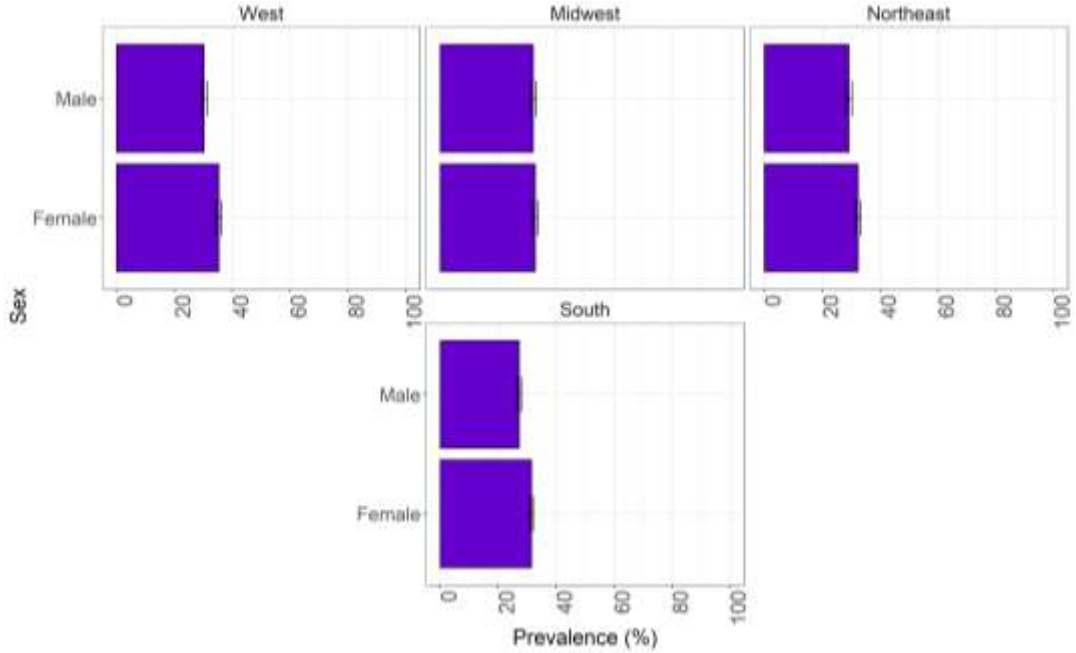
Regional residence, overall, was not associated with increased reports of low back pain in either sex. Between around 2000 and 2007, Midwestern residents of both sexes reported significantly more low back pain compared to those in the South, which aligns well with the overall population findings, but was not sex-specific. In the last six years of my analyses, female Midwesterners tended to report significantly more low back pain than female Northeasterners, whereas no such trend emerged in males (Figure 4.11). A table of weighted prevalence data for each region, by sex, in each year analysed, can be found in Appendix M, Tables XIII and XIV.



A: 1997 - *OR (95% CI), p-value*

Male M: 0.254 (0.215, 0.299); N: 0.823 (0.727, 0.931), 0.002*; S: 0.901 (0.810, 1.00), 0.053
W: 1.00 (0.889, 1.13), 0.970

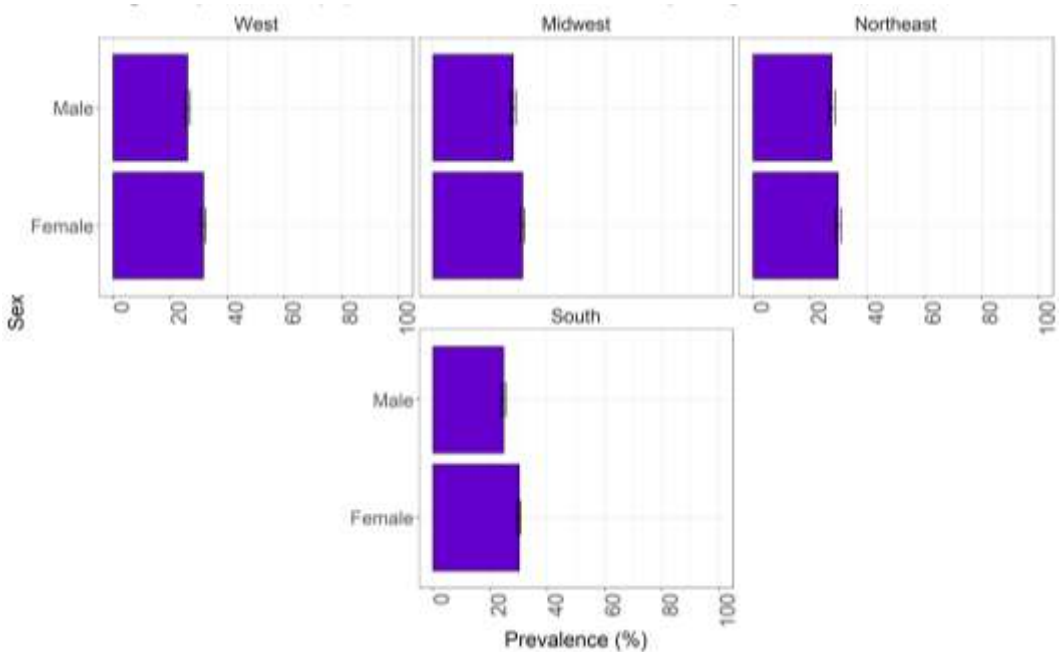
Female M: 0.323 (0.284, 0.369); N: 1.00 (0.903, 1.11), 0.976; S: 0.983 (0.898, 1.08), 0.703;
W: 1.11 (1.00, 1.23), 0.041*



B: 2001 - *OR (95% CI), p-value*

Male M: 0.344 (0.295, 0.402); N: 0.860 (0.757, 0.977), 0.021*; S: 0.793 (0.512, 0.883), < 0.001*
W: 0.918 (0.814, 1.03), 0.158

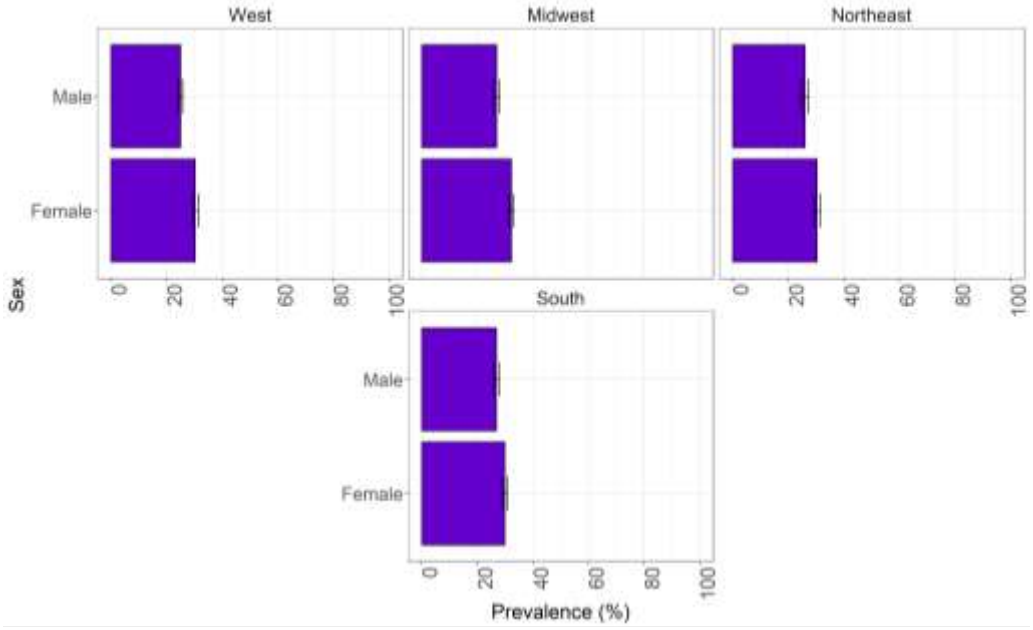
Female M: 0.397 (0.347, 0.454); N 0.977 (0.877, 1.09), 0.680; S: 0.939 (0.855, 1.03), 0.184;
W: 1.13 (1.01, 1.25), 0.029*



C: 2005 - *OR (95% CI), p-value*

Male M: 0.222 (0.185, 0.266); N: 0.932 (0.813, 1.07), 0.309; S: 0.842 (0.751, 0.944), 0.003* W: 0.898 (0.789, 1.02), 0.100

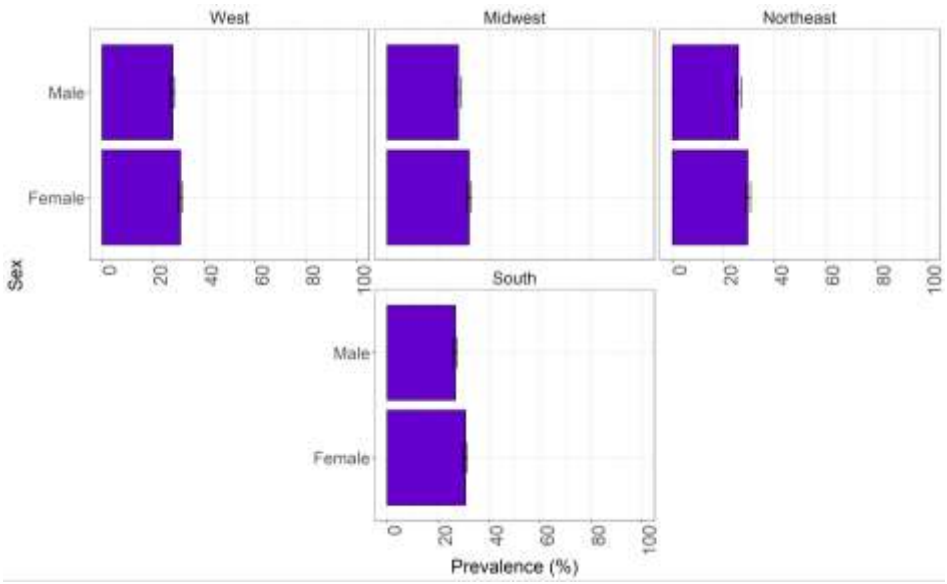
Female M: 0.328 (0.283, 0.380); N: 0.918 (0.817, 1.03), 0.150; S: 0.942 (0.855, 1.04), 0.226; W:1.02 (0.912, 1.14), 0.741



D: 2009 - *OR (95% CI), p-value*

Male M: 0.202 (0.164, 0.248); N: 0.940 (0.797, 1.11), 0.458; S: 0.998 (0.872, 1.14), 0.981; W: 0.916 (0.791, 1.06), 0.246

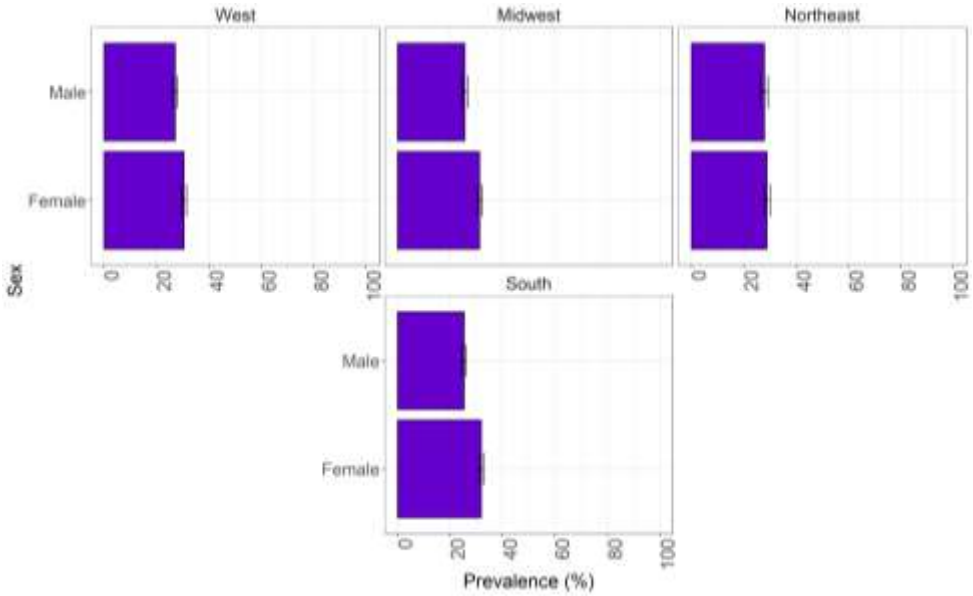
Female M: 0.266 (0.221, 0.321); N: 0.894 (0.778, 1.03), 0.119; S: 0.896 (0.800, 1.01), 0.065 W: 0.918 (0.805, 1.05), 0.197



E: 2013 - *OR (95% CI), p-value*

Male M: 0.165 (0.131, 0.209); N: 0.867 (0.740, 1.02), 0.079; S: 0.924 (0.812, 1.05), 0.226; W: 1.01 (0.880, 1.16), 0.904

Female M: 0.308 (0.258, 0.367); N 0.863 (0.751, 0.991), 0.037*; S: 0.925 (0.828, 1.03), 0.165 W: 0.933 (0.828, 1.05), 0.251



F: 2017 - *OR (95% CI), p-value*

Male M: 0.142 (0.113, 0.178); N: 1.09 (0.932, 1.29), 0.271; S: 0.994 (0.874, 1.13), 0.925 W: 1.08 (0.942, 1.25), 0.262

Female M: 0.272 (0.224, 0.329); N: 0.879 (0.762, 1.01), 0.077; S: 1.02 (0.911, 1.14), 0.756 W: 0.969 (0.853, 1.10), 0.631

Figure 4.11: Geofacet plots of the prevalence (%) (standard error) of low back pain in US residents within the previous three months, by sex, according to the NHIS[α], in 1997 (A), 2001 (B), 2005 (C), 2009 (D), 2013 (E) and 2017 (F)

Legends per year contain the first letter of each region (where M is the Midwest, N is the Northeast, S is the South, and W is the West), OR (95% CI) (odds ratio (95% confidence interval)), and corresponding P-value (*significant), for each year in question

[α]NHIS Sample Adult Questionnaire

SECTION 2 DISCUSSION

Geospatial trends of low back pain using the NHIS survey

Summary of findings

Using the National Health Interview Survey (NHIS), I calculated the appropriately weighted prevalence of self-reported low back pain in the previous three months, per US region (Midwest, Northeast, South, and West). I conducted annual logistic regressions to establish whether there was an association between low back pain and regional residence. Overall, a median across regions of around 28% of people in the US report having experienced low back pain in the preceding three months. However, regional residence was not associated with reports of low back pain consistently across time. Southern residents reported less low back pain than other regions for a decade between circa 1998 and 2008, however, thereafter the regional low back prevalence is largely random.

I then repeated these analyses for the various age groups [age range (in years) 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. There was little to no evidence to suggest that regional residence was associated with reporting of low back pain in any age group. Any significant result generated was sparsely distributed across time, was random in region, and was likely due to sampling. I also then repeated analyses on the sexes (males and females), however, regional residence was not associated with low back pain in either sex, with the exception of an alignment with the overall findings that Southern residents reported less low back pain between 1998 and 2008; and an emerging trend in recent years, where females in the Northeast had significantly less low back reports than in the Midwest.

Geospatial trends of prevalence of low back pain in the US

There is a dearth of data on US spatial trends of low back pain prevalences. Although much data exists on the overall prevalence and burden of low back pain, the spatial trends thereof simply has not been well-researched at all. CDC reports showed that the prevalence of low back pain in

1997, 2010, and 2012 were 27.1%, 28.0%, and 25.7% in the Northeast, 28.7%, 28.1%, and 30.2% in the Midwest, 27.5%, 28.3%, and 27.2% in the South, and 30.0%, 29.3%, and 29.1% in the West, respectively (CDC, 2013). From these snapshot data, which align well with my own, there is little geospatial trend in low back pain.

Using research on low back pain-related medical interventions (for example, medication and surgeries) and health insurance claims, there are some proxy geospatial trends on low back pain. Research that looked at health insurance claims for back pain-related surgeries over time and space found that there were small area variations in claims, with a small increase over time along the Eastern seaboard, but the highest intensity found in Texas (Fulton and Kruse, 2019). Moreover, lumbar spine disorder-related surgical management saw spatial disparities, where geography was a significant predictor of surgical management, as well as costs of surgery and quality of outcome (Azad *et al.*, 2018). For example, low back pain surgery varied significantly by region, where the South had the most surgical management, followed by the Midwest, Northeast, and then West (Raad *et al.*, 2019). While there is some indication that there may be geospatial trends in low back disorders, the aforementioned research does not account for those who have not sought surgical treatment for their low back pain. Research on opioid prescriptions and regional residence showed that that the prevalence of opioid prescription for low back pain is highest in the South, followed by the Midwest, West, and Northeast (Raad *et al.*, 2020), thus also indicating that there may be regional trends in the low back pain of those of higher socioeconomic status. The research papers I have cited in this paragraph have shown that the South has increased healthcare interventions for low back pain, but the research may not be a direct proxy for geospatial low back pain trends as many US residents do not necessarily have the economic means to have low back pain health interventions. Furthermore, surgery and opioids are not best practice for treating low back pain according to clinical guidelines (Qaseem *et al*., 2017). The aforementioned data, therefore, may also be missing mild-to-moderate intensity low back pain data. The use of these data to assess low back pain is therefore limited. Research that investigates healthcare interventions for low back pain would also miss groups of lower socioeconomic status. The role of nation-wide population-based surveys is imperative here as they have access to all people, irrespective of these confounding variables.

Previous research has found that there were geographical disparities in various musculoskeletal pains at state- and county-level (Chowdhury *et al*., 2010; Gamble *et al.*, 2017; Barbour *et al.*, 2018). Research on opioid prescriptions for low back pain specifically established spatial disparities by state, where Hawaii has the lowest prevalence of opioid prescriptions (12.9%) and Arkansas has the highest (33.6%), and all other states fall at different prevalences within this range (Raad *et al.*, 2020). Furthermore, low back pain prevalence has been cited as being correlated with the rural-urban divide (Yoshimura *et al.*, 2014), although the research cites rural-urban low back pain correlations as being contentious (Bath *et al.*, 2014; Hurwitz *et al.*, 2018). My research could not establish geospatial trends in low back pain by region. However, it may be that geospatial trends do exist, but that they are not visible at a regional level; that is, that regions are too large and diverse within themselves to detect a geospatial trend in low back pain.

Geospatial trends of prevalence of low back pain in the US by age and sex

According to this thesis, it was difficult to discern trends of low back pain in various demographic (age and sex) groups by region. The prevalence of low back pain in young people is generally already high, where the Midwest has slightly more low back pain in young people compared to the South and Northeast. Thereafter, as people age, there is no trend. The only other trend established occurred across all regions, as well as the overall sample, was that females reported a higher prevalence of low back pain than males (although demographic trends will be further explored in the next chapter). The increased low back pain reporting in females compared to males is also seen globally, across various countries (Wu *et al.*, 2020). The sex effect of females reporting more low back pain could therefore have far more of an effect than a potential geographical difference.

Limitations and section conclusion

This geospatial analysis on low back pain does have limitations. Firstly, low back pain data were only available from the NHIS survey, thus I was not able to compare these data with geospatial trends from other surveys. Secondly, US regions are large, and consist of multiple states, which have spatial disparities in other musculoskeletal disorders. From the data available in the NHIS,

the extent to which I could conduct a spatial analysis was compromised, and no state- or county-level prevalences and associations could be established. Given the lack of clarity on geospatial trends on low back pain prevalences (without using healthcare intervention as a proxy), representative and nationwide population-based surveys would benefit from improving the questions necessary to conduct a more in-depth analysis. By releasing more geographically specific data (for example state residence), the NHIS could help to establish more rigorous data on geospatial trends in low back pain. The BRFSS has more rigorous spatial data (state- and county-level), and therefore could greatly add to the research on low back pain geography by adding a low back pain question.

There is still much work that can be done on geospatial trends of low back pain. Although my work detected very little–to-no trends in this regard, geospatial trends for low back pain may be found if the research is done on more specific spaces, such as states or counties. Alternatively, more geospatially-specific research is required to show that low back pain is in fact geographically randomly dispersed, in which case other variables (such as age, sex, or socioeconomic status) would then be better targets for intervention. I do, however, think that streamlining more specific research on low back pain geography is imperative to the distribution of funding, especially as low back pain is very costly to society both financially and in terms of quality of life. Low back pain has been reported to be responsible for 60.1 million disability-adjusted life years (Hartvigsen *et al*., 2018). In the US specifically, back pain results in 264 million work days lost and 182 million bed days in workforce-aged Americans annually (Lo, Chan and Flynn, 2020). Overall, low back pain costs are estimated at up to $365 billion in healthcare costs alone in the US (Lo, Chan and Flynn., 2020). Given that the CDC and the Health Resources & Service Administration distributes funding to states, it is imperative that there is an awareness of the financial requirements for each state for low back pain. A lack of knowledge on geographical distributions of low back pain limit the ability of state governors to design targeted and efficient policies in addressing the low back pain burden through health education or promotion programmes, as well as treatment regimens on the affected people.

CHAPTER FIVE

Demographic trends of musculoskeletal pain: painful arthropathies and low back pain

In Chapter One, I discussed how musculoskeletal pain has been previously associated with a number of demographic variables, including age, sex, and socioeconomic status. Older people have previously been found to have higher prevalences of musculoskeletal pain than younger people (Hootman *et al*., 2016; Shmagel, Foley and Ibrahim, 2016; Safiri *et al*., 2020). Female sex, too, has been associated with musculoskeletal pain (Maher, Underwood and Buchbinder, 2017; Cimas *et al*., 2018). Finally, low socioeconomic status has been associated with musculoskeletal pain, including employment status (Shmagel, Foley and Ibrahim, 2016; Callhoff *et al*., 2017; Ikeda *et al*., 2019), low income (Wolfe *et al*., 2005), and low education level (Bengtsson *et al*., 2005). The demographic trends in musculoskeletal pain have been shown both in painful arthropathies as well as low back pain.

I also discussed the limitations of the available research on musculoskeletal pain and demographic factors in Chapter One. Namely, the research is often geographically isolated or cross-sectional. In the case of low back pain, obtaining temporal consistency in these trends is also difficult due to the heterogeneity in low back pain definitions in previous research. Therefore, Chapter Five of my thesis aims to address my third objective: to describe the association between demographic factors (age, sex, and socioeconomic status) with having a painful arthropathy (Section 1), or low back pain (Section 2).

SECTION 1: DEMOGRAPHIC TRENDS OF PAINFUL ARTHROPATHIES

The Behavioural Risk Factor Surveillance System (BRFSS), National Health Interview Survey (NHIS), and the National Health and Nutrition Examination Survey (NHANES) (Continuous) record self-reported data on age, sex, and employment status. The BRFSS and NHANES (Continuous) also record self-reported data on annual household income, and education level. I used appropriate complex survey design methods and appropriately weighted data to analyse self-reported data on rheumatic disorder diagnoses (BRFSS, telephonic interview survey data), joint symptoms (NHIS, in-person interview survey data), and arthritis diagnoses (NHANES Continuous, in-person interview survey data).

Using the aforementioned data, Section 1 of this chapter aimed to address my third thesis objective: to describe the association between demographic factors (age, sex, and socioeconomic

status) with having a painful arthropathy. I established the prevalence of rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses, respectively, within each age group, as well as between sexes. I also mapped the prevalence of particular joint site complaints within age-sex divided demographic groups. I conducted logistic regressions on rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses, respectively with age, and sex. Finally, I also conducted logistic regressions on rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses with employment status. I conducted logistic regressions on rheumatic disorder diagnoses, and arthritis diagnoses with annual household income, and education level too.

5.1 Behavioural Risk Factor Surveillance System (BRFSS)

Rheumatic disorder diagnosis

Using the BRFSS survey question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?", I calculated the prevalence of a diagnosis of a rheumatic disorder in US residents, by age group, and by sex. After accounting for complex survey design and applying appropriate design weights to each year's data individually, I calculated the aforementioned prevalence statistics annually from 1996 until 2018, with the exception of 2006 and 2008 where rheumatic disorder data was unavailable. I then conducted logistic regressions to assess whether a particular age, sex, or socioeconomic status was associated with having a rheumatic disorder diagnosis.

Tables consisting of all prevalence values (95% confidence intervals), odds ratios (95% confidence intervals), and p-values are available in the appendices. Age-specific statistics can be found in Appendix H (Table I). Sex-specific statistics can be found in Appendix I (Table I). Employment-specific statistics can be found in Appendix J (Table I).

5.1.1 Rheumatic disorder diagnosis by age

The prevalence of a rheumatic disorder diagnosis was calculated in 11 age groups, namely: ages 18 to 24 years, 25 to 29 years, 30 to 34 years, 35 to 39 years, 40 to 44 years, 45 to 49 years, 50 to 54 years, 55 to 59 years, 60 to 64 years, 65 to 69 years, and 70 years and above. Thereafter,

annual sex-adjusted logistic regressions were conducted, where the comparator group was the youngest age category, age 18 to 24 years.

I calculated the prevalence across years 1997 to 2018 (except 2006 and 2008) in all age groups. In 18- to 24-year-olds, the prevalence of a rheumatic disorder diagnosis was between 3.0% and 5.7%, and the most recent estimate (2018) was 3.4%. In those aged 25 to 29 years, the prevalence of a rheumatic disorder diagnosis was between 5.4% and 8.8%, and the most recent prevalence was 5.6%. In 30- to 34-year-olds, the prevalence of rheumatic disorder diagnoses was between 5.6% and 12.3%, and the most recent prevalence was 8.6%. In those aged 35 to 39 years, the prevalence of a rheumatic disorder diagnosis ranged between 10.2% and 16.7%, and the most recent prevalence was 12.1%. In those aged 40 to 44 years, the prevalence of rheumatic disorder diagnoses was between 12.1% and 22.8%, and the most recent prevalence was 16.1%. In the 45 to 49 years' age group, the prevalence of a rheumatic disorder diagnosis was between 16.7% and 29.2%, and the most recent prevalence was 22.3%. In those aged 50 to 54 years, the prevalence of rheumatic disorder diagnoses was between 22.3% and 37.0%, and the most recent prevalence was 29.5%. In those aged 55 to 59 years, the prevalence of rheumatic disorder diagnoses was between 30.1% and 46.2%, and the most recent prevalence was 37.1%. In 60- to 64-year-olds, the prevalence of rheumatic disorder diagnoses was between 37.0% and 51.9%, and the most recent prevalence was 42.9%. In those aged 65- to 69-years-old, the prevalence of rheumatic disorder diagnoses was between 43.6% and 60.7%, and the most recent prevalence was 47.3%. Finally, the prevalence of rheumatic disorder diagnoses in people aged 70 years and above was between 50.2% and 60.4%, and the most recent prevalence was 54.3%. The prevalence of rheumatic disorder diagnoses therefore increases incrementally with older age groups in a progressive manner (Figure 5.1).

Annual sex-adjusted logistic regressions showed that age was significantly associated with having been diagnosed with a rheumatic disorder in one's lifetime, across all years of analysis. Those aged 18 to 24 years reported significantly fewer diagnoses than all groups older than 18- to 24-years-old, for every year of analysis, including years where the survey question was only included as a module question. The only exception was in 1998, where 18- to 24-year-olds reported comparable diagnoses to those in age groups between 24- to 34-years old, but significantly fewer compared to all age groups older than 35 years old. The exception was likely

due to sampling, supported by wide confidence intervals, particularly as 1998 was a module year, and there were fewer people asked the survey question and from only eight states.

The standard error bars are wider in years where the rheumatic disorder diagnosis question was only included as a module question and only asked in a small number of states, thus limiting the sample. Narrower standard error bars and prevalence values that are closer together in value were observed when the question was included in the core questionnaire. The weighting methodology used from 2011 onwards also improves the prevalence estimates, narrowing the standard error bars, as well as the range between prevalences in different years.

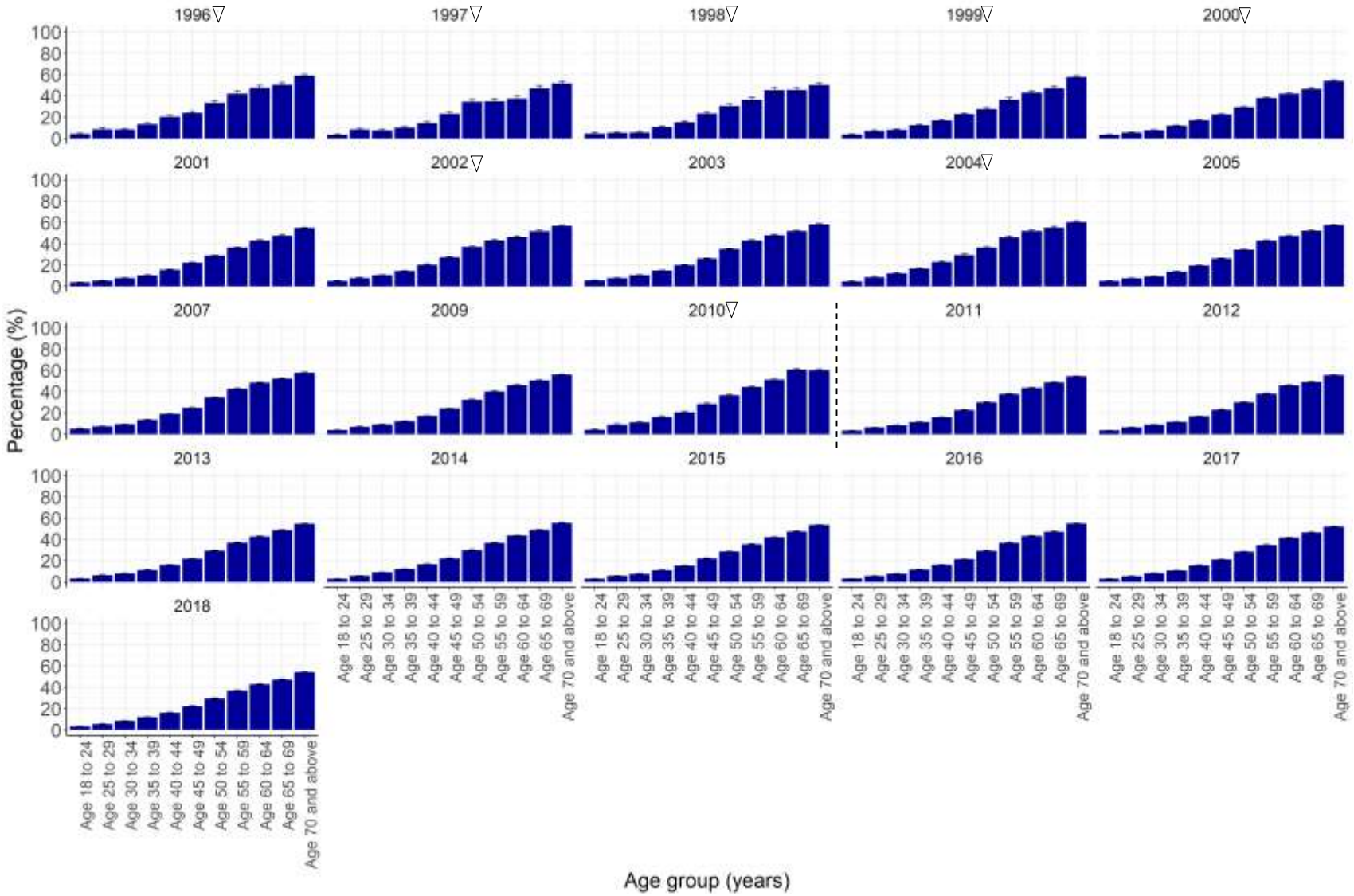


Figure 5.1: Prevalence (%) of US residents, by age group, who reported having been diagnosed with a rheumatic disorder[α] by a medical or health practitioner, according to the Behavioural Risk Factor Surveillance System (BRFSS), from 1996 to 2018

[α] Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

▽Module questionnaire years

Dashed vertical line: changed weighting methods thereafter

5.1.2 Rheumatic disorder diagnosis by sex

The prevalence of a rheumatic disorder diagnosis was calculated in males and females. Thereafter, annual age-adjusted logistic regressions were conducted, where the comparator group was males. The prevalence of rheumatic disorder diagnoses in males was between 17.3% and 26.6% between 1996 and 2018, and the most recent prevalence (2018) was 21.4%. In females, the prevalence of rheumatic disorder diagnoses was between 26.5% and 33.7%, and the most recent prevalence was 29.7% (Figure 5.2). Annual age-adjusted logistic regressions showed that rheumatic disorder diagnoses were statistically significantly higher in females compared to males, across all years of analysis ($P < 0.001$ for all years). Much like the age analysis, the improvement of weighting methodology also resulted in a narrower range of prevalence values within each sex, from 2011.

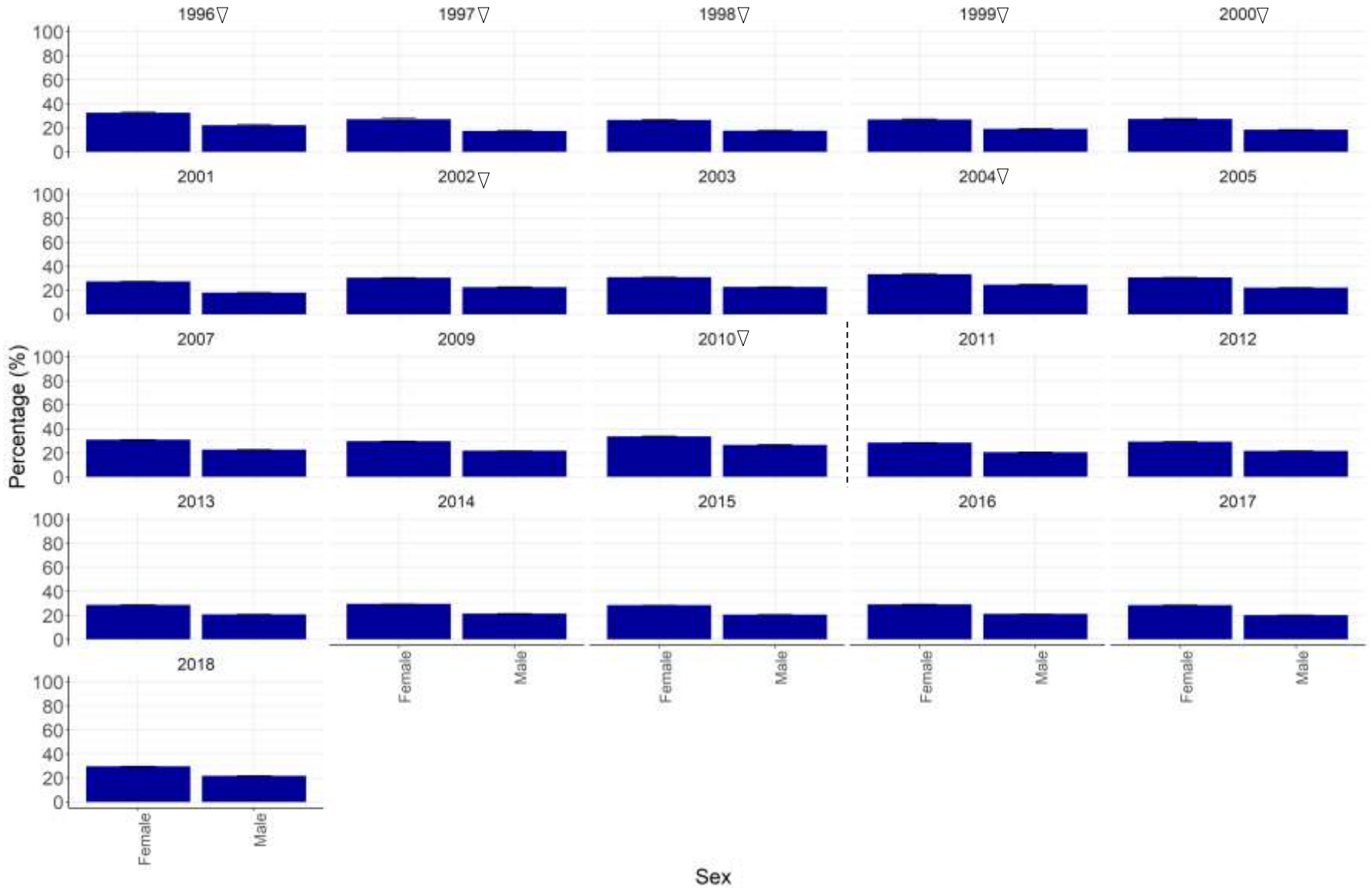


Figure 5.2: Prevalence (%) of US residents, by sex, who reported having been diagnosed with a rheumatic disorder[α] by a medical or health practitioner, according to the Behavioural Risk Factor Surveillance System (BRFSS), from 1996 to 2018

[α] Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

▽ Module questionnaire years

Dashed vertical line: changed weighting methods thereafter

5.1.3 Rheumatic disorder diagnosis by socioeconomic status

Socioeconomic status was assessed using three indices, namely: employment status, annual household income, and education level.

5.1.3.1 Employment status

Annual age- and sex-adjusted logistic regressions were conducted on employment status, comparing rheumatic disorder diagnoses between individuals who were employed for wages, self-employed, unemployed, homemakers, students, retired, and unable to work. The comparator group was those employed for wages.

Across all years of my analysis, those who were unemployed (except 1997), and those unable to work reported significantly more rheumatic disorder diagnoses compared to those who were employed for wages. Retired individuals also reported significantly more rheumatic disorder diagnoses compared to those employed for wages, the only exceptions being in 1996 and 1997 where no significant difference between the employed and the retired was established. Homemakers reported significantly more rheumatic disorder diagnoses compared to those who were employed for wages more so in later years (1999, 2000, 2007, and 2009 to 2018) but not in early years of analysis (1996, 1997, 1998, and 2001 to 2005). The later emergence of the association between having a rheumatic disorder and being a homemaker is likely to be as a result of the improvement of sampling and weighting methodology. Students' reports of rheumatic disorder diagnoses were mostly comparable to reports by the employed for wages population, but were significantly fewer than the employed population in some years (years 2000, 2001, 2003, and 2018). Likewise, those who were self-employed either reported comparable rheumatic disorder diagnoses to the employed for wages group (1996 to 1999, 2001, 2004, 2010, 2011, 2012, 2015, and 2017), or reported significantly fewer diagnoses (2000, 2002, 2003, 2005, 2007, 2009, 2013, 2014, 2016, and 2018) (Table 5.1).

5.1.3.2 Annual household income bracket

Age- and sex-adjusted logistic regressions were conducted on annual household income bracket, comparing rheumatic disorder diagnoses in those with an annual household income of: less than $10 000, between $10 000 and $14 999, between $15 000 and $19 999, between $20 000 and $24 999, between $25 000 and $34 999, between $35 000 and $49 999, between $50 000 and $74 999, and $75 000 or above. The reference group was the highest annual household income bracket of $75 000 or above.

Those with an annual household income of $75 000 or above reported significantly fewer joint symptoms compared to all groups with lower annual household income. A few exceptions were noted, where there was no statistically significant difference between the $75 000 or above group, and those with an annual household income of $50 000 to $74 999 (1996, 1997, 1998, and 1999). The exception can be explained by the changed median annual household income over time, and the fact that early questions on rheumatic disorders were from module BRFSS questionnaires. The median annual household income in the US was $38 900 in 1998 (US Census of the Bureau collaborators, 1999). The top tiers of annual household income groups were thus well above the median, and therefore both groups could have been wealthy enough, relative to the median, to have similar outcomes in joint symptom reports. There was also no significant difference between the $75 000 or above group compared to those with an annual household income of $20 000 to $24 999 (1996), and those with an annual household income of $25 000 to $34 999 (1998). However, these discrepancies were likely as a result of sampling, particularly as they from module survey years (Table 5.1).

5.1.3.3 Education level

Age- and sex-adjusted logistic regressions were conducted on education level, comparing rheumatic disorder diagnosis reports in those with varying levels of highest education attained. These education levels were those who never attended school or only attended kindergarten, those who completed elementary school, those who did some high school, high school graduates, those who had some college or some technical schooling, and college graduates. The comparator group was the highest education level of having graduated from college.

Individuals who graduated from college reported significantly fewer rheumatic disorder diagnoses compared to those who had had some college or technical school, those who graduated from high school, those who completed some high school, and those who completed elementary school. There was no significant difference however between those who graduated from college and those who had no formal education or only attended kindergarten, with the exception of 2000, 2001, 2009, and 2011, likely as a result of sampling as observed by the very wide confidence intervals of the no formal education or only kindergarten group (Table 5.1).

Table 5.1: Comparison of lifetime rheumatic disorder diagnoses[α] by three socioeconomic status indices (employment status, education level, and annual household income bracket), according to the BRFSS, from 1996 to 2018

Y[π]	Socioeconomic status indicator		OR *(95% CI)*	P-value
1996[ι]	*Employment Status*	Employed for wages	0.053 *(0.035, 0.082)*	
		Homemaker	1.08 *(0.867, 1.36)*	0.476
		Retired	1.20 *(0.963, 1.49)*	0.105
		Self-employed	1.09 *(0.850, 1.39)*	0.504
		Student	0.803 *(0.423, 1.53)*	0.504
		Unable to work	4.26 *(3.10, 5.86)*	< 0.001*
		Unemployed	1.40 *(1.01, 1.94)*	0.044*
	Education Level	College graduate	0.037 *(0.025, 0.055)*	
		Some college/technical school	1.42 *(1.21, 1.67)*	< 0.001*
		High school graduate	1.53 *(1.30, 1.79)*	< 0.001*
		Some high school	2.06 *(1.63, 2.60)*	< 0.001*
		Elementary school	1.76 *(1.32, 2.36)*	< 0.001*
		No formal education/kindergarten only	0.574 *(0.187, 1.77)*	0.333
	Income Bracket	$75 000 or more	0.037 *(0.022, 0.061)*	
		$50 000 to $74 999	1.06 *(0.812, 1.39)*	0.658
		$35 000 to $49 999	1.35 *(1.05, 1.76)*	0.022*
		$25 000 to $34 999	1.31 *(1.01, 1.72)*	0.045*
		$20 000 to $24 999	1.31 *(0.991, 1.74)*	0.058
		$15 000 to $19 999	1.68 *(1.21, 2.34)*	0.002*
		$10 000 to $14 999	1.68 *(1.21, 2.35)*	0.002*
		Less than $10 000	2.08 *(1.50, 2.89)*	< 0.001*
1997[ι]	*Employment Status*	Employed for wages	0.036 *(0.024, 0.055)*	
		Homemaker	1.26 *(0.990, 1.61)*	0.060
		Retired	1.27 *(0.992, 1.63)*	0.058
		Self-employed	1.09 *(0.820, 1.44)*	0.557
		Student	1.54 *(0.851, 2.77)*	0.154
		Unable to work	4.52 *(3.28, 6.23)*	< 0.001*
		Unemployed	1.37 *(0.980, 1.92)*	0.066
	Education Level	College graduate	0.026 *(0.016, 0.043)*	
		Some college/technical school	1.72 *(1.41, 2.11)*	< 0.001*
		High school graduate	1.78 *(1.48, 2.14)*	< 0.001*
		Some high school	2.13 *(1.66, 2.11)*	< 0.001*
		Elementary school	2.84 *(2.13, 3.79)*	< 0.001*
		No formal education/kindergarten only	2.90 *(0.975, 8.61)*	0.055
	Income Bracket	$75 000 or more	0.029 *(0.017, 0.051)*	
		$50 000 to $74 999	1.15 *(0.871, 1.51)*	0.328
		$35 000 to $49 999	1.33 *(1.00, 1.76)*	0.048*
		$25 000 to $34 999	1.47 *(1.10, 1.95)*	0.009*
		$20 000 to $24 999	1.63 *(1.20, 2.22)*	0.002*
		$15 000 to $19 999	1.66 *(1.21, 2.27)*	0.002*
		$10 000 to $14 999	2.22 *(1.60, 3.07)*	< 0.001*
		Less than $10 000	2.63 *(1.89, 3.65)*	< 0.001*

1998'	*Employment Status*	Employed for wages	0.050 *(0.029, 0.086)*	
		Homemaker	1.10 *(0.846, 1.43)*	0.478
		Retired	1.41 *(1.08, 1.85)*	0.013*
		Self-employed	0.789 *(0.563, 1.02)*	0.069
		Student	1.29 *(0.522, 3.18)*	0.581
		Unable to work	5.06 *(3.55, 7.22)*	< 0.001*
		Unemployed	1.59 *(1.04, 2.43)*	0.032*
	Education Level	College graduate	0.036 *(0.021, 0.063)*	
		Some college/technical school	1.55 *(1.27, 1.90)*	< 0.001*
		High school graduate	1.58 *(1.31, 1.90)*	< 0.001*
		Some high school	1.91 *(1.46, 2.49)*	< 0.001*
		Elementary school	2.76 *(1.96, 3.87)*	< 0.001*
		No formal education/kindergarten only	1.08 *(0.279, 4.20)*	0.910
	Income Bracket	$75 000 or more	0.044 *(0.023, 0.083)*	
		$50 000 to $74 999	1.14 *(0.844, 1.54)*	0.391
		$35 000 to $49 999	1.33 *(1.00, 1.75)*	0.047*
		$25 000 to $34 999	1.32 *(0.999, 1.74)*	0.051
		$20 000 to $24 999	1.75 *(1.31, 2.35)*	< 0.001*
		$15 000 to $19 999	1.97 *(1.44, 2.68)*	< 0.001*
		$10 000 to $14 999	2.51 *(1.76, 3.58)*	< 0.001*
		Less than $10 000	2.39 *(1.69, 3.38)*	< 0.001*
1999'	*Employment Status*	Employed for wages	0.045 *(0.032, 0.063)*	
		Homemaker	1.17 *(1.01, 1.35)*	0.041*
		Retired	1.41 *(1.19, 1.67)*	< 0.001*
		Self-employed	0.836 *(0.687, 1.02)*	0.075
		Student	0.626 *(0.313, 1.25)*	0.187
		Unable to work	4.66 *(3.83, 5.68)*	< 0.001*
		Unemployed	1.53 *(1.11, 2.10)*	0.009*
	Education Level	College graduate	0.032 *(0.022, 0.045)*	
		Some college/technical school	1.33 *(1.15, 1.54)*	< 0.001*
		High school graduate	1.43 *(1.24, 1.63)*	< 0.001*
		Some high school	1.77 *(1.49, 2.10)*	< 0.001*
		Elementary school	1.99 *(1.66, 2.40)*	< 0.001*
		No formal education/kindergarten only	1.09 *(0.574, 2.07)*	0.795
	Income Bracket	$75 000 or more	0.030 *(0.021, 0.045)*	
		$50 000 to $74 999	*1.19 (0.942, 1.50)*	0.016
		$35 000 to $49 999	1.42 *(1.14, 1.78)*	0.002*
		$25 000 to $34 999	1.55 *(1.23, 1.94)*	< 0.001*
		$20 000 to $24 999	1.75 *(1.39, 2.21)*	< 0.001*
		$15 000 to $19 999	1.75 *(1.38, 2.23)*	< 0.001*
		$10 000 to $14 999	2.17 *(1.72, 2.73)*	< 0.001*
		Less than $10 000	2.06 *(1.65, 2.57)*	< 0.001*
2000'	*Employment Status*	Employed for wages	0.044 *(0.038, 0.052)*	
		Homemaker	1.17 *(1.06, 1.29)*	0.002*
		Retired	1.35 *(1.23, 1.49)*	< 0.001*
		Self-employed	0.861 *(0.779, 0.951)*	0.003*

		Student	0.748 *(0.582, 0.961)*	0.023*
		Unable to work	4.13 *(3.64, 4.68)*	< 0.001*
		Unemployed	1.32 *(1.14, 1.52)*	< 0.001*
	Education Level	College graduate	0.031 *(0.026, 0.036)*	
		Some college/technical school	1.42 *(1.33, 1.52)*	< 0.001*
		High school graduate	1.46 *(1.37, 1.57)*	< 0.001*
		Some high school	1.83 *(1.66, 2.02)*	< 0.001*
		Elementary school	1.46 *(1.28, 1.66)*	< 0.001*
		No formal education/kindergarten only	1.61 *(1.03, 2.51)*	0.037*
	Income Bracket	$75 000 or more	0.031 *(0.026, 0.037)*	
		$50 000 to $74 999	1.18 *(1.07, 1.30)*	< 0.001*
		$35 000 to $49 999	1.33 *(1.21, 1.46)*	< 0.001*
		$25 000 to $34 999	1.40 *(1.26, 1.55)*	< 0.001*
		$20 000 to $24 999	1.50 *(1.35, 1.68)*	< 0.001*
		$15 000 to $19 999	1.55 *(1.38, 1.75)*	< 0.001*
		$10 000 to $14 999	2.06 *(1.79, 2.37)*	< 0.001*
		Less than $10 000	2.18 *(1.88, 2.52)*	< 0.001*
	Employment Status	Employed for wages	0.047 *(0.041, 0.054)*	
		Homemaker	1.06 *(0.987, 1.14)*	0.109
		Retired	1.34 *(1.25, 1.44)*	< 0.001*
		Self-employed	0.950 *(0.880, 1.03)*	0.189
		Student	0.748 *(0.620, 0.902)*	0.002*
		Unable to work	4.45 *(4.07, 4.87)*	< 0.001*
		Unemployed	1.57 *(1.41, 1.74)*	< 0.001*
2001	*Education Level*	College graduate	0.032 *(0.028, 0.036)*	
		Some college/technical school	1.49 *(1.41, 1.56)*	< 0.001*
		High school graduate	1.54 *(1.47, 1.62)*	< 0.001*
		Some high school	1.92 *(1.78, 2.07)*	< 0.001*
		Elementary school	1.70 *(1.54, 1.89)*	< 0.001*
		No formal education/kindergarten only	1.86 *(1.26, 2.75)*	0.002*
		$75 000 or more	0.031 *(0.026, 0.036)*	
	Income Bracket	$50 000 to $74 999	1.21 *(1.13, 1.30)*	< 0.001*
		$35 000 to $49 999	1.34 *(1.25, 1.44)*	< 0.001*
		$25 000 to $34 999	1.48 *(1.38, 1.60)*	< 0.001*
		$20 000 to $24 999	1.67 *(1.54, 1.81)*	< 0.001*
		$15 000 to $19 999	1.78 *(1.63, 1.94)*	< 0.001*
		$10 000 to $14 999	2.02 *(1.82, 2.24)*	< 0.001*
		Less than $10 000	2.29 *(2.08, 2.52)*	< 0.001*
	Employment Status	Employed for wages	0.061 *(0.052, 0.071)*	
		Homemaker	1.05 *(0.955, 1.15)*	0.324
		Retired	1.42 *(1.30, 1.55)*	< 0.001*
		Self-employed	0.903 *(0.823, 0.992)*	0.033*
2002'		Student	0.983 *(0.783, 1.24)*	0.885
		Unable to work	3.97 *(3.54, 4.45)*	< 0.001*
		Unemployed	1.17 *(1.03, 1.32)*	0.014*

	Education Level	College graduate	0.045 *(0.039, 0.053)*	
		Some college/technical school	1.49 *(1.40, 1.59)*	< 0.001*
		High school graduate	1.43 *(1.34, 1.52)*	< 0.001*
		Some high school	1.73 *(1.55, 1.92)*	< 0.001*
		Elementary school	1.24 *(1.08, 1.44)*	0.003*
		No formal education/kindergarten only	0.940 *(0.504, 1.75)*	0.847
	Income Bracket	$75 000 or more	0.050 *(0.042, 0.060)*	
		$50 000 to $74 999	1.17 *(1.07, 1.28)*	< 0.001*
		$35 000 to $49 999	1.21 *(1.11, 1.32)*	< 0.001*
		$25 000 to $34 999	1.37 *(1.26, 1.50)*	< 0.001*
		$20 000 to $24 999	1.36 *(1.23, 1.51)*	< 0.001*
		$15 000 to $19 999	1.52 *(1.36, 1.69)*	< 0.001*
		$10 000 to $14 999	1.54 *(1.35, 1.77)*	< 0.001*
		Less than $10 000	1.96 *(1.70, 2.27)*	< 0.001*
2003	*Employment Status*	Employed for wages	0.069 *(0.062, 0.077)*	
		Homemaker	1.06 *(1.00, 1.13)*	0.052
		Retired	1.37 *(1.29, 1.45)*	< 0.001*
		Self-employed	0.891 *(0.835, 0.952)*	< 0.001*
		Student	0.838 *(0.714, 0.983)*	0.030*
		Unable to work	4.20 *(3.87, 4.55)*	< 0.001*
		Unemployed	1.48 *(1.36, 1.61)*	< 0.001*
	Education Level	College graduate	0.050 *(0.045, 0.056)*	
		Some college/technical school	1.45 *(1.39, 1.52)*	< 0.001*
		High school graduate	1.47 *(1.41, 1.54)*	< 0.001*
		Some high school	1.69 *(1.57, 1.81)*	< 0.001*
		Elementary school	1.25 *(1.15, 1.37)*	< 0.001*
		No formal education/kindergarten only	1.38 *(0.954, 2.00)*	0.087
	Income Bracket	$75 000 or more	0.052 (0.064, 0.059)	
		$50 000 to $74 999	1.19 (1.12, 1.26)	< 0.001*
		$35 000 to $49 999	1.31 (1.24, 1.39)	< 0.001*
		$25 000 to $34 999	1.41 (1.32, 1.51)	< 0.001*
		$20 000 to $24 999	1.51 (1.41, 1.62)	< 0.001*
		$15 000 to $19 999	1.59 (1.47, 1.72)	< 0.001*
		$10 000 to $14 999	1.77 (1.62, 1.93)	< 0.001*
		Less than $10 000	2.02 (1.85, 2.20)	< 0.001*
2004	*Employment Status*	Employed for wages	0.057 *(0.045, 0.072)*	
		Homemaker	1.07 *(0.945, 1.22)*	0.275
		Retired	1.35 *(1.20, 1.52)*	< 0.001*
		Self-employed	0.989 *(0.866, 1.13)*	0.865
		Student	0.843 *(0.591, 1.20)*	0.348
		Unable to work	4.54 *(3.88, 5.30)*	< 0.001*
		Unemployed	1.40 *(1.16, 1.68)*	< 0.001*
	Education Level	College graduate	0.040 *(0.032, 0.051)*	
		Some college/technical school	1.60 *(1.46, 1.75)*	< 0.001*
		High school graduate	1.54 *(1.41, 1.68)*	< 0.001*
		Some high school	1.85 *(1.59, 2.16)*	< 0.001*

		Elementary school	1.54 *(1.28, 1.88)*	< 0.001*
		No formal education/kindergarten only	0.632 *(0.260, 1.53)*	0.311
	Income Bracket	$75 000 or more	0.038 *(0.029, 0.050)*	
		$50 000 to $74 999	1.23 *(1.12, 1.41)*	< 0.001*
		$35 000 to $49 999	1.32 *(1.18, 1.49)*	< 0.001*
		$25 000 to $34 999	1.46 *(1.29, 1.66)*	< 0.001*
		$20 000 to $24 999	1.52 *(1.32, 1.75)*	< 0.001*
		$15 000 to $19 999	1.71 *(1.46, 2.00)*	< 0.001*
		$10 000 to $14 999	1.78 *(1.48, 2.14)*	< 0.001*
		Less than $10 000	2.45 *(2.05, 2.92)*	< 0.001*
	Employment Status	Employed for wages	0.062 *(0.055, 0.070)*	
		Homemaker	0.995 *(0.939, 1.05)*	0.855
		Retired	1.40 *(1.33, 1.48)*	< 0.001*
		Self-employed	0.906 *(0.854, 0.961)*	< 0.001*
		Student	0.873 *(0.745, 1.02)*	0.091
		Unable to work	4.16 *(3.88, 4.46)*	< 0.001*
		Unemployed	1.36 *(1.25, 1.47)*	< 0.001*
2005	*Education Level*	College graduate	0.047 *(0.042, 0.053)*	
		Some college/technical school	1.39 *(1.34, 1.45)*	< 0.001*
		High school graduate	1.41 *(1.36, 1.47)*	< 0.001*
		Some high school	1.74 *(1.63, 1.85)*	< 0.001*
		Elementary school	1.20 *(1.09, 1.31)*	< 0.001*
		No formal education/kindergarten only	1.07 *(0.771, 1.48)*	0.692
	Income Bracket	$75 000 or more	0.047 *(0.041, 0.054)*	
		$50 000 to $74 999	1.27 *(1.20, 1.33)*	< 0.001*
		$35 000 to $49 999	1.37 *(1.30, 1.44)*	< 0.001*
		$25 000 to $34 999	1.41 *(1.34, 1.49)*	< 0.001*
		$20 000 to $24 999	1.52 *(1.43, 1.62)*	< 0.001*
		$15 000 to $19 999	1.65 *(1.55, 1.77)*	< 0.001*
		$10 000 to $14 999	1.83 *(1.70, 1.98)*	< 0.001*
		Less than $10 000	1.96 *(1.81, 2.12)*	< 0.001*
	Employment Status	Employed for wages	0.061 *(0.053, 0.071)*	
		Homemaker	1.06 *(1.01, 1.12)*	0.031*
		Retired	1.39 *(1.32, 1.45)*	< 0.001*
		Self-employed	0.943 *(0.891, 0.997)*	0.040*
		Student	0.898 *(0.748, 1.08)*	0.247
		Unable to work	4.35 *(4.10, 4.63)*	< 0.001*
		Unemployed	1.43 *(1.32, 1.55)*	< 0.001*
2007	*Education Level*	College graduate	0.045 *(0.039, 0.052)*	
		Some college/technical school	1.46 *(1.41, 1.52)*	< 0.001*
		High school graduate	1.49 *(1.44, 1.54)*	< 0.001*
		Some high school	1.66 *(1.56, 1.76)*	< 0.001*
		Elementary school	1.18 *(1.07, 1.29)*	< 0.001*
		No formal education/kindergarten only	1.19 *(0.829, 1.69)*	0.350
	Income Bracket	$75 000 or more	0.048 *(0.041, 0.057)*	
		$50 000 to $74 999	1.17 *(1.12, 1.22)*	< 0.001*
		$35 000 to $49 999	1.31 *(1.25, 1.37)*	< 0.001*

		$25 000 to $34 999	1.38 *(1.30, 1.45)*	< 0.001*
		$20 000 to $24 999	1.43 *(1.35, 1.52)*	< 0.001*
		$15 000 to $19 999	1.58 *(1.48, 1.68)*	< 0.001*
		$10 000 to $14 999	1.79 *(1.64, 1.95)*	< 0.001*
		Less than $10 000	1.87 *(1.73, 2.03)*	< 0.001*
2009	*Employment Status*	Employed for wages	0.045 *(0.038, 0.053)*	
		Homemaker	1.06 *(1.01, 1.13)*	0.031*
		Retired	1.41 *(1.35, 1.47)*	< 0.001*
		Self-employed	0.943 *(0.893, 0.996)*	0.037 *
		Student	0.907 *(0.761, 1.08)*	0.273
		Unable to work	4.76 *(4.48, 5.06)*	< 0.001*
		Unemployed	1.35 *(1.27, 1.44)*	< 0.001*
	Education Level	College graduate	0.033 *(0.028, 0.038)*	
		Some college/technical school	1.51 *(1.46, 1.56)*	< 0.001*
		High school graduate	1.52 *(1.47, 1.58)*	< 0.001*
		Some high school	1.76 *(1.65, 1.88)*	< 0.001*
		Elementary school	1.19 *(1.11, 1.28)*	< 0.001*
		No formal education/kindergarten only	0.625 *(0.428, 0.913)*	0.015*
	Income Bracket	$75 000 or more	0.037 *(0.031, 0.044)*	
		$50 000 to $74 999	1.25 *(1.20, 1.30)*	< 0.001*
		$35 000 to $49 999	1.33 *(1.28, 1.40)*	< 0.001*
		$25 000 to $34 999	1.35 *(1.29, 1.42)*	< 0.001*
		$20 000 to $24 999	1.55 *(1.46, 1.64)*	< 0.001*
		$15 000 to $19 999	1.65 *(1.56, 1.76)*	< 0.001*
		$10 000 to $14 999	1.89 *(1.77, 2.02)*	< 0.001*
		Less than $10 000	1.97 *(1.82, 2.14)*	< 0.001*
2010'	*Employment Status*	Employed for wages	0.043 *(0.028, 0.066)*	
		Homemaker	1.19 *(1.03, 1.37)*	0.017*
		Retired	1.45 *(1.30, 1.62)*	< 0.001*
		Self-employed	0.915 *(0.788, 1.06)*	0.248
		Student	1.13 *(0.709, 1.79)*	0.614
		Unable to work	4.63 *(4.05, 5.30)*	< 0.001*
		Unemployed	1.39 *(1.14, 1.70)*	< 0.001*
	Education Level	College graduate	0.031 *(0.021, 0.047)*	
		Some college/technical school	1.63 *(1.47, 1.80)*	< 0.001*
		High school graduate	1.53 *(1.49, 2.12)*	< 0.001*
		Some high school	2.05 *(1.77, 2.37)*	< 0.001*
		Elementary school	1.78 *(1.49, 2.12)*	< 0.001*
		No formal education/kindergarten only	0.805 *(0.239, 2.71)*	0.726
	Income Bracket	$75 000 or more	0.030 *(0.018, 0.049)*	
		$50 000 to $74 999	1.15 *(1.02, 1.31)*	0.028*
		$35 000 to $49 999	1.27 *(1.12, 1.45)*	< 0.001*
		$25 000 to $34 999	1.25 *(1.09, 1.43)*	0.001*
		$20 000 to $24 999	1.66 *(1.41, 1.94)*	< 0.001*
		$15 000 to $19 999	1.96 *(1.60, 2.31)*	< 0.001*
		$10 000 to $14 999	2.52 *(2.10, 3.03)*	< 0.001*
		Less than $10 000	2.16 *(1.80, 2.60)*	< 0.001*

2011	*Employment Status*	Employed for wages	0.036 *(0.032, 0.042)*	
		Homemaker	1.13 *(1.08, 1.19)*	< 0.001*
		Retired	1.53 *(1.47, 1.60)*	< 0.001*
		Self-employed	0.984 *(0.931, 1.04)*	0.572
		Student	0.968 *(0.828, 1.13)*	0.684
		Unable to work	5.40 *(5.11, 5.70)*	< 0.001*
		Unemployed	1.51 *(1.42, 1.60)*	< 0.001*
	Education Level	College graduate	0.026 *(0.023, 0.029)*	
		Some college/technical school	1.56 *(1.51, 1.62)*	< 0.001*
		High school graduate	1.63 *(1.58, 1.68)*	< 0.001*
		Some high school	2.13 *(2.02, 2.25)*	< 0.001*
		Elementary school	1.60 *(1.49, 1.71)*	< 0.001*
		No formal education/kindergarten only	1.70 *(1.23, 2.35)*	0.001*
	Income Bracket	$75 000 or more	0.026 *(0.023, 0.030)*	
		$50 000 to $74 999	1.28 *(1.22, 1.33)*	< 0.001*
		$35 000 to $49 999	1.40 *(1.34, 1.47)*	< 0.001*
		$25 000 to $34 999	1.54 *(1.46, 1.62)*	< 0.001*
		$20 000 to $24 999	1.74 *(1.65, 1.83)*	< 0.001*
		$15 000 to $19 999	1.88 *(1.77, 1.99)*	< 0.001*
		$10 000 to $14 999	2.36 *(2.22, 2.52)*	< 0.001*
		Less than $10 000	2.26 *(2.12, 2.41)*	< 0.001*
2012	*Employment Status*	Employed for wages	0.038 *(0.033, 0.043)*	
		Homemaker	1.19 *(1.12, 1.26)*	< 0.001*
		Retired	1.59 *(1.52, 1.66)*	< 0.001*
		Self-employed	0.980 *(0.926, 1.04)*	0.493
		Student	1.01 *(0.870, 1.16)*	0.935
		Unable to work	5.64 *(5.32, 5.98)*	< 0.001*
		Unemployed	1.54 *(1.44, 1.64)*	< 0.001*
	Education Level	College graduate	0.027 *(0.024, 0.030)*	
		Some college/technical school	1.62 *(1.57, 1.68)*	< 0.001*
		High school graduate	1.68 *(1.63, 1.74)*	< 0.001*
		Some high school	2.22 *(2.10, 2.36)*	< 0.001*
		Elementary school	1.60 *(1.47, 1.73)*	< 0.001*
		No formal education/kindergarten only	1.32 *(0.893, 1.96)*	0.163
	Income Bracket	$75 000 or more	0.027 *(0.024, 0.031)*	
		$50 000 to $74 999	1.24 *(1.18, 1.30)*	< 0.001*
		$35 000 to $49 999	1.35 *(1.29, 1.42)*	< 0.001*
		$25 000 to $34 999	1.57 *(1.49, 1.66)*	< 0.001*
		$20 000 to $24 999	1.76 *(1.67, 1.86)*	< 0.001*
		$15 000 to $19 999	1.91 *(1.80, 2.03)*	< 0.001*
		$10 000 to $14 999	2.39 *(2.23, 2.56)*	< 0.001*
		Less than $10 000	2.40 *(2.24, 2.56)*	< 0.001*
2013	*Employment Status*	Employed for wages	0.035 *(0.031, 0.040)*	
		Homemaker	1.14 *(1.07, 1.21)*	< 0.001*
		Retired	1.51 *(1.45, 1.58)*	< 0.001*
		Self-employed	0.942 *(0.890, 0.997)*	0.038*

		Student	1.05 *(0.906, 1.23)*	0.500
		Unable to work	5.43 *(5.14, 5.73)*	< 0.001*
		Unemployed	1.66 *(1.56, 1.77)*	< 0.001*
	Education Level	College graduate	0.026 *(0.023, 0.029)*	
		Some college/technical school	1.57 *(1.52, 1.63)*	< 0.001*
		High school graduate	1.63 *(1.57, 1.68)*	< 0.001*
		Some high school	2.20 *(2.08, 2.33)*	< 0.001*
		Elementary school	1.46 *(1.35, 1.58)*	< 0.001*
		No formal education/kindergarten only	1.34 *(0.957, 1.88)*	0.088
	Income Bracket	$75 000 or more	0.027 *(0.024, 0.030)*	
		$50 000 to $74 999	1.29 *(1.24, 1.36)*	< 0.001*
		$35 000 to $49 999	1.41 *(1.34, 1.48)*	< 0.001*
		$25 000 to $34 999	1.53 *(1.46, 1.62)*	< 0.001*
		$20 000 to $24 999	1.87 *(1.76, 1.97)*	< 0.001*
		$15 000 to $19 999	1.90 *(1.80, 2.02)*	< 0.001*
		$10 000 to $14 999	2.23 *(2.09, 2.38)*	< 0.001*
		Less than $10 000	2.46 *(2.30, 2.64)*	< 0.001*
2014	*Employment Status*	Employed for wages	0.033 *(0.029, 0.037)*	
		Homemaker	1.14 *(1.07, 1.21)*	< 0.001*
		Retired	1.57 *(1.50, 1.64)*	< 0.001*
		Self-employed	0.942 *(0.890, 0.997)*	0.038*
		Student	1.04 *(0.885, 1.22)*	0.652
		Unable to work	5.32 *(5.05, 5.60)*	< 0.001*
		Unemployed	1.66 *(1.54, 1.78)*	< 0.001*
	Education Level	College graduate	0.023 *(0.021, 0.026)*	
		Some college/technical school	1.61 *(1.55, 1.66)*	< 0.001*
		High school graduate	1.66 *(1.61, 1.72)*	< 0.001*
		Some high school	2.18 *(2.06, 2.32)*	< 0.001*
		Elementary school	1.51 *(1.40, 1.63)*	< 0.001*
		No formal education/kindergarten only	1.02 *(0.754, 1.38)*	0.893
	Income Bracket	$75 000 or more	0.024 *(0.021, 0.028)*	
		$50 000 to $74 999	1.27 *(1.22, 1.33)*	< 0.001*
		$35 000 to $49 999	1.45 *(1.39, 1.52)*	< 0.001*
		$25 000 to $34 999	1.59 *(1.51, 1.68)*	< 0.001*
		$20 000 to $24 999	1.76 *(1.67, 1.86)*	< 0.001*
		$15 000 to $19 999	1.93 *(1.82, 2.05)*	< 0.001*
		$10 000 to $14 999	2.28 *(2.14, 2.44)*	< 0.001*
		Less than $10 000	2.39 *(2.23, 2.56)*	< 0.001*
2015	*Employment Status*	Employed for wages	0.035 *(0.031, 0.039)*	
		Homemaker	1.24 *(1.17, 1.32)*	< 0.001*
		Retired	1.64 *(1.57, 1.72)*	< 0.001*
		Self-employed	0.948 *(0.895, 1.00)*	0.070
		Student	0.978 *(0.842, 1.14)*	0.773
		Unable to work	5.26 *(5.00, 5.55)*	< 0.001*
		Unemployed	1.53 *(1.43, 1.63)*	< 0.001*

	Education Level	College graduate	0.024 *(0.022, 0.027)*	
		Some college/technical school	1.61 *(1.56, 1.67)*	< 0.001*
		High school graduate	1.68 *(1.63, 1.74)*	< 0.001*
		Some high school	2.12 *(2.00, 2.24)*	< 0.001*
		Elementary school	1.43 *(1.33, 1.55)*	< 0.001*
		No formal education/kindergarten only	1.05 *(0.791, 1.49)*	0.809
	Income Bracket	$75 000 or more	0025 *(0.022, 0.028)*	
		$50 000 to $74 999	1.31 *(1.25, 1.37)*	< 0.001*
		$35 000 to $49 999	1.46 *(1.39, 1.53)*	< 0.001*
		$25 000 to $34 999	1.54 *(1.46, 1.62)*	< 0.001*
		$20 000 to $24 999	1.75 *(1.65, 1.85)*	< 0.001*
		$15 000 to $19 999	1.80 *(1.70, 1.92)*	< 0.001*
		$10 000 to $14 999	2.34 *(2.19, 2.51)*	< 0.001*
		Less than $10 000	2.33 *(2.17, 2.50)*	< 0.001*
	Employment Status	Employed for wages	0.036 *(0.032, 0.041)*	
		Homemaker	1.15 *(1.08, 1.22)*	< 0.001*
		Retired	1.66 *(1.58, 1.73)*	< 0.001*
		Self-employed	0.944 *(0.892, 0.999)*	0.044*
		Student	0.893 *(0.759, 1.05)*	0.169
		Unable to work	5.18 *(4.91, 5.46)*	< 0.001*
		Unemployed	1.61 *(1.50, 1.73)*	< 0.001*
2016	*Education Level*	College graduate	0.025 *(0.022, 0.028)*	
		Some college/technical school	1.63 *(1.58, 1.69)*	< 0.001*
		High school graduate	1.63 *(1.58, 1.69)*	< 0.001*
		Some high school	2.14 *(2.02, 2.28)*	< 0.001*
		Elementary school	1.42 *(1.31, 1.53)*	< 0.001*
		No formal education/kindergarten only	1.20 *(0.882, 1.63)*	0.247
	Income Bracket	$75 000 or more	0.025 *(0.022, 0.028)*	
		$50 000 to $74 999	1.34 *(1.28, 1.40)*	< 0.001*
		$35 000 to $49 999	1.41 *(1.34, 1.48)*	< 0.001*
		$25 000 to $34 999	1.61 *(1.53, 1.70)*	< 0.001*
		$20 000 to $24 999	1.74 *(1.64, 1.84)*	< 0.001*
		$15 000 to $19 999	1.97 *(1.85, 2.09)*	< 0.001*
		$10 000 to $14 999	2.48 *(2.31, 2.66)*	< 0.001*
		Less than $10 000	2.31 *(2.15, 2.48)*	< 0.001*
	Employment Status	Employed for wages	0.036 *(0.031, 0.041)*	
		Homemaker	1.16 *(1.08, 1.25)*	< 0.001*
		Retired	1.51 *(1.43, 1.59)*	< 0.001*
		Self-employed	0.971 *(0.912, 1.03)*	0.348
		Student	0.875 *(0.733, 1.04)*	0.137
		Unable to work	5.23 *(4.93, 5.54)*	< 0.001*
		Unemployed	1.79 *(1.66, 1.93)*	< 0.001*
2017	*Education Level*	College graduate	0.024 *(0.021, 0.027)*	
		Some college/technical school	1.69 *(1.62, 1.75)*	< 0.001*
		High school graduate	1.61 *(1.56, 1.67)*	< 0.001*
		Some high school	2.17 *(2.03, 2.31)*	< 0.001*

		Elementary school	1.35 *(1.24, 1.48)*	< 0.001*
		No formal education/kindergarten only	0.892 *(0.612, 1.30)*	0.550
	Income Bracket	$75 000 or more	0.025 *(0.022, 0.029)*	
		$50 000 to $74 999	2.38 *(2.20, 2.58)*	< 0.001*
		$35 000 to $49 999	1.46 *(1.38, 1.54)*	< 0.001*
		$25 000 to $34 999	1.53 *(1.45, 1.63)*	< 0.001*
		$20 000 to $24 999	1.72 *(1.62, 1.83)*	< 0.001*
		$15 000 to $19 999	1.84 *(1.72, 1.97)*	< 0.001*
		$10 000 to $14 999	2.44 *(2.26, 2.64)*	< 0.001*
		Less than $10 000	2.38 *(2.20, 2.58)*	< 0.001*
	Employment Status	Employed for wages	0.041 *(0.036, 0.046)*	
		Homemaker	1.17 *(1.09, 1.26)*	< 0.001*
		Retired	1.58 *(1.50, 1.67)*	< 0.001*
		Self-employed	0.971 *(0.915, 1.03)*	0.323
		Student	0.801 *(0.679, 0.945)*	0.009*
		Unable to work	4.72 *(4.45, 5.01)*	< 0.001*
		Unemployed	1.59 *(1.46, 1.73)*	< 0.001*
2018	*Education Level*	College graduate	0.028 *(0.025, 0.031)*	
		Some college/technical school	1.62 *(1.56, 1.68)*	< 0.001*
		High school graduate	1.58 *(1.53, 1.64)*	< 0.001*
		Some high school	1.92 *(1.80, 2.05)*	< 0.001*
		Elementary school	1.32 *(1.20, 1.46)*	< 0.001*
		No formal education/kindergarten only	1.45 *(0.940, 2.24)*	0.093
	Income Bracket	$75 000 or more	0.030 *(0.026, 0.034)*	
		$50 000 to $74 999	1.33 *(1.27, 1.40)*	< 0.001*
		$35 000 to $49 999	1.41 *(1.33, 1.49)*	< 0.001*
		$25 000 to $34 999	1.41 *(1.33, 1.49)*	< 0.001*
		$20 000 to $24 999	1.72 *(1.62, 1.83)*	< 0.001*
		$15 000 to $19 999	1.93 *(1.80, 2.06)*	< 0.001*
		$10 000 to $14 999	2.15 *(1.99, 2.33)*	< 0.001*
		Less than $10 000	2.12 *(1.96, 2.30)*	< 0.001*

[α] Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[ᵻ] Y: Year

[ι] Module questionnaire years

* P < 0.05: for a significant difference between the comparator group (employed for wages, college graduate, and $75 000 or more, respectively) and remaining groups in the respective socioeconomic status index, by logistic regression analysis

5.2 National Health Interview Survey (NHIS)

Joint Symptoms

Using NHIS data from 2002 until 2018 (with the exception of 2004, where no stratum data was available to construct the design object), I calculated the prevalence of joint symptoms in US residents. The prevalence of joint symptoms was taken as those who answered "Yes" to the question, "The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?". I calculated the prevalence in various age groups and in the sexes, after accounting for appropriate complex survey design methods, and assigning appropriate design weights to the data. I also calculated the prevalence of joint symptoms at particular sites per age-sex divided demographic group, calculated as the proportion of people who mentioned a particular joint site as an area where they experience joint symptoms. Thereafter, I conducted adjusted annual logistic regressions to assess whether a particular age, sex, or socioeconomic status (indicated by employment status) was associated with having joint symptoms.

Tables consisting of all prevalence values (95% confidence intervals), odds ratios (95% confidence intervals) and p-values are available in the appendices. Age-specific statistics are available in Appendix H (Table II). Sex-specific statistics are available in Appendix I (Table II). Employment-specific statistics are available in Appendix J (Table II).

5.2.1 Joint symptoms by age

The prevalence of joint symptoms was calculated in 11 age groups, namely: 18- to 24-year-olds, 25- to 29-year-olds, 30- to 34-year-olds, 35- to 39-year-olds, 40- to 44-year-olds, 45- to 49-year-olds, 50- to 54-year-olds, 55- to 59-year-olds, 60- to 64-year-olds, 65- to 69-year-olds, and age 70 years and above. Thereafter, annual sex-adjusted logistic regressions were conducted, where the comparator group was the youngest age category, age 18 to 24 years.

In 18- to 24-year-olds, the prevalence of joint symptoms across all the years that I analysed was between 9.9% and 15.6%, and the most recent prevalence (2018) was 13.9%. In those aged 25 to 29 years, the prevalence of joint symptoms was between 13.4% and 18.8%, and the most recent prevalence was 17.3%. In 30- to 34-year-olds, the prevalence of joint symptoms was between

16.6% and 21.8%, and the most recent prevalence was 20.9%. In those aged 35 to 39 years, the prevalence of joint symptoms was between 19.4% and 24.6%, and the most recent prevalence was 23.4%. In 40- to 44-year-olds, the prevalence of joint symptoms was between 22.5% and 29.9%, and the most recent prevalence was 27.0%. In those aged 45 to 49 years, the prevalence of joint symptoms was between 30.6% and 36.2%, and the most recent prevalence was 33.3%. In 50- to 54-year-olds, the prevalence of joint symptoms was between 35.3% and 42.9%, and the most recent prevalence was 40.3%. In those aged 55 to 59 years, the prevalence of joint symptoms was between 39.4% and 48.7%, and he most recent prevalence was 44.9%. In the 60- to 64-year-old age group, the prevalence of joint symptoms was between 42.0% and 51.7%, and the most recent prevalence was 48.4%. In those aged 65 to 69 years, the prevalence of joint symptoms was between 40.1% and 51.9%, and the most recent prevalence was 51.1%. Finally, in those aged 70 years or above, the prevalence of joint symptoms was between 45.6% and 55.3%, where 55.3% was also the most recent prevalence. There was a progressive increasing trend in the prevalence of joint symptoms with age, where each increasing age group had incremental increases in prevalence of joint symptoms (Figure 5.3).

A sex-adjusted logistic regression showed that age was significantly associated with reporting joint symptoms, where those aged 18 to 24 years reported significantly fewer joint symptoms compared to all older age groups in all years of analysis. The only exception was no significant difference between the youngest two age groups in 2002, 2005 and 2009.

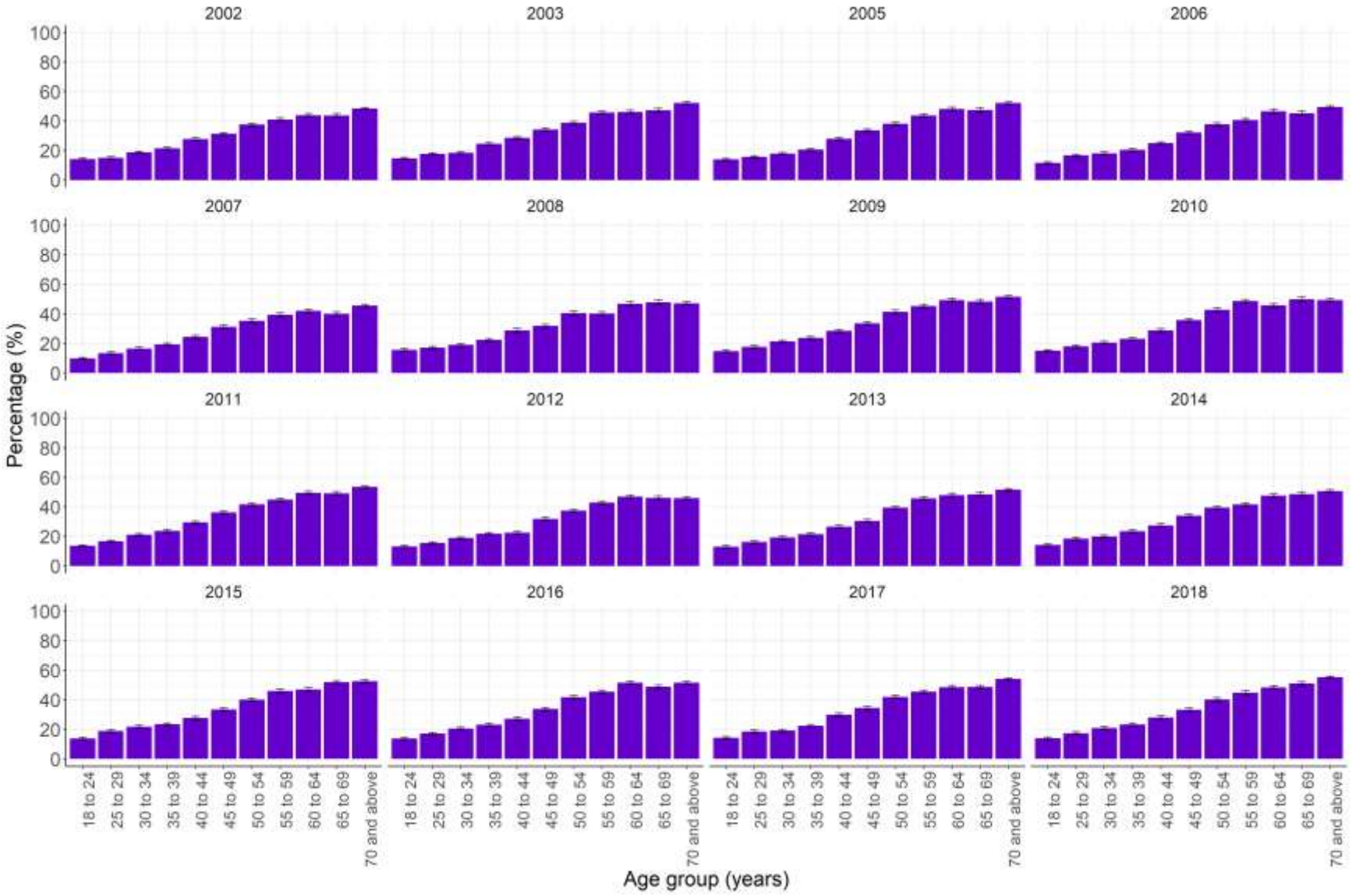


Figure 5.3: Prevalence (%) of US residents, by age group, who reported joint symptoms[α] in the previous 30 days, according to the National Health Interview Survey (NHIS)*, from 2002 until 2018

[α] Pain, aching, or stiffness

*Sample Adult Questionnaire

5.2.2 Joint symptoms by sex

The prevalence of joint symptoms was calculated in males and females, and annual age-adjusted logistic regressions were conducted, where the comparator group was males. In males, the prevalence of joint symptoms was between 25.2% and 33.4%, where 33.4% was also the most recent prevalence. In females, the prevalence of joint symptoms was between 29.9% and 37.1%, and the most recent prevalence was 35.1% (Figure 5.4). Annual age-adjusted logistic regressions showed that females consistently had statistically significantly more joint symptom reports than males ($P < 0.001$), except for 2018 ($P = 0.359$), where they were statistically similar.

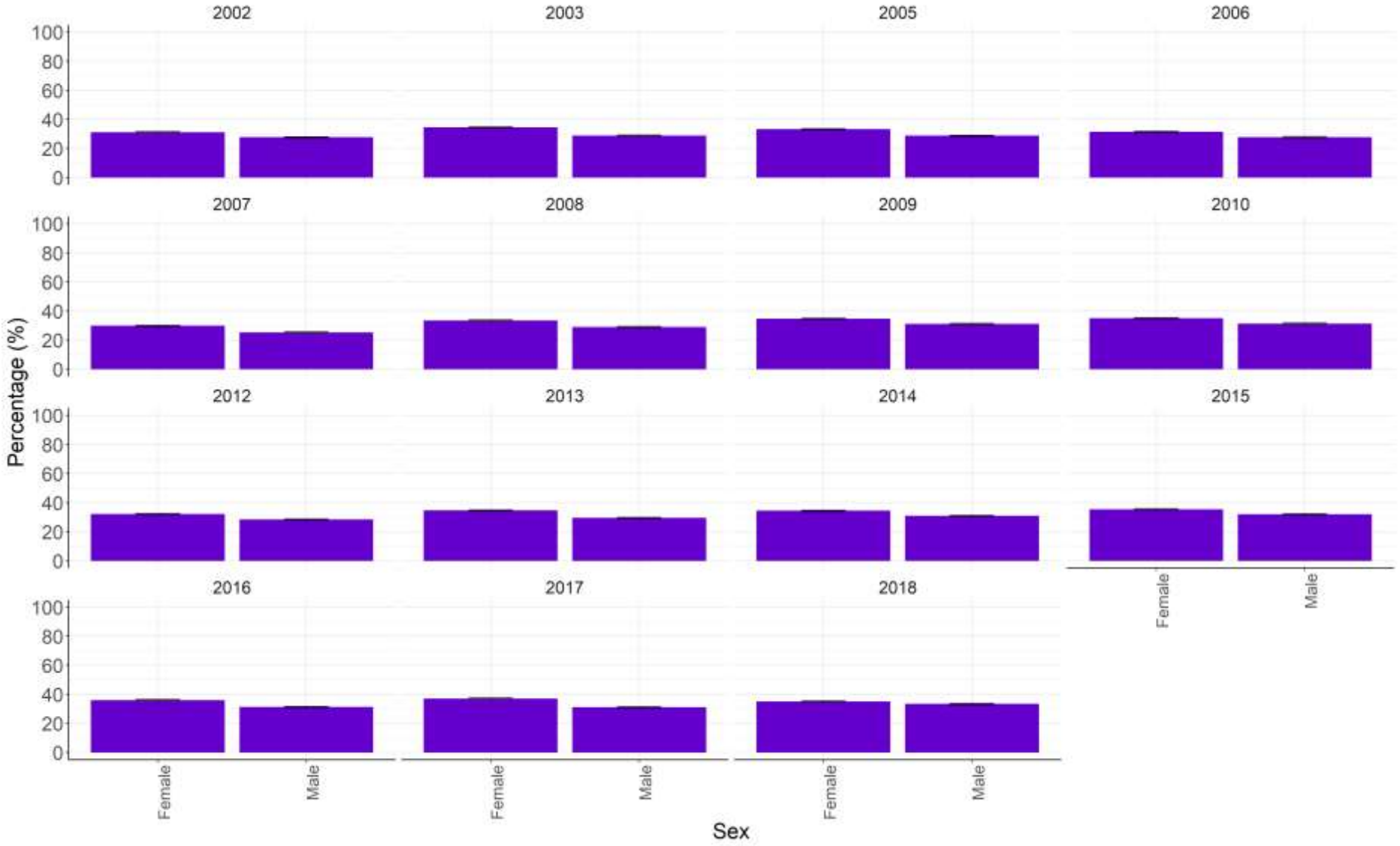


Figure 5.4: Prevalence (%) of US residents, by sex, who reported joint symptoms[α] in the previous 30 days, according to the National Health Interview Survey (NHIS)*, from 2002 until 2018

[α] Pain, aching, or stiffness

*Sample Adult Questionnaire

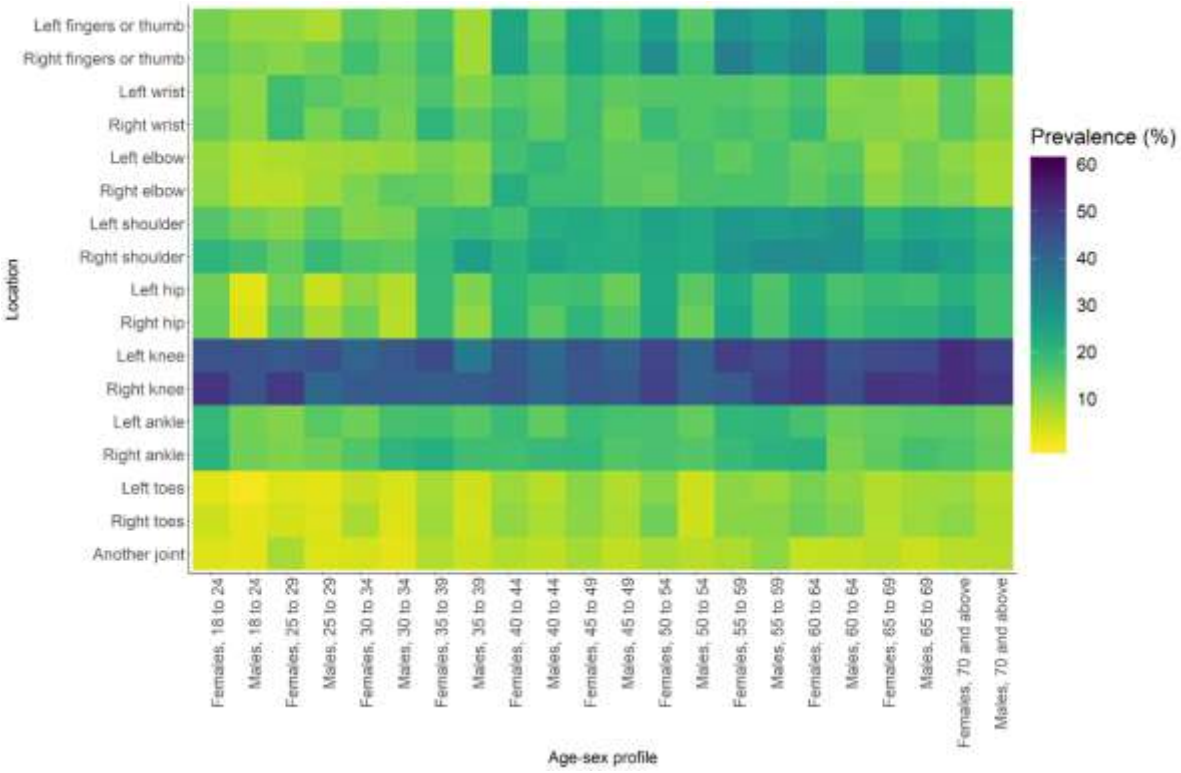
5.2.3 Interaction between age, sex and joint symptom location

NHIS survey participants who reported experiencing joint symptoms within the previous 30 days were asked which joints were affected, and the resultant cited joints were recorded as "Mentioned" when the participant cited a particular joint, and "Not mentioned" if they did not mention that joint. For each joint in the survey (including the left and right shoulders, left and right elbows, left and right wrists, fingers and thumbs on left and right hands, left and right hips, left and right knees, left and right ankles, toes on left and right feet, and an "other" joint location), I calculated the appropriately weighted proportion of locations mentioned in each age-sex demographic profile. The age-sex demographic profiles were females, aged 18 to 24 years; males, aged 18 to 24 years; females, aged 25 to 29 years; males, aged 25 to 29 years; females, aged 30 to 34 years; males, aged 30 to 34 years; females, aged 35 to 39 years; males, aged 35 to 39 years; females, aged 40 to 44 years; males, aged 40 to 44 years; females, aged 45 to 49 years; males, aged 45 to 49 years; females, aged 50 to 54 years; males, aged 50 to 54 years; females, aged 55 to 59 years; males, aged 55 to 59 years; females, aged 60 to 64 years; males, aged 60 to 64 years; females, aged 65 to 69 years; males, aged 65 to 69 years; females, aged 70 years and above; and males, aged 70 and above. I used the proportions of joint symptoms mentioned, and age-sex demographic groups to create heat maps for 2002 to 2018 (except 2004) to observe age-sex group differences in joints affected when joint symptoms were reported.

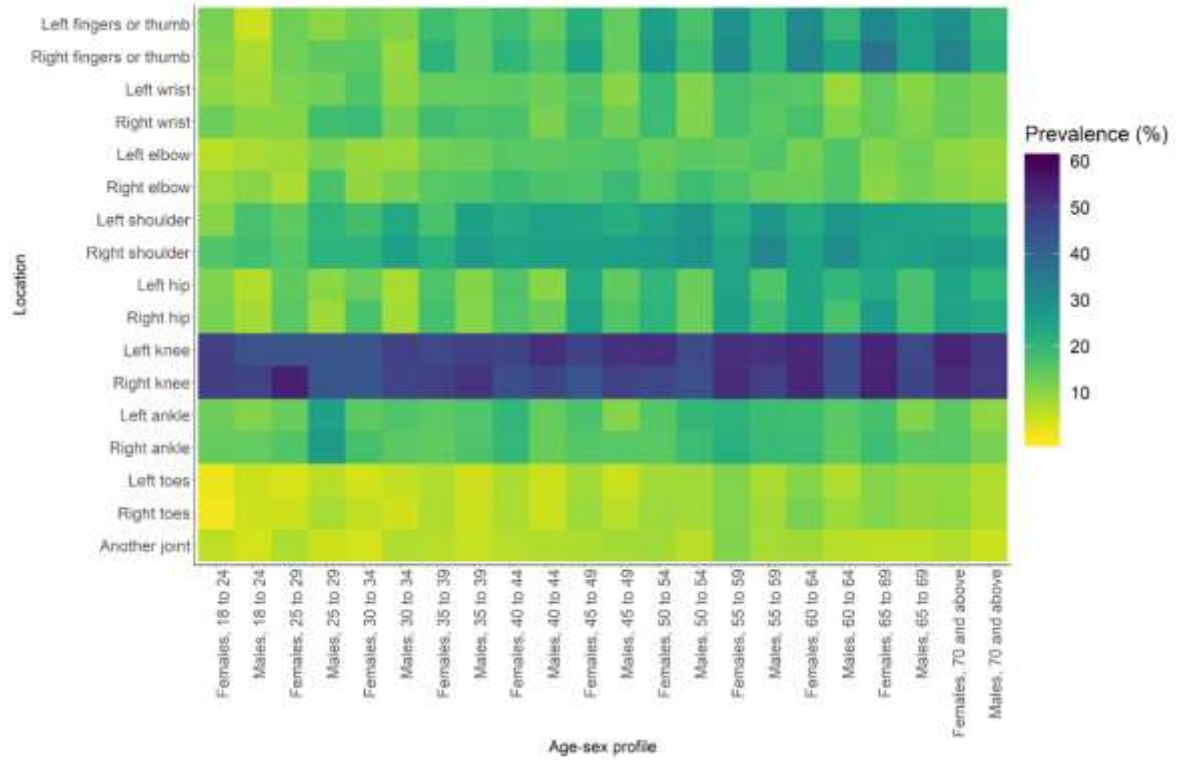
There was one very distinct joint site that was predominantly affected in people reporting joint symptoms, irrespective of demographic group: the knees. People of all ages and both sexes reported more knee-related joint symptoms compared to any other joint, across all years of analysis. The knee was cited up to 62% of the time as a site where there was pain, aching, or stiffness. Joint symptoms of the fingers/thumbs on both hands was low in younger groups, and increased slightly with older age in both sexes. Shoulder joint symptoms also increased with age in both sexes, however, in younger and middle-aged groups, males reported shoulder joint symptoms more often than females. Notably, the shoulder joints were the only joint region more frequently reported by males. Reports of hip joint symptoms was different between the sexes in younger age groups, where young adult women reported more hip-related joint symptoms compared to young adult men. Reports of elbow joint symptoms remain mostly steady across the adult lifetime and between sexes, where a small increase could be seen from around 30 years old

to 55 years old. The wrists and ankle joint symptom prevalences were generally low and remained steady across life. Wrist joint symptoms were reported slightly more by young females compared to age-matched males. Joint symptoms in the toes did increase slightly with age, but were low in comparison to other joint sites throughout the adult lifetime. The “another site” group was also very low across all demographic groups, suggesting that the joints most often affected by joint symptoms had already been marked as mentioned within the options for selection in the survey (Figure 5.5A-P).

A: 2002


Left fingers or thumb
Right fingers or thumb
Left wrist
Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

B: 2003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Left wrist
Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
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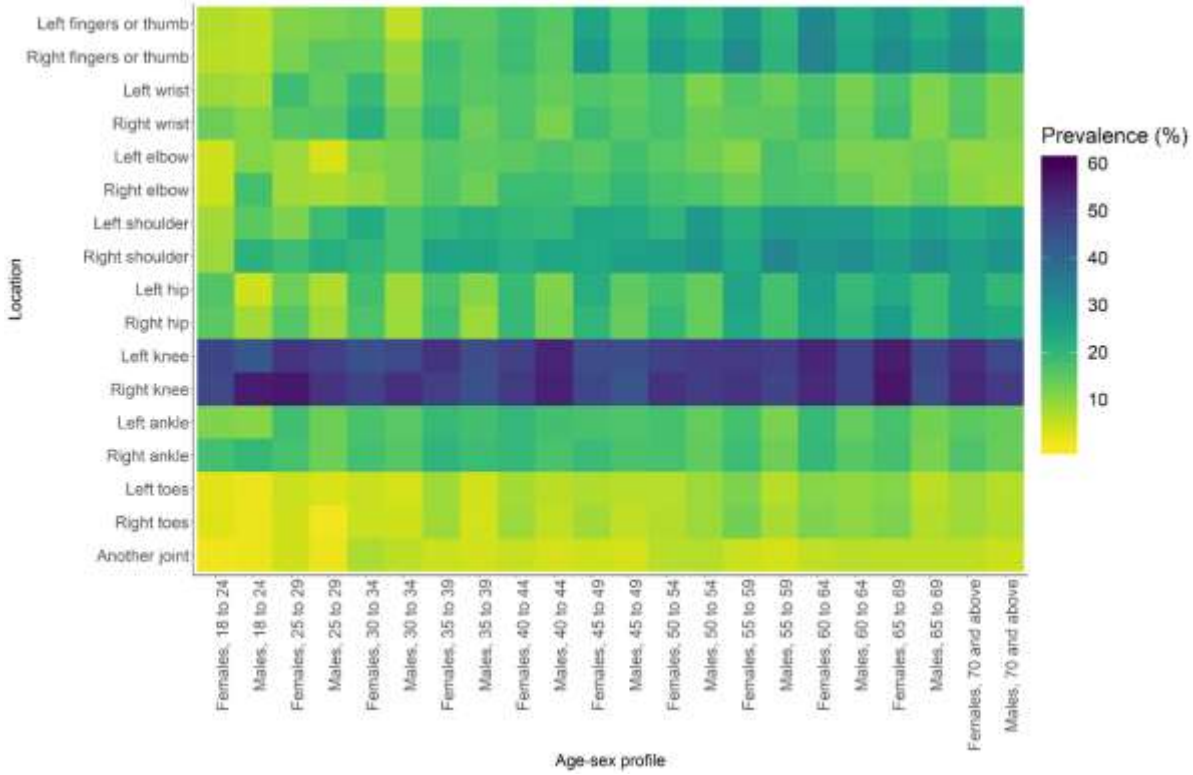
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

C: 2005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Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
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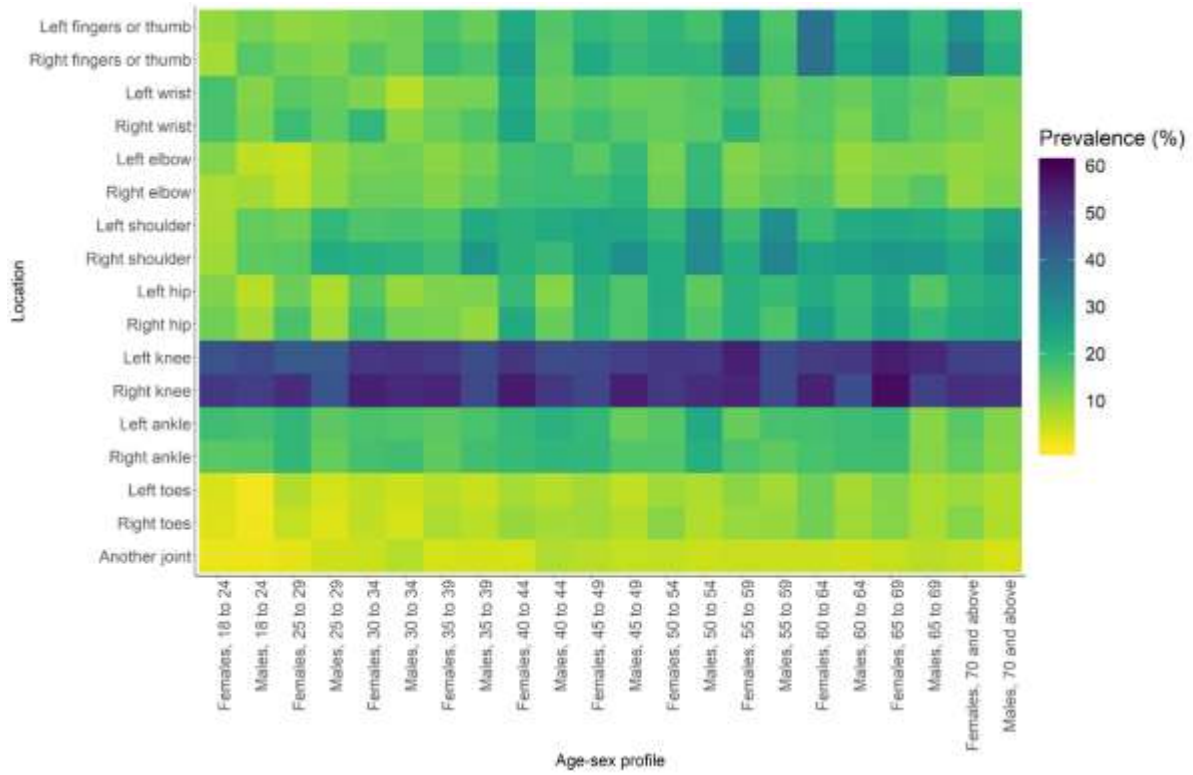
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

D: 2006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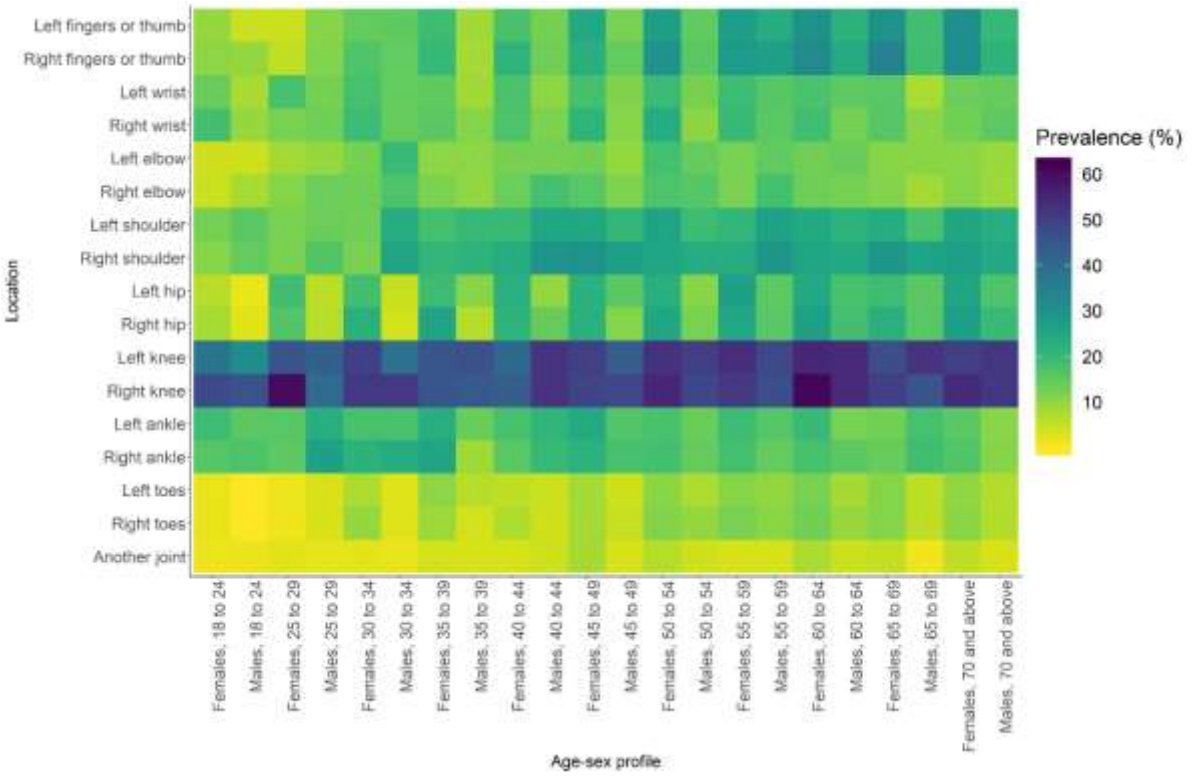
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

E: 2007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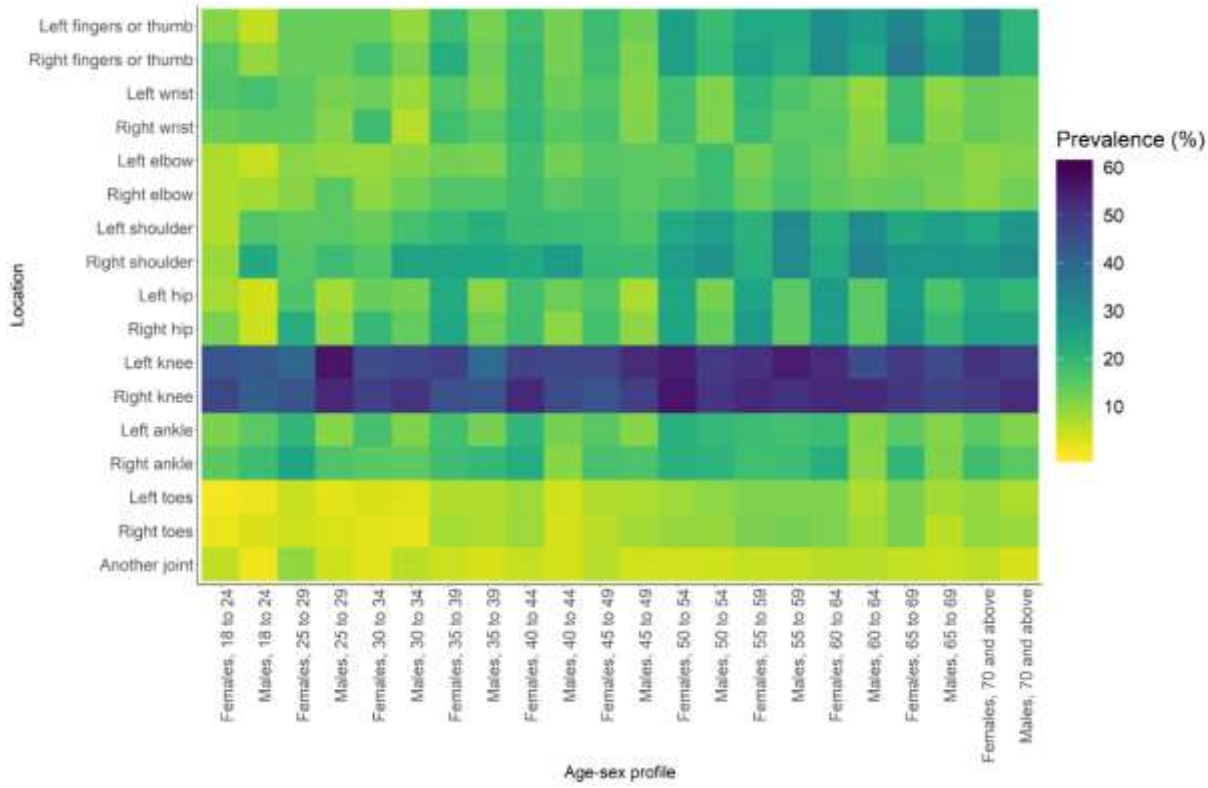
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

F: 2008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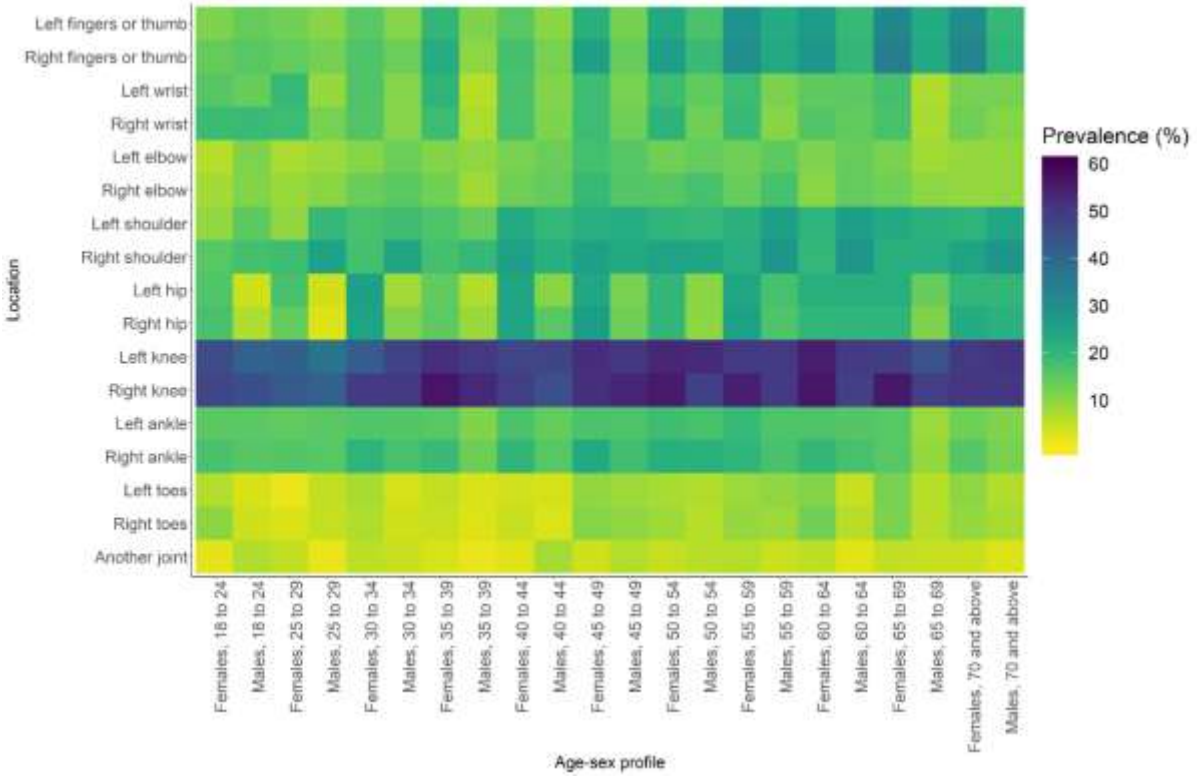
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

G: 2009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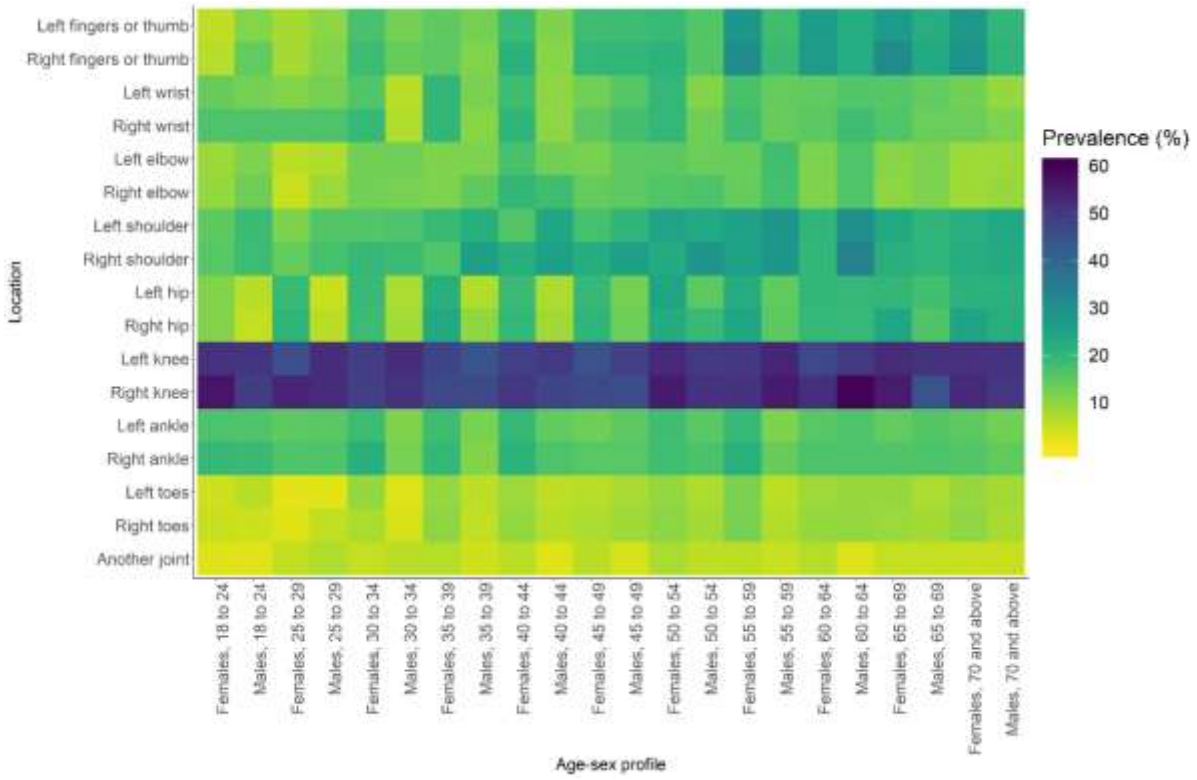
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

H: 2010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Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
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Left toes
Right toes
Another joint
Location
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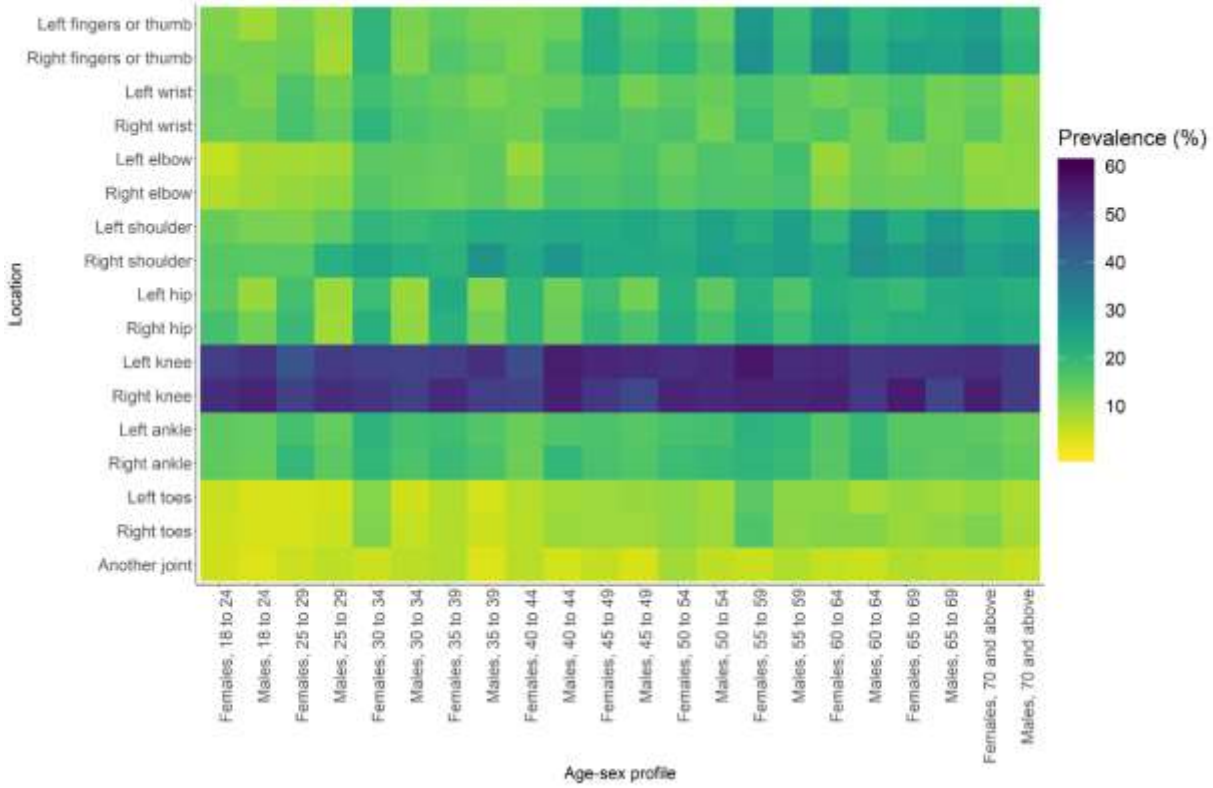
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

I: 2011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Right shoulder
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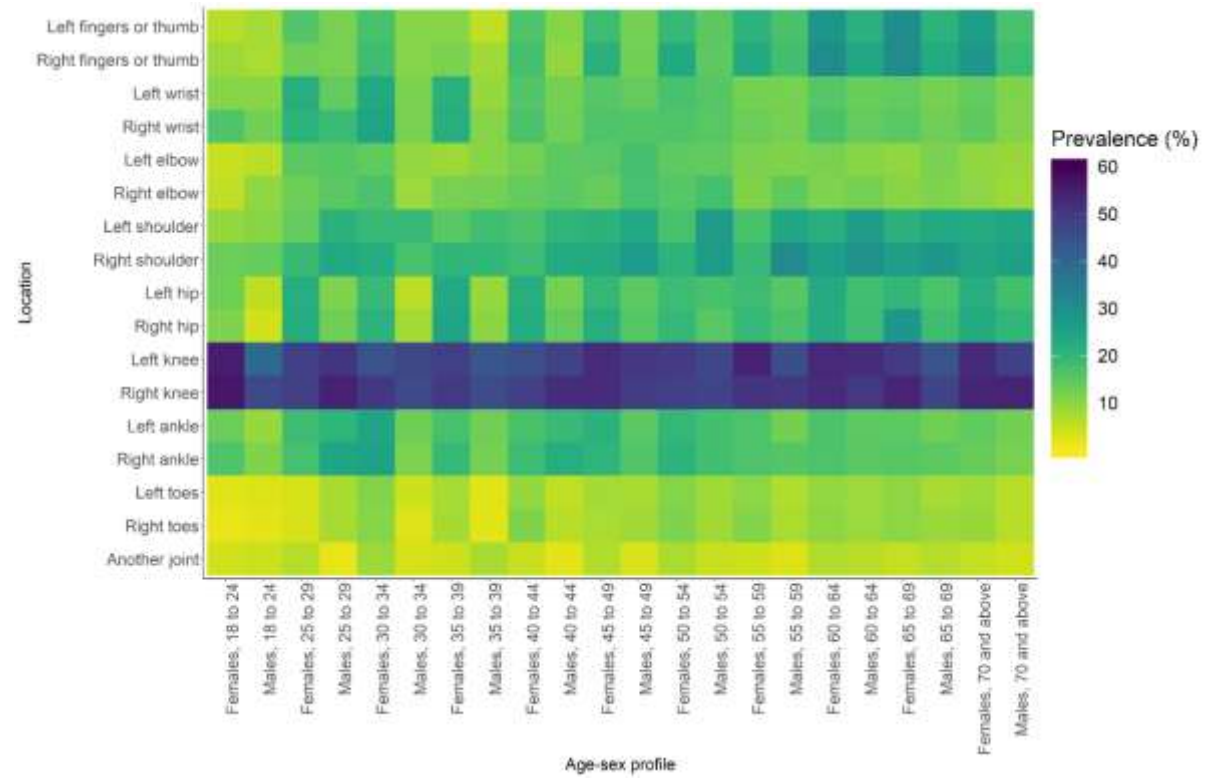
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

J: 2012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Right knee
Left ankle
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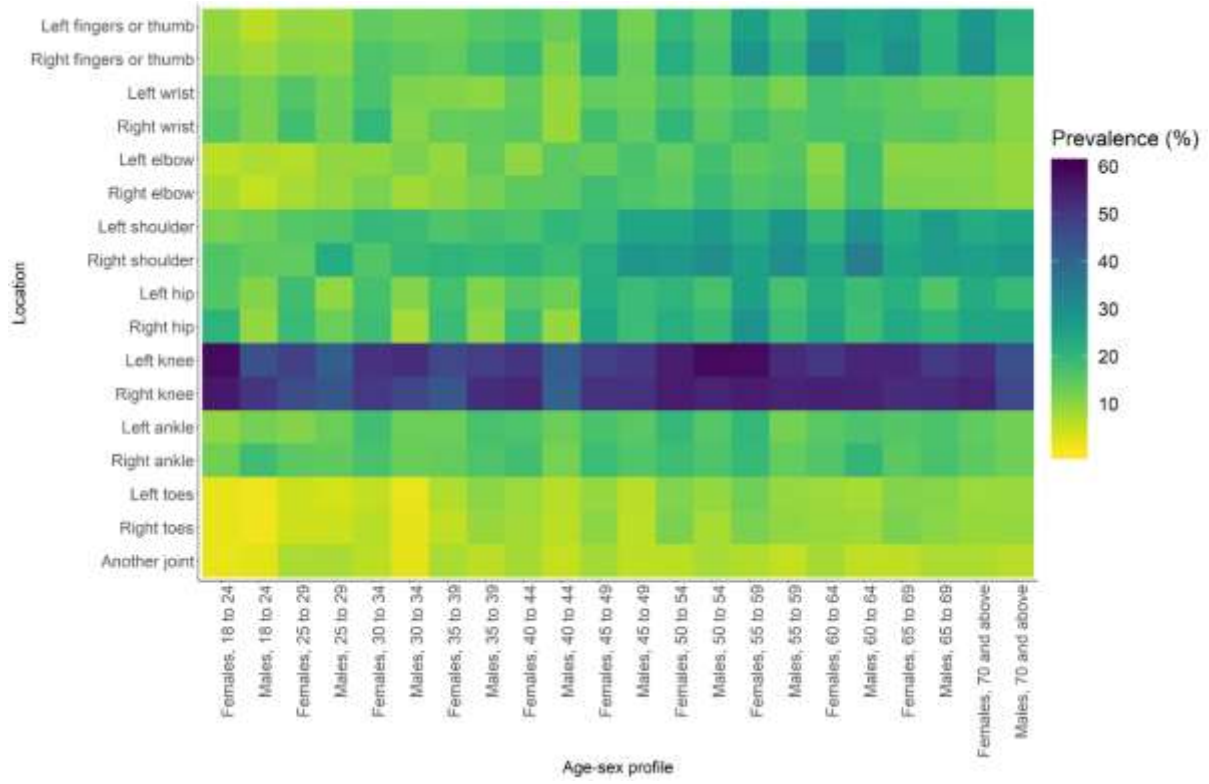
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

K: 2013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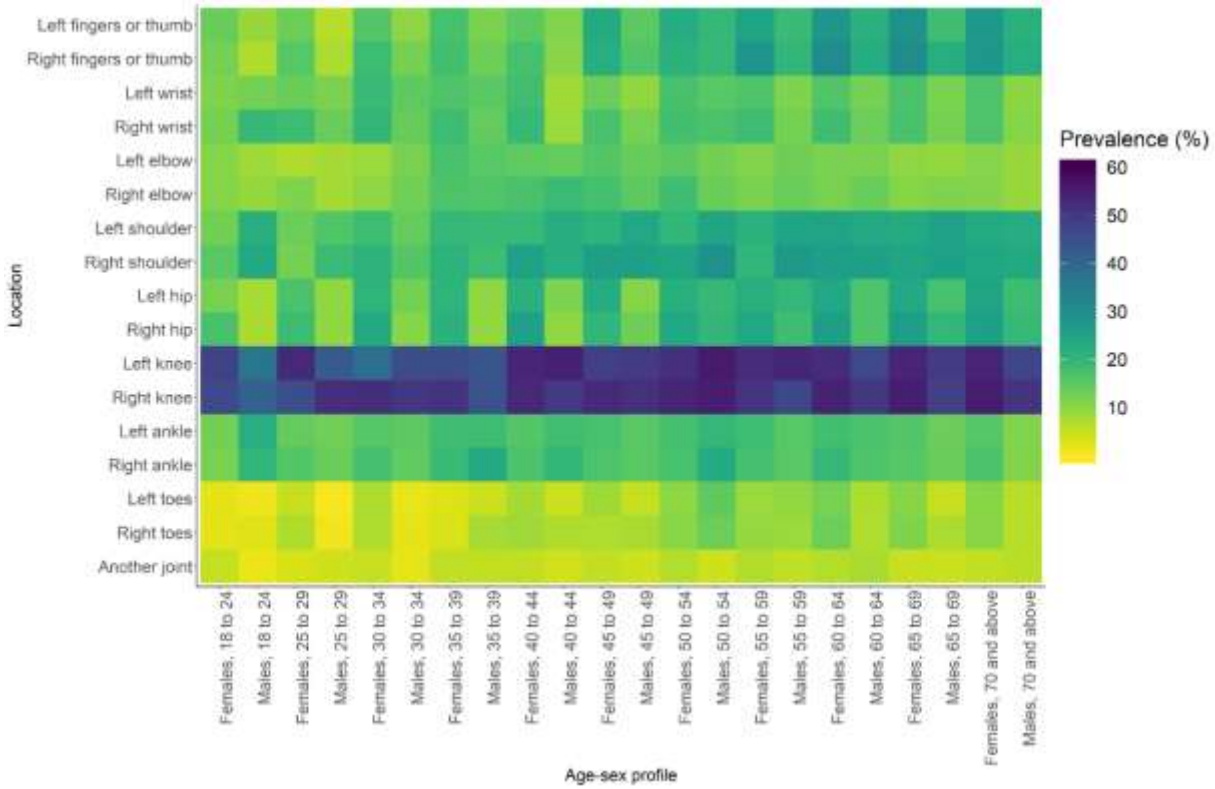
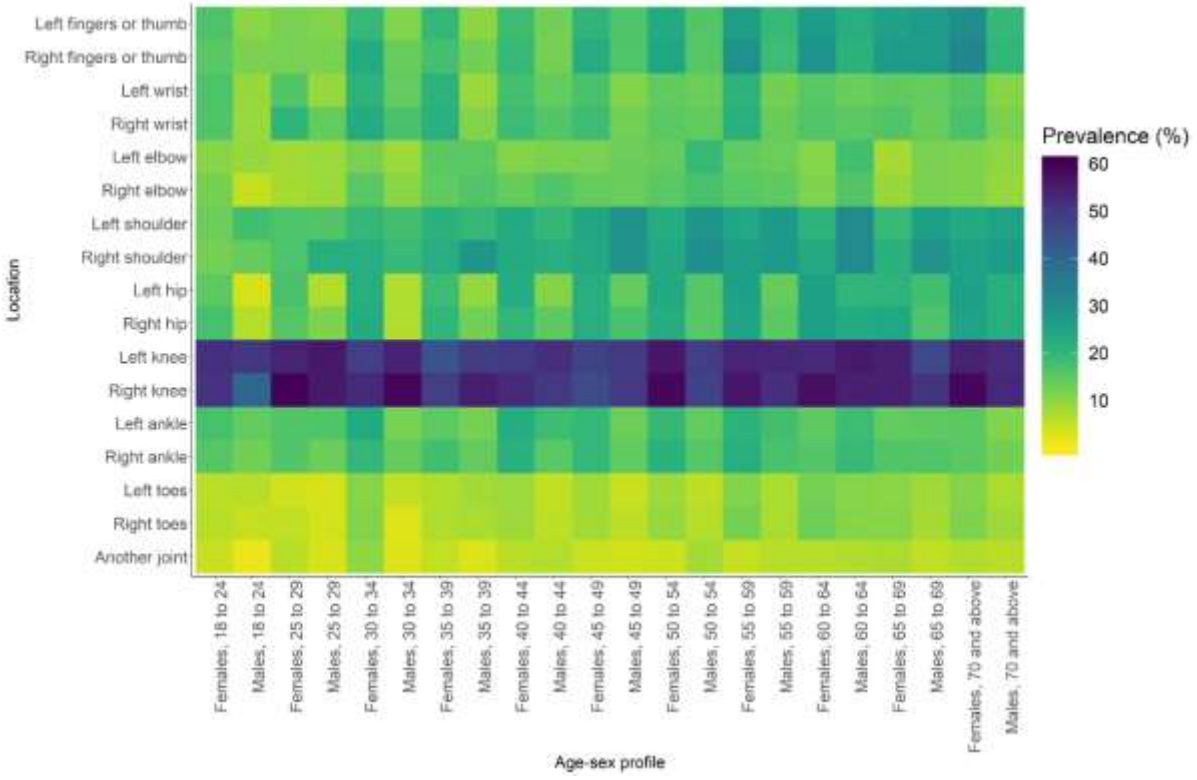
Right fingers or thumb
Left wrist
Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

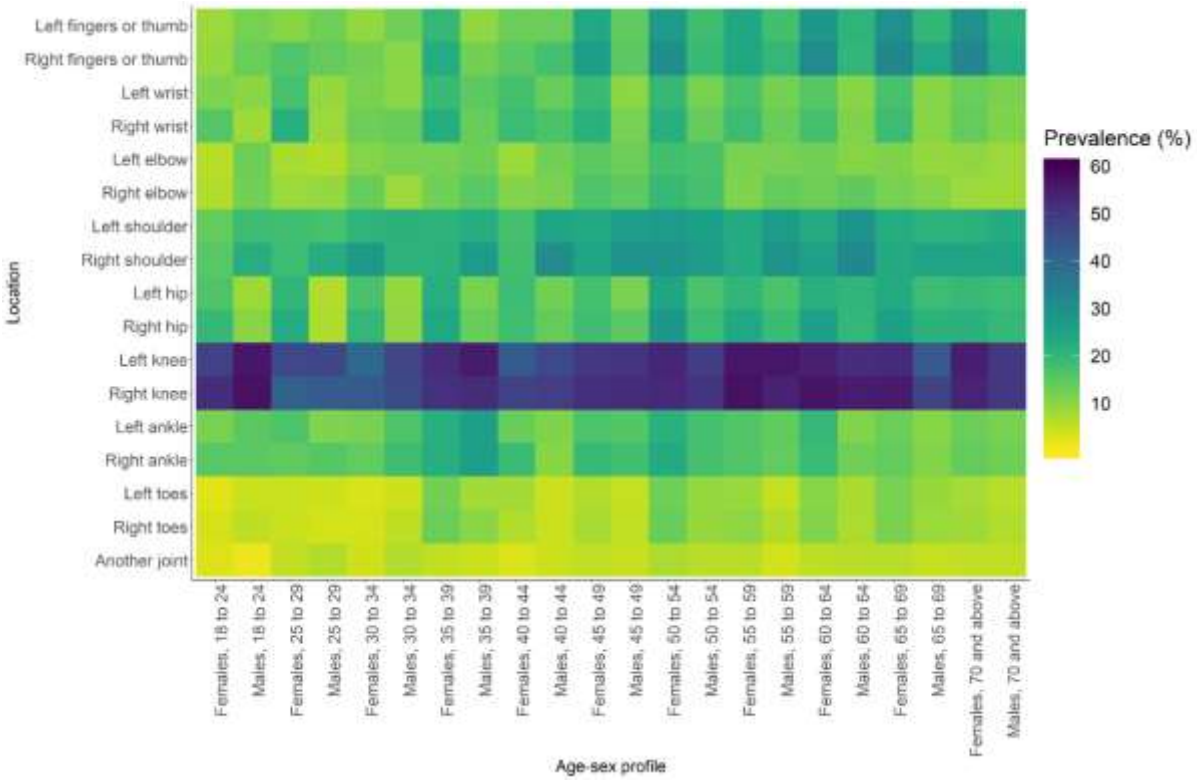
L: 2014


Left fingers or thumb
Right fingers or thumb
Left wrist
Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

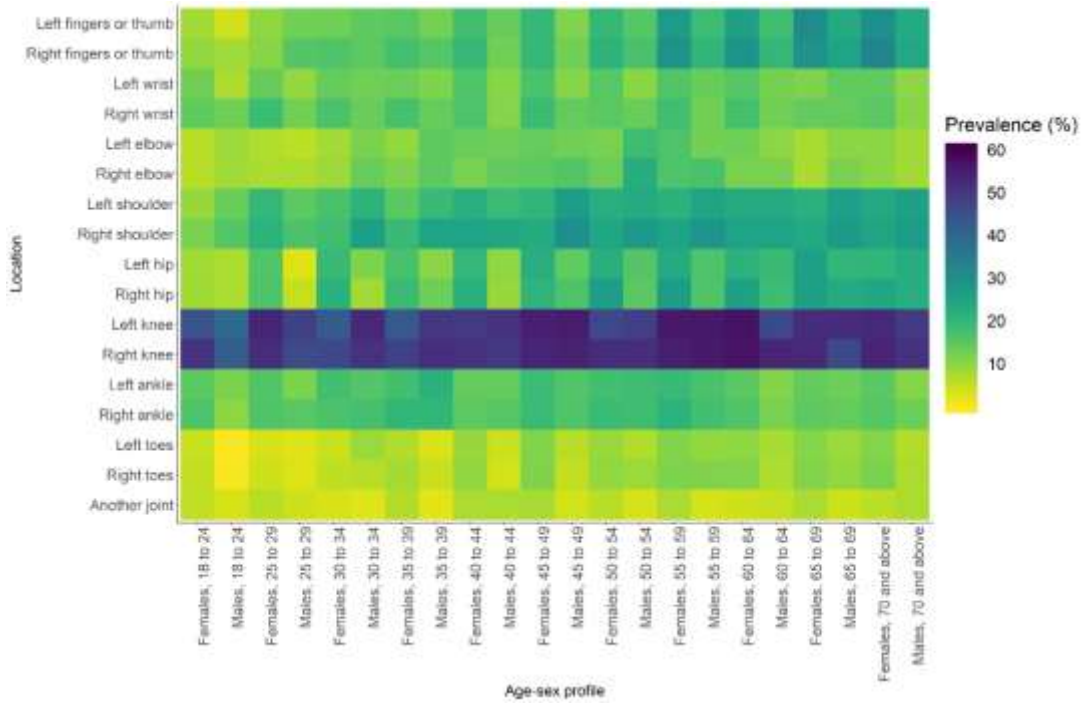
M: 2015


Left fingers or thumb
Right fingers or thumb
Left wrist
Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

N: 2016


Left fingers or thumb
Right fingers or thumb
Left wrist
Right wrist
Left elbow
Right elbow
Left shoulder
Right shoulder
Left hip
Right hip
Left knee
Right knee
Left ankle
Right ankle
Left toes
Right toes
Another joint
Location
Females, 18 to 24
Males, 18 to 24
Females, 25 to 29
Males, 25 to 29
Females, 30 to 34
Males, 30 to 34
Females, 35 to 39
Males, 35 to 39
Females, 40 to 44
Males, 40 to 44
Females, 45 to 49
Males, 45 to 49
Females, 50 to 54
Males, 50 to 54
Females, 55 to 59
Males, 55 to 59
Females, 60 to 64
Males, 60 to 64
Females, 65 to 69
Males, 65 to 69
Females, 70 and above
Males, 70 and above
Age-sex profile
Prevalence (%)
60
50
40
30
20
10

O: 2017



P: 2018

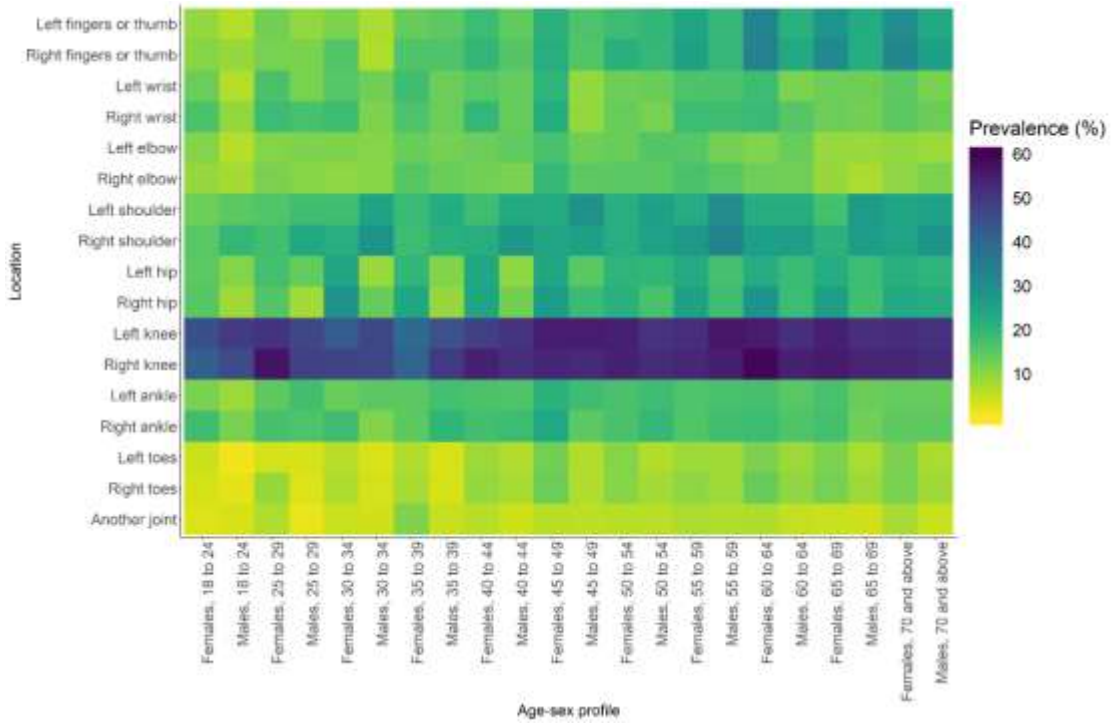


Figure 5.5: Proportion (%) of people in age- and sex-split demographic groups who reported a particular joint site at which they have experienced joint symptoms[α] within the previous 30 days, according to the National Health Interview Survey (NHIS)*, for years 2002 (A), 2003 (B), 2005 (C), 2006 (D), 2007 (E), 2008 (F), 2009 (G), 2010 (H), 2011 (I), 2012 (J), 2013 (K), 2014 (L), 2015 (M), 2016 (N), 2017 (O), and 2018 (P)

[α] Pain, aching or stiffness

* Sample Adult Questionnaire

5.2.4 Joint symptoms by socioeconomic status

5.2.4.1 Employment status

Socioeconomic status was assessed using employment status. Annual age- and sex-adjusted logistic regressions were done on each survey year to compare joint symptoms between individuals who were working for pay at a job/business, and those not working. Those who were not working reported significantly more joint symptoms than those who were working for pay every year of NHIS data analysis (Table 5.2).

Table 5.2: Comparison of joint symptoms[α] in the previous 30 days in different socioeconomic groups (indicated by employment status), according to the National Health Interview Survey (NHIS)[ι], from 2002 to 2018

Year	Socioeconomic status indicator *Employment status*	OR *(95% CI)*	P-value
2002	Working for pay at a job/business Not working	0.148 *(0.130, 0.168)* 1.49 *(1.38, 1.60)*	< 0.001*
2003	Working for pay at a job/business Not working	0.165 *(0.145, 0.187)* 1.43 *(1.33, 1.54)*	< 0.001*
2005	Working for pay at a job/business Not working	0.143 *(0.123, 0.165)* 1.47 *(1.37, 1.59)*	< 0.001*
2006	Working for pay at a job/business Not working	0.115 *(0.097, 0.135)* 1.45 *(1.33, 1.59)*	< 0.001*
2007	Working for pay at a job/business Not working	0.100 *(0.083, 0.120)* 1.43 *(1.31, 1.57)*	< 0.001*
2008	Working for pay at a job/business Not working	0.173 *(0.146, 0.205)* 1.41 *(1.29, 1.55)*	< 0.001*
2009	Working for pay at a job/business Not working	0.155 *(0.131, 0.185)* 1.44 *(1.32, 1.56)*	< 0.001*
2010	Working for pay at a job/business Not working	0.166 *(0.142, 0.194)* 1.39 *(1.28, 1.51)*	< 0.001*
2011	Working for pay at a job/business Not working	0.131 *(0.114, 0.151)* 1.60 *(1.48, 1.72)*	< 0.001*
2012	Working for pay at a job/business Not working	0.130 *(0.112, 0.151)* 1.70 *(1.57, 1.83)*	< 0.001*
2013	Working for pay at a job/business Not working	0.140 *(0.119, 0.165)* 1.56 *(1.44, 1.68)*	< 0.001*
2014	Working for pay at a job/business Not working	0.160 *(0.137, 0.186)* 1.37 *(1.27, 1.48)*	< 0.001*
2015	Working for pay at a job/business Not working	0.146 *(0.123, 0.173)* 1.44 *(1.33, 1.56)*	< 0.001*
2016	Working for pay at a job/business Not working	0.148 *(0.126, 0.173)* 1.48 *(1.37, 1.60)*	< 0.001*
2017	Working for pay at a job/business Not working	0.162 *(0.138, 0.191)* 1.46 *(1.35, 1.58)*	< 0.001*

2018	Working for pay at a job/business	0.138 *(0.115, 0.166)*	< 0.001*
	Not working	1.49 *(1.37, 1.62)*	

* P < 0.05: for a significant difference between those working for pay at a job/business (comparator group) and those without work, by logistic regression analysis

[α] Pain, aching, or stiffness

[ι] Sample Adult Questionnaire

5.3 National Health and Nutrition Examination Survey (NHANES) (Continuous)

Arthritis diagnosis

Using NHANES (Continuous) survey data, I calculated the prevalence of an arthritis diagnosis in US residents for survey cycles 1999-2000 until 2017-18, as those who answered, "Yes" to the question, "Has a doctor or other health professional ever told you that you had arthritis?". The data were appropriately weighted, and complex survey design accounted for. I calculated the prevalence of an arthritis diagnosis in age groups, and in the sexes. Thereafter, I conducted logistic regressions to assess whether a particular age, sex, or socioeconomic status was associated with having an arthritis diagnosis.

Tables consisting of all prevalence values (95% confidence intervals), odds ratios (95% confidence intervals) and p-values are available in the appendices. Age-specific statistics are available in Appendix H (Table III). Sex-specific statistics are available in Appendix I (Table III). Employment-specific statistics are available in Appendix J (Table III).

5.3.1 Arthritis diagnosis by age

The prevalence of an arthritis diagnosis was calculated in 11 age groups, namely: ages 18 to 24 years, 25 to 29 years, 30 to 34 years, 35 to 39 years, 40 to 44 years, 45 to 49 years, 50 to 54 years, 55 to 59 years, 60 to 64 years, 65 to 69 years, and 70 years and above. Thereafter, sex-adjusted logistic regressions were conducted for each survey cycle, where the comparator group was the youngest age category, age 18 to 24 years.

In 18- to 24-year-olds, the prevalence of an arthritis was low, where it has ranged between 2.2% and 4.4% across all survey cycles that we analysed, where the most recent prevalence was 2.2%. In those aged 25 to 29 years, the prevalence of arthritis diagnoses was between 1.6% and 5.5%, for which 5.5% was the most recent prevalence. In 30- to 34-year-olds, the prevalence of arthritis diagnoses was between 3.0% and 10.4%, and was 7.5% most recently. In those aged 35 to 39 years, the prevalence of arthritis diagnoses was between 8.3% and 14.3%, and the most recent estimate was 12.1%. In 40- to 44-year-olds, the prevalence of arthritis diagnoses was between 11.1% and 20.4%, and was 16.8% most recently. In those aged 45 to 49 years, the prevalence of

arthritis diagnoses was between 19.4% and 24.1%, and was 19.4% in the most recent survey cycle. In the 50 to 54-year-old age group, the prevalence of arthritis diagnoses was between 23.9% and 37.9%, where the upper limit was the most recent estimate. In those aged 55 to 59 years, the prevalence of arthritis diagnoses was between 30.8% and 41.2%, and most recently was 36.5%. In 60- to 64-year-olds, the prevalence of arthritis diagnoses was between 33.9% and 51.5%, and the most recent prevalence was 44.1%. In 65- to 69-year-olds, the prevalence of arthritis diagnoses was between 45.2% and 56.4%, and most recently was 53.1%. Finally, in those aged 70 years old and above, the prevalence of arthritis diagnoses was between 50.4% and 60.6%, where 60.6% was also the most recent prevalence. There was a steady increase in arthritis diagnoses across age groups, as people got older, in a progressive manner (Figure 5.6).

Furthermore, sex-adjusted logistic regressions showed that the youngest two age groups had comparable arthritis diagnosis reports, whilst age groups from 30 years old and above had significantly more reports of arthritis diagnoses compared to the youngest age group.

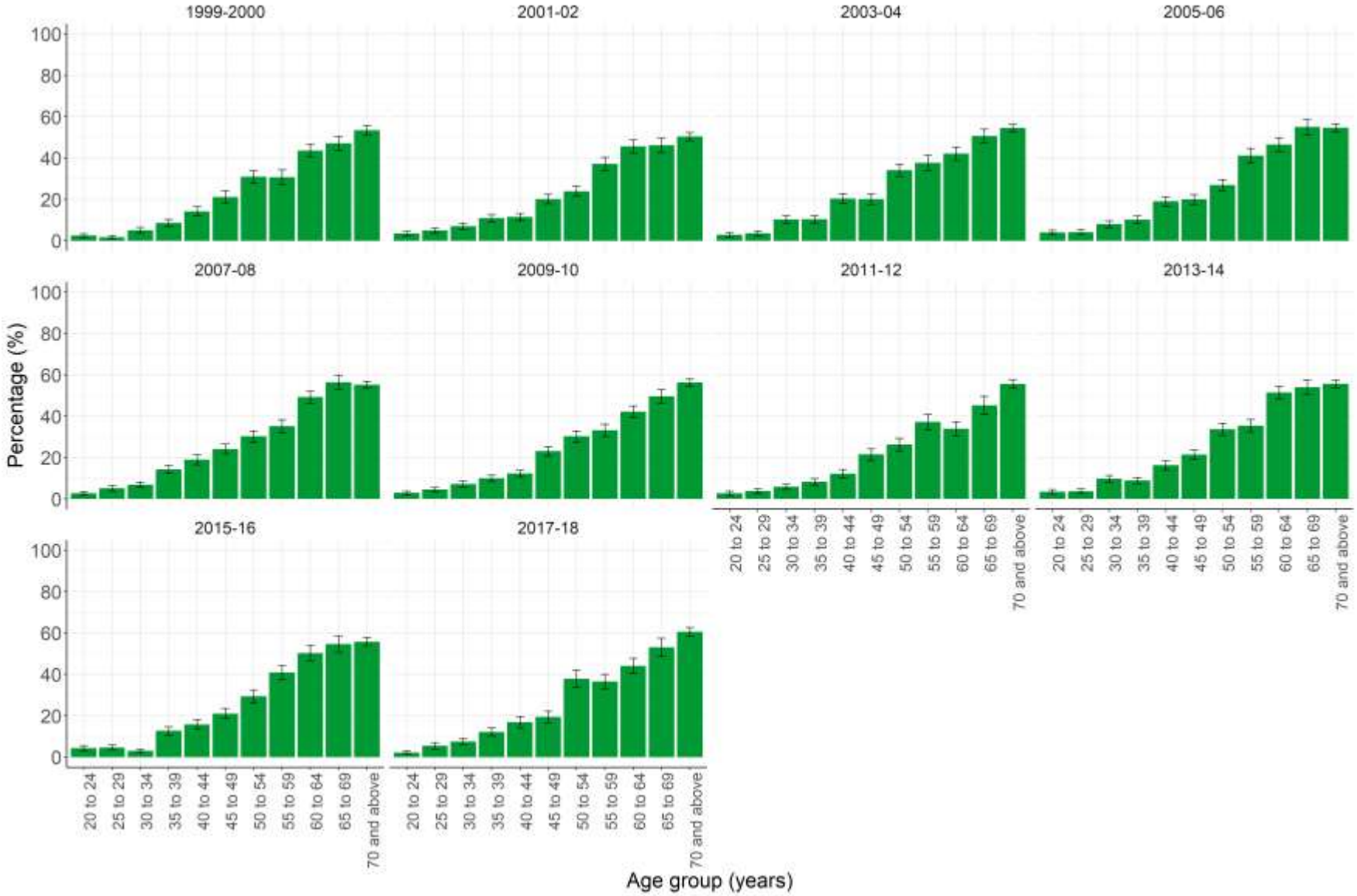


Figure 5.6: Prevalence (%) of US residents, by age group, who reported an arthritis diagnosis in their lifetime, according to the National Health and Nutrition Examination Survey (NHANES) (Continuous) survey, from the 1999-2000 survey cycle until the 2017-18 survey cycle

5.3.2 Arthritis diagnosis by sex

The prevalence of an arthritis diagnosis was calculated in males and females. Thereafter, an age-adjusted logistic regression was conducted, where the comparator group was males. Calculations were done on all survey cycles (every two years) on the NHANES (Continuous) data, from 1999-2000 until 2017-18. In males, the prevalence of arthritis diagnoses was between 16.4% and 24.4%, where 24.4% was the most recent estimate (2017-2018). In females, the prevalence of arthritis diagnoses was between 23.4% and 32.0%, and the most recent prevalence of arthritis diagnoses in female US residents was 31.0% (Figure 5.7). Age-adjusted logistic regressions showed that females had statistically significantly more arthritis diagnoses reports than males, for every NHANES (Continuous) survey cycle ($P < 0.001$ for all years).

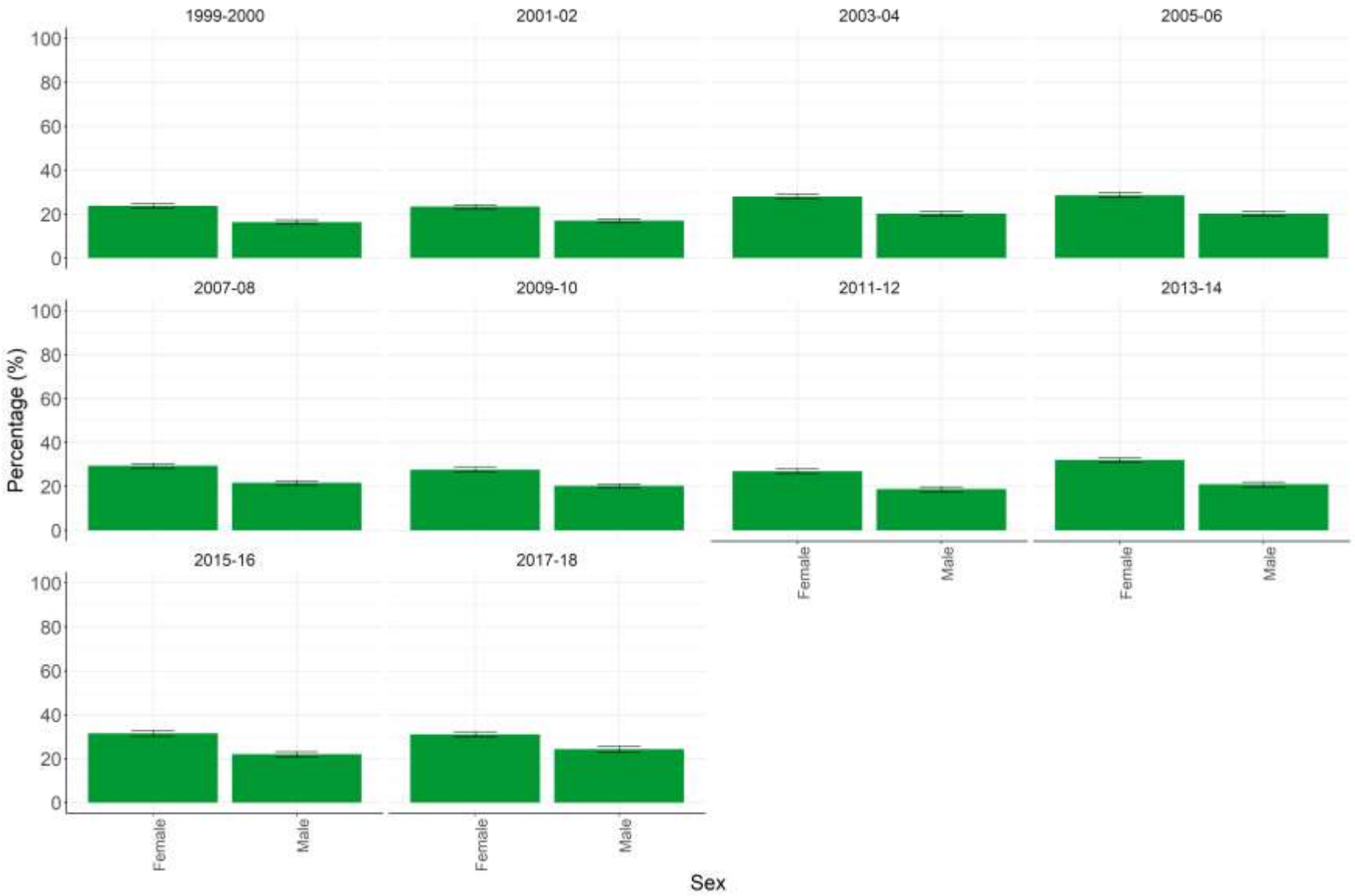


Figure 5.7: Prevalence (%) of US residents, by sex, who reported an arthritis diagnosis in their lifetime, according to the National Health and Nutrition Examination Survey (NHANES) (Continuous) survey, from the 1999-2000 survey cycle until the 2017-18 survey cycle

5.3.3 Arthritis diagnosis by socioeconomic status

Socioeconomic status was assessed using three indices, namely: employment status, annual household income bracket, and education level.

5.3.3.1 Employment status

Age- and sex-adjusted logistic regressions were conducted on employment status for each survey cycle, comparing arthritis diagnoses between individuals who were working for pay at a job or business, and those not working. Those who were not working reported significantly more arthritis diagnoses than those who were working for pay for every NHANES (Continuous) survey cycle (Table 5.3).

5.3.3.2 Annual household income bracket

Age- and sex-adjusted logistic regressions were conducted on annual household income bracket, comparing arthritis diagnosis reports in those with an annual household income of: $0 to $4 999, $5000 to $9 999, $10 000 to $14 999, $15 000 to $19 999, $20 000 to $24 999, $25 000 to $34 999, $35 000 to $44 999, $50 000 to $64 999, $65 000 to $74 999, and $75 000 or above. The comparator group was the highest annual household income, $75 000 or above.

Those with an annual household income of $75 000 or more reported significantly fewer arthritis diagnoses compared to those earning $5 999 to $9 999 (all survey cycles), $10 000 to $14 999 (all survey cycles bar 2013-14), and those earning $15 000 to $19 999 (all survey cycles bar 2005-06, 2009-10, and 2017-18). People with annual household incomes in the upper ranges ($65 000 to $74 999 and $55 000 to $64 999) reported no significant difference in arthritis diagnoses compared to those with an annual household income of over $75 000 across most years. Those with an annual household income of $75 000 or more reported significantly fewer arthritis diagnoses, on rare occasion, compared to those with an annual household income of $65 000 to $74 999 (survey cycles 2003-04, and 2007-08), and annual household income of $55 000 to $64 999 (2003-04 and 2015-16). Notably, however, there was no significant difference between reports of arthritis diagnoses between those with annual household income of over $75

000, and those with annual household income of between $0 and $4 999, except in 2007-08, 2011-12 and 2013-14, however the confidence intervals for the lowest income group are very large (Table 5.3).

Middle-range annual household income groups oscillate between reporting significantly more, and reporting statistically similar arthritis diagnoses compared to those in the top earning group. Those who with an annual household income of $20 000 to $24 999 reported significantly more diagnoses than those in the $75 000 or above group in most years, namely 1999-2000, 2001-02, 2003-04, 2007-08, 2009-10, 2015-16, and 2017-18. Those with an annual household income of between $25 000 and $34 999 reported significantly more arthritis diagnoses in 1999-2000, 2001-02, 2003-04, 2007-08, 2011-12, and 2015-16. Those with an annual household income of $35 000 to $44 999 reported significantly more arthritis diagnoses compared to the $75 000 or above group in 1999-2000, 2003-04, 2007-08, and 2013-14. Those with an annual household income of $45 000 to $54 999 reported significantly more arthritis diagnoses compared to those in the $75 000 or above group in 2001-02, 2003-04, 2007-08, 2009-10, and 2015-16 (Table 5.3).

5.3.3.3 Education level

Age- and sex-adjusted logistic regressions were conducted on education level, comparing arthritis diagnosis reports in those with varying levels of highest education attained, namely: 9th grade or below, between 9th and 11th grade, high school graduate or equivalent, some college or an AA degree, or a college graduate or above. The comparator group was the highest education level of college graduate or above.

People who reported having completed some college or an AA degree reported significantly more arthritis diagnoses compared to college graduates or above in the majority of survey cycles (1999-2000, 2001-02, 2003-04, 2007-08, 2009-10, 2011-12, 2013-14, 2015-16, and 2017-18). College graduates also had significantly fewer arthritis diagnoses than high school graduates or equivalent (1999-2000, 2001-02, 2003-04, 2005-06, 2007-08, 2009-10, 2013-14, and 2017-18); and 9th to 11th grade (1999-2000, 2001-02, 2003-04, 2005-06, 2007-08, 2009-10, 2011-12, 2013-14, and 2015-16). Those with an education level of below 9th grade reported significantly fewer arthritis diagnoses in some years (1999-2000, 2001-02, 2003-04, 2007-08, 2011-12), but not

others. However, much like the lowest annual household income category, the confidence intervals are wide (Table 5.3).

Table 5.3: Comparison of lifetime arthritis diagnoses by three socioeconomic status indices (employment status, education level, and annual household income bracket), according to the National Health and Nutrition Examination Survey (NHANES) (Continuous) survey, from the 1999-2000 survey cycle until the 2017-18 survey cycle

Y[π]	Socioeconomic status indicator		OR *(95% CI)*	P-value
1999-2000	*Employment Status*	Working for pay at a job/business	0.026 *(0.011, 0.062)*	
		Not working	1.81 *(1.41, 2.33)*	< 0.001*
	Education Level	College graduate or above	0.021 *(0.009, 0.051)*	
		Some college/AA degree	1.40 *(1.02, 1.92)*	0.038*
		High school graduate/equivalent	1.50 *(1.09, 2.06)*	0.013*
		9th to 11th grade	1.81 *(1.28, 2.56)*	< 0.001*
		Below 9th grade	1.74 *(1.28, 2.47)*	0.002*
	Income Bracket	\$75 000 or more	0.010 *(0.003, 0.038)*	
		\$65 000 to \$74 999	0.982 *(0.556, 1.70)*	0.949
		\$55 000 to \$64 999	1.41 *(0.809, 2.46)*	0.226
		\$45 000 to \$54 999	1.33 *(0.829, 2.12)*	0.238
		\$35 000 to \$44 999	1.65 *(1.06, 2.58)*	0.027*
		\$25 000 to \$34 999	1.86 *(1.22, 2.82)*	0.004*
		\$20 000 to \$24 999	1.73 *(1.07, 2.82)*	0.026*
		\$15 000 to \$19 999	2.17 *(1.35, 3.48)*	0.001*
		\$10 000 to \$14 999	2.03 *(1.30, 3.16)*	0.002*
		\$5 000 to \$9 999	2.88 *(1.81, 4.57)*	< 0.001*
		\$0 to \$4 999	1.76 *(0.729, 4.26)*	0.208
2001-02	*Employment Status*	Working for pay at a job/business	0.038 *(0.020, 0.069)*	
		Not working	1.69 *(1.35, 2.11)*	< 0.001*
	Education Level	College graduate or above	0.023 *(0.012, 0.042)*	
		Some college/AA degree	1.85 *(1.42, 2.41)*	< 0.001*
		High school graduate/equivalent	1.83 *(1.40, 2.38)*	< 0.001*
		9th to 11th grade	2.58 *(1.93, 3.44)*	< 0.001*
		Below 9th grade	1.90 *(1.37, 2.63)*	< 0.001*
	Income Bracket	\$75 000 or more	0.022 *(0.011, 0.043)*	
		\$65 000 to \$74 999	1.44 *(0.893, 2.33)*	0.135
		\$55 000 to \$64 999	0.994 *(0.682, 1.45)*	0.979
		\$45 000 to \$54 999	1.90 *(1.32, 2.74)*	< 0.001*
		\$35 000 to \$44 999	1.01 *(0.700, 1.46)*	0.953
		\$25 000 to \$34 999	1.43 *(1.03, 1.99)*	0.034*
		\$20 000 to \$24 999	2.18 *(1.50, 3.17)*	< 0.001*
		\$15 000 to \$19 999	2.03 *(1.50, 3.17)*	< 0.001*
		\$10 000 to \$14 999	3.58 *(2.41, 5.32)*	< 0.001*
		\$5 000 to \$9 999	2.84 *(1.79, 4.49)*	< 0.001*
		\$0 to \$4 999	1.54 *(0.801, 2.95)*	0.196
2003-04	*Employment Status*	Working for pay at a job/business	0.028 *(0.014, 0.058)*	
		Not working	1.98 *(1.60, 2.46)*	< 0.001*

	Education Level	College graduate or above	0.023 *(0.011, 0.046)*	
		Some college/AA degree	1.44 *(1.10, 1.90)*	0.009*
		High school graduate/equivalent	1.63 *(1.23, 2.14)*	< 0.001*
		9th to 11th grade	2.32 *(1.70, 3.16)*	< 0.001*
		Below 9th grade	1.62 *(1.20, 2.19)*	0.002*
	Income Bracket	$75 000 or more	0.023 *(0.011, 0.048)*	
		$65 000 to $74 999	1.80 *(1.12, 2.89)*	0.016*
		$55 000 to $64 999	2.00 *(1.28, 3.11)*	0.002*
		$45 000 to $54 999	1.69 *(1.15, 2.47)*	0.007*
		$35 000 to $44 999	1.59 *(1.12, 2.26)*	0.010*
		$25 000 to $34 999	1.95 *(1.39, 2.75)*	< 0.001*
		$20 000 to $24 999	1.78 *(1.23, 2.57)*	0.002*
		$15 000 to $19 999	2.05 *(1.44, 2.93)*	< 0.001*
		$10 000 to $14 999	2.27 *(1.60, 3.20)*	< 0.001*
		$5 000 to $9 999	2.46 *(1.62, 3.75)*	< 0.001*
		$0 to $4 999	2.04 *(0.976, 4.26)*	0.058
2005-06	*Employment Status*	Working for pay at a job/business	0.041 *(0.023, 0.073)*	
		Not working	1.74 *(1.39, 2.17)*	< 0.001*
	Education Level	College graduate or above	0.041 *(0.024, 0.071)*	
		Some college/AA degree	1.18 *(0.916, 1.51)*	0.207
		High school graduate/equivalent	1.36 *(1.05, 1.76)*	0.020*
		9th to 11th grade	1.54 *(1.12, 2.10)*	0.007*
		Below 9th grade	1.00 *(0.734, 1.37)*	0.980
	Income Bracket	$75 000 or more	0.038 *(0.020, 0.069)*	
		$65 000 to $74 999	0.958 *(0.636, 1.44)*	0.836
		$55 000 to $64 999	0.987 *(0.660, 1.48)*	0.949
		$45 000 to $54 999	1.16 *(0.819, 1.66)*	0.396
		$35 000 to $44 999	1.15 *(0.803, 1.65)*	0.442
		$25 000 to $34 999	1.09 *(0.798, 1.49)*	0.583
		$20 000 to $24 999	1.24 *(0.851, 1.80)*	0.264
		$15 000 to $19 999	1.23 *(0.835, 1.82)*	0.291
		$10 000 to $14 999	1.52 *(1.05, 2.20)*	0.026
		$5 000 to $9 999	2.09 *(1.33, 3.29)*	0.001*
		$0 to $4 999	1.31 *(0.657, 2.61)*	0.444
2007-08	*Employment Status*	Working for pay at a job/business	0.021 *(0.010, 0.046)*	
		Not working	1.90 *(1.57, 2.31)*	< 0.001*
	Education Level	College graduate or above	0.022 *(0.011, 0.045)*	
		Some college/AA degree	1.52 *(1.19, 1.95)*	< 0.001*
		High school graduate/equivalent	1.50 *(1.17, 1.92)*	0.001*
		9th to 11th grade	1.69 *(1.29, 2.21)*	< 0.001*
		Below 9th grade	1.79 *(1.33, 2.41)*	< 0.001*
	Income Bracket	$75 000 or more	0.022 *(0.011, 0.046)*	
		$65 000 to $74 999	1.53 *(1.03, 2.28)*	0.036*
		$55 000 to $64 999	1.41 *(0.958, 2.06)*	0.082
		$45 000 to $54 999	1.49 *(1.02, 2.19)*	0.039*

		$35 000 to $44 999	1.40 *(1.00, 1.96)*	< 0.050*
		$25 000 to $34 999	1.56 *(1.16, 2.10)*	0.003*
		$20 000 to $24 999	1.41 *(1.03, 1.96)*	0.031*
		$15 000 to $19 999	1.98 *(1.45, 2.69)*	< 0.001*
		$10 000 to $14 999	2.10 *(1.52, 2.91)*	< 0.001*
		$5 000 to $9 999	2.99 *(2.06, 4.34)*	< 0.001*
		$0 to $4 999	3.44 *(1.83, 6.46)*	< 0.001*
2009-10	*Employment Status*	Working for pay at a job/business	0.029 *(0.015, 0.055)*	
		Not working	1.87 *(1.55, 2.26)*	< 0.001*
	Education Level	College graduate or above	0.026 *(0.014, 0.048)*	
		Some college/AA degree	1.38 *(1.10, 1.74)*	0.006*
		High school graduate/equivalent	1.62 *(1.27, 2.06)*	< 0.001*
		9th to 11th grade	1.54 *(1.19, 2.00)*	0.001*
		Below 9th grade	1.22 *(0.930, 1.61)*	0.149
	Income Bracket	$75 000 or more	0.031 *(0.017, 0.057)*	
		$65 000 to $74 999	1.06 *(0.701, 1.59)*	0.795
		$55 000 to $64 999	1.14 *(0.790, 1.65)*	0.480
		$45 000 to $54 999	1.48 *(1.08, 2.03)*	0.015*
		$35 000 to $44 999	0.978 *(0.703, 1.36)*	0.897
		$25 000 to $34 999	1.30 *(0.985, 1.72)*	0.064
		$20 000 to $24 999	1.64 *(1.18, 2.26)*	0.003*
		$15 000 to $19 999	1.22 *(0.872, 1.71)*	0.247
		$10 000 to $14 999	1.64 *(1.21, 2.21)*	0.001*
		$5 000 to $9 999	2.17 *(1.38, 3.41)*	< 0.001*
		$0 to $4 999	1.01 *(0.552, 1.84)*	0.978
2011-12	*Employment Status*	Working for pay at a job/business	0.023 *(0.009, 0.063)*	
		Not working	1.79 *(1.41, 2.28)*	< 0.001*
	Education Level	College graduate or above	0.023 *(0.009, 0.054)*	
		Some college/AA degree	1.69 *(1.27, 2.25)*	< 0.001*
		High school graduate/equivalent	1.31 *(0.963, 1.78)*	0.085
		9th to 11th grade	1.71 *(1.22, 2.41)*	0.002*
		Below 9th grade	1.77 *(1.25, 2.51)*	0.001*
	Income Bracket	$75 000 or more	0.021 *(0.009, 0.050)*	
		$65 000 to $74 999	1.16 *(0.969, 1.94)*	0.567
		$55 000 to $64 999	1.25 *(0.759, 2.07)*	0.377
		$45 000 to $54 999	1.52 *(0.976, 2.35)*	0.064
		$35 000 to $44 999	1.24 *(0.834, 1.85)*	0.288
		$25 000 to $34 999	1.60 *(1.10, 2.34)*	0.014*
		$20 000 to $24 999	1.51 *(0.998, 2.29)*	0.051
		$15 000 to $19 999	2.78 *(1.88, 4.09)*	< 0.001*
		$10 000 to $14 999	1.95 *(1.34, 2.83)*	< 0.001*
		$5 000 to $9 999	2.41 *(1.63, 3.56)*	< 0.001*
		$0 to $4 999	2.81 *(1.75, 4.50)*	< 0.001*
2013-14	*Employment Status*	Working for pay at a job/business	0.037 *(0.019, 0.074)*	
		Not working	1.83 *(1.50, 2.23)*	< 0.001*

	Education Level	College graduate or above	0.033 *(0.017, 0.065)*	
		Some college/AA degree	1.42 *(1.13, 1.78)*	0.003*
		High school graduate/equivalent	1.34 *(1.05, 1.72)*	0.018*
		9th to 11th grade	1.64 *(1.24, 2.16)*	< 0.001*
		Below 9th grade	0.887 *(0.655, 1.20)*	0.436
	Income Bracket	$75 000 or more	0.042 (*0.021, 0.081)*	
		$65 000 to $74 999	1.27 *(0.813, 1.98)*	0.295
		$55 000 to $64 999	0.954 *(0.656, 1.41)*	0.812
		$45 000 to $54 999	1.18 *(0.831, 1.68)*	0.352
		$35 000 to $44 999	1.42 *(1.03, 1.96)*	0.033*
		$25 000 to $34 999	1.20 *(0.870, 1.67)*	0.262
		$20 000 to $24 999	1.21 *(0.849, 1.73)*	0.292
		$15 000 to $19 999	1.66 *(1.18, 2.31)*	0.003*
		$10 000 to $14 999	1.31 *(0.923, 1.85)*	0.132
		$5 000 to $9 999	1.66 *(1.12, 2.47)*	0.012*
		$0 to $4 999	1.83 *(1.01, 3.31)*	0.046*
2015-16	*Employment Status*	Working for pay at a job/business	0.050 *(0.027, 0.091)*	
		Not working	1.96 *(1.55, 2.48)*	< 0.001*
	Education Level	College graduate or above	0.047 *(0.026, 0.086)*	
		Some college/AA degree	1.34 *(1.04, 1.73)*	0.025*
		High school graduate/equivalent	1.16 *(0.879, 1.54)*	0.288
		9th to 11th grade	1.59 *(1.12, 2.24)*	0.009*
		Below 9th grade	0.961 *(0.706, 1.31)*	0.802
	Income Bracket	$75 000 or more	0.049 *(0.027, 0.089)*	
		$65 000 to $74 999	1.23 *(0.764, 1.97)*	0.399
		$55 000 to $64 999	1.61 *(1.06, 2.45)*	0.025*
		$45 000 to $54 999	1.56 *(1.07, 2.29)*	0.022*
		$35 000 to $44 999	1.23 *(0.858, 1.76)*	0.260
		$25 000 to $34 999	1.36 *(0.965, 1.93)*	0.079
		$20 000 to $24 999	1.51 *(1.03, 2.20)*	0.033*
		$15 000 to $19 999	1.85 *(1.28, 2.67)*	0.001*
		$10 000 to $14 999	1.70 *(1.18, 2.45)*	0.004*
		$5 000 to $9 999	1.60 *(1.01, 2.51)*	0.043*
		$0 to $4 999	1.29 *(0.707, 2.36)*	0.405
2017-18	*Employment Status*	Working for pay at a job/business	0.021 *(0.010, 0.043)*	
		Not working	2.07 *(1.62, 2.63)*	< 0.001*
	Education Level	College graduate or above	0.017 *(0.008, 0.035)*	
		Some college/AA degree	1.74 *(1.31, 2.31)*	< 0.001*
		High school graduate/equivalent	1.52 *(1.13, 2.06)*	0.006*
		9th to 11th grade	1.38 *(0.960, 1.97)*	0.082
		Below 9th grade	1.22 *(0.873, 1.72)*	0.240
	Income Bracket	$75 000 or more	0.025 *(0.012, 0.054)*	
		$65 000 to $74 999	0.838 *(0.526, 1.34)*	0.457
		$55 000 to $64 999	0.797 *(0.504, 1.26)*	0.330
		$45 000 to $54 999	0.856 *(0.531, 1.38)*	0.522

$35 000 to $44 999	1.25 *(0.871, 1.81)*	0.224
$25 000 to $34 999	1.08 *(0.773, 1.50)*	0.659
$20 000 to $24 999	1.55 *(1.05, 2.29)*	0.026*
$15 000 to $19 999	1.31 *(0.897, 1.91)*	0.162
$10 000 to $14 999	1.94 *(1.31, 2.85)*	< 0.001*
$5 000 to $9 999	1.96 *(1.07, 3.58)*	0.029*
$0 to $4 999	1.20 *(0.674, 2.14)*	0.535

* P < 0.05: for a significant difference between males (comparator group) and females, by logistic regression analysis

ᵻ Y: Year (survey cycle)

SECTION 1 DISCUSSION

Demographic trends in painful arthropathies using the BRFSS, NHIS, and NHANES (Continuous) surveys

Summary of findings

I used the Behavioural Risk Factor Surveillance System (BRFSS) to calculate the prevalence of rheumatic disorder diagnoses amongst various demographic groups, and conducted logistic regressions to assess whether certain demographic groups associated with having a rheumatic disorder diagnosis. These analyses were conducted from years 1996 to 2018, including years where the rheumatic disorder question was only included in the module questionnaire (1996 to 2000, 2002, 2004, and 2010), with the exception of years 2006 and 2008.

The first demographic analysis was done on age [ages (in years): 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]. The prevalence of rheumatic disorder diagnoses increased in age groups as they get older. The prevalence of rheumatic disorder diagnoses in the youngest age category (age 18 to 24 years) was between 3.0% and 5.7%, and increased incrementally to being between 50.2% to 60.4% in the oldest age category (age 70 years and above). Furthermore, sex-adjusted logistic regressions showed that rheumatic disorder diagnosis reports were significantly higher in all five-year age groups older than 25 years old compared to 18- to 24-year-olds.

Thereafter, I calculated the prevalence of rheumatic disorder diagnoses in males and females, and conducted age-adjusted logistic regressions to assess whether sex was associated with rheumatic disorder diagnoses. The prevalence of rheumatic disorder diagnoses was between 17.3% and 26.6% in males, and was between 26.5% and 33.7% in females. The prevalence of rheumatic disorder diagnoses was consistently higher in females, where my age-adjusted logistic regression showed that females did have significantly more rheumatic disorder diagnoses than males.

Finally, I conducted age- and sex-adjusted logistic regressions on three indices of socioeconomic status: employment status, highest education level obtained, and annual household income bracket. Socioeconomic status was associated with rheumatic disorder diagnoses, where those

with high socioeconomic status reported significantly fewer rheumatic disorder diagnoses compared to those of lower socioeconomic status, across all three socioeconomic status indices. Being employed for wages resulted in significantly fewer rheumatic disorder diagnoses compared to homemakers, the retired, those unable to work, and those unemployed. Being employed for wages resulted in similar reports of diagnoses compared to students, and resulted in comparable or more diagnoses versus the self-employed. On annual household income, I established that those with an annual household income of $75 000 or above (the top tier) reported significantly fewer rheumatic disorder diagnoses compared to all groups with lower annual household incomes, with the only minor exceptions explained by median US annual household income statistics, or large confidence intervals due to using module data or small samples in certain groups. Finally, education level also associated with rheumatic disorder diagnoses. Individuals who graduated from college reported significantly fewer rheumatic disorder diagnoses compared to those who graduated high school, completed some high school, and completed some elementary school. No significant difference in rheumatic disorder diagnoses were observed between college graduates and those who had had no formal education or had attended kindergarten only, likely as a result of sampling as observed by wide confidence intervals on the odds ratios for the no formal education/kindergarten only group.

I then used the National Health Interview Survey (NHIS) to calculate the prevalence of joint symptoms (defined as pain, aching, or stiffness within the 30 days prior to taking the Sample Adult Questionnaire), in various demographic groups. I also conducted logistic regressions to see whether certain groups amongst those of different ages, sexes, and socioeconomic statuses associated with positive reports of joint symptoms.

I conducted these analyses from 2002 until 2018, with the exception of 2004. In age groups [ages (in years) 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above], the prevalence of joint symptoms started at 9.9% to 15.6% in the youngest age group, and increased in increments consistently as age groups got older, until the prevalence in those aged 70 years and above was between 45.6% and 55.3%. Sex-adjusted logistic regressions showed that those in the youngest age category had significantly lower joint symptoms compared to all other age groups.

When examining sex, I established that the prevalence of joint symptoms was consistently higher in females, ranging between 29.9% and 37.1% compared to that of 25.2% and 33.4% in males. Furthermore, age-adjusted logistic regression showed that females consistently reported significantly more joint symptoms than males.

Thereafter, using the population that reported joint symptoms, I established the prevalence of reporting of various joint sites in age-sex divided groups. The joint site most frequently cited as having pain, aching, or stiffness within the previous 30 days was the knees. Knee joint symptom prevalences were also common to all demographic groups who reported joint symptoms. Joint symptoms in the fingers or thumbs increased slightly with age in both hands. Shoulder joint symptoms also increased with age in both sexes, but young adult males reported more shoulder joint symptoms compared to age-matched females. Conversely, while hip joint symptoms also increased with age in both sexes, young adult females reported a greater prevalence of hip joint symptoms compared to age-matched males. Elbow joint symptoms remained fairly steady with a slight increase in late-young to middle adulthood. Wrist and ankle joint symptoms remained fairly steady across adult life, but wrist symptoms were reported slightly more by young females compared to young males. The prevalence of another joint site (marked as an "other" category by the NHIS Sample Adult Questionnaire) was low in all age groups, suggesting that the main sites of joint symptoms experienced by adult US residents were already included in the survey.

I then conducted age- and sex-adjusted logistic regressions across all years on employment status in order to establish whether socioeconomic status was associated with joint symptom reports. Those who were employed for pay at a job or business reported significantly fewer joint symptoms compared to those unemployed, for every year of my analysis.

Finally, I used the National Health and Nutrition Examination Survey (NHANES) (Continuous) survey to calculate the prevalence of an arthritis diagnoses in various demographic groups, and conducted logistic regressions to establish whether certain demographic groups were associated with having been diagnosed with arthritis. These analyses were done in all survey cycles from 1999-2000 until 2017-18.

Across age groups [ages (in years) 20 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above]), the prevalence of an arthritis diagnosis increased incrementally as groups got older. Prevalences ranged from 2.2% to 4.4% in the

youngest age category, and reached between 48.8% and 60.6% in the oldest age category. Sex-adjusted logistic regressions also showed that those in the youngest age category (age 20 to 24 years) reported similar prevalences of arthritis diagnoses as 25- to 29-year-olds, but significantly fewer joint symptoms compared to groups older than 29 years old.

The prevalence of arthritis diagnoses in females is consistently higher than that of males, ranging from 23.9% and 32.0%, compared to a range of 16.2% and 24.4% in males. Age-adjusted logistic regressions also showed that females reported significantly more arthritis diagnoses compared to males.

I conducted age- and sex-adjusted logistic regressions on three indices of socioeconomic status: employment status, highest education level obtained, and annual household income. Those who were employed reported significantly fewer arthritis diagnoses compared to those who were unemployed. People who reported having low annual household incomes (groups between $5 999 and $19 999) reported significantly more arthritis diagnoses compared to those in the top income bracket ($75 000 or above). Those who had annual household incomes in the upper ranges (groups between $55 000 to $74 999) most often had no significant difference in arthritis diagnoses compared to those in the top income group. Notably, those in the $0 to $4 999 annual household income group also most often had no significant difference in arthritis diagnoses compared to those in the top income group, likely as a result of sampling, as odds ratio confidence intervals were wide. Middle-range annual household income groups fluctuated across the years, sometimes reporting significantly more arthritis diagnoses compared to the top income bracket, but not so in other years. Education status was associated with arthritis diagnosis reports, where college graduates or above reported significantly less arthritis diagnoses than those who completed some college (but never graduated) or AA degrees, high school graduates, and those whose highest education was between 9th and 11th grades. Those whose education ended before 9th grade reported significantly more arthritis diagnoses in some years but not in others, and the confidence intervals on the odds ratios were also very wide.

Painful arthropathies and age

Diseases often affect different demographic groups in different proportions, and in different ways. Research on aging and arthritis has been documented for almost 100 years, and so I was

not surprised when my analyses of all three surveys on painful arthropathies showed high painful arthropathy prevalences in the older population, and an age association. Older age was associated with rheumatic disorder diagnoses (BRFSS), arthritis diagnoses (NHANES), and joint symptoms (NHIS), across all years of analysis. Other research has also previously shown the progressive increase in rheumatic disease (including arthritis) diagnoses with age (Safiri *et al.*, 2019; 2020) that my own analysis showed, where youngest demographic groups had prevalences of between 3.9% and 5.2%, and increased in increments and reaching between 46.0% and 55.2% in people aged 75 to 84 years old (Hootman *et al.*, 2016). A cross-sectional study on NHIS data also showed that the prevalence of general chronic pain, but specifically high-impact chronic pain, also increased as people got older (Dahlhamer *et al*., 2018). Potential reasons and underlying mechanisms for the relationship between aging and rheumatic disorders have been extensively researched. According to a systematic review and meta-analysis, older age is significantly associated with obesity (Wang and Beydoun, 2007), which in turn has been extensively associated with arthritis (Reyes *et al.*, 2016). Degradation of joints also occurs with age, where bone remodelling, age-related loss in the ability of cells to maintain homeostasis, chondrocyte senescence, and calcification and crystal formation of menisci within joints have been cited as potential mechanisms responsible for the development of age-related osteoarthritis (Shane Anderson and Loeser, 2010).

Whilst understanding the potential underlying mechanisms behind rheumatic disorders in the elderly is important, so too is understanding the societal gravitas of the burden of rheumatic disorders in the elderly. The US (and global) population is aging (Bloom *et al.*, 2011), and the cost of rheumatic disorders is high, estimated at $303.5 billion in 2013 for medical care and earnings losses (Murphy *et al.*, 2018). The burden of arthritis in an aging population ripples into multiple sectors of society. Microsimulations have shown that older arthritic individuals with lost productive life years received AU$706.16 less in total income, and AU$311.67 more in welfare payments per week, compared to fulltime workers without arthritis. An estimated projected loss GDP of AU$6.2 billion was established in 2015 (Schofield *et al.*, 2018). Therefore, there is a large burden on society, where large proportions of an already large demographic group are experiencing a disease associated with high costs, pain (Bas *et al.*, 2016; Owens and Conaghan, 2016), and disability (James, Walsh and Ferguson, 2019; Safiri *et al.*, 2019; 2020).

At the individual level, a systematic review and meta-analysis identified key themes on the lived experiences of older adults with arthritic pain, including that their arthritis was "the centre of their daily living, was a lonely path, was an inevitable and endless process, and was down to surviving through pain management" (Chen *et al.*, 2020). The research, therefore, found that the elderly identified pain as being integrated into their everyday lives, as well as overlapping with other aspects of their lives (such as their mental health, and sleep quality). The elderly also saw pain as a reality they lived with, and tried to do things as normal, managing their pain as best as possible around their lives. These qualitative themes highlight the heavy burden of pain on the elderly. Other research has, however, shown that reduced depressive symptoms, social support, as well as intact cognitive functioning were important predictors for older adults in managing arthritic pain (Lee, Kahana and Kahana, 2016). The challenge is that the elderly have often cited mental health problems as a result of loneliness (Crewdson, 2016; O'Súilleabháin, Gallagher and Steptoe, 2019). Furthermore, cognitive decline frequently occurs with age (Deary *et al.*, 2009). By managing depressive symptoms, cognitive decline, and social support in the elderly, the individual burden of rheumatic disorders too could be addressed.

A large aging population has resulted in a large societal burden due to musculoskeletal pain. What is of concern is that population-based longitudinal research has evaluated the arthritis reports of various "generations" of people (World War II – born 1935-1945, older baby boomers – born 1945-1954, younger baby boomers – born 1955-1964, and generation X – born 1965-1974), and has found that increases in prevalence of arthritis within these generations was earlier in the lifetime of each successive age group (Badley, Canizares and Perruccio, 2017). Therefore, although an aging population is a present concern and is often cited as being a burden on society, particularly with non-fatal disability-causing diseases such as arthritis and other rheumatic disorders, the burden on society after the death of the baby boomer generation may not decline. Therefore, the arthritis prevalences in middle-aged and younger adults should not be ignored.

On arthritis in younger people, my results on rheumatic disorders and arthritis diagnoses showed far fewer reports compared to prevalence data for joint symptom reports, which suggests that the joint-related pathologies in young people are likely for other reasons, such as injuries. Injuries are also serious however, where population-based longitudinal research has shown that in young adults, knee injuries increased the risk of being diagnosed with osteoarthritis later in life six-fold (Snoeker *et al.*, 2020). Indeed, I suggest a future area of longitudinal research examine potential

interventions at the time of injury in young adults (for example physical therapy), and whether post-traumatic arthritis could be attenuated later in life, as well as to reduce injury associated-pain.

Painful arthropathies and sex

The association between sex and pain has been well-documented, and the association between rheumatic disorders and joint symptoms with female sex is well-established in the academic literature (Wijnhoven, de Vet and Picavet, 2006; LeResche, 2011; Fillingim, 2017; Cimas *et al.*, 2018). A number of potential reasons have been presented across research, including sex-related genetics, sex hormones, and even the microbiome (Krasselt and Baerwald, 2019). Other research suggests that risk factors for a sex-specific association were being overweight (Wijnhoven, de Vet and Picavet, 2006), or even psychological factors, such as coping strategies (LeResche, 2011; Fillingim, 2017).

It is not only in the musculoskeletal condition state prevalence data that pain differences between the sexes materialise. Being male not only reduces the odds of having a rheumatic disorder, but has also predicted rheumatoid arthritis remission (Yu *et al.*, 2019). Furthermore, females have reported worse function and disability outcomes compared to males in cross-sectional research, at a multinational level (Putrik *et al.*, 2019). Women with disabling musculoskeletal injuries also recover less quickly and return to work less quickly compared to men (LeResche, 2011). Research has also shown a sex effect on socioeconomic status-related outcomes of rheumatic disease. Socioeconomic status rheumatic disorder predictor variables (such as education level and employment status) were more polarised in men, where greater differences in rheumatic disorder reports were seen in in men of different socioeconomic statuses, compared to women, whose outcomes were not as starkly opposed (Leino-Arjas, Hänninen and Puska, 1998).

Although the sex and pain association and prevalence results of all three types of painful arthropathies were clear in their outcome that females report more pain than males, a consideration must be given to sex differences in reporting pain. Women are more willing to report pain compared to men (LeResche, 2011). Moreover, women are more likely to report having received healthcare for their musculoskeletal pain compared to men (LeResche, 2011). Therefore, there is a chance that the decreased painful arthropathy prevalence in males may be attributable to a lack of health-seeking behaviour for pain in men. Indeed, according to my

findings, the prevalence of joint symptoms (NHIS) in men was higher compared to the prevalence of rheumatic disorder (BRFSS) and arthritis diagnoses (NHANES) (Continuous) in men. There may, therefore, be undiagnosed rheumatic disorders in the male population, albeit not as high as the rheumatic disorder diagnoses in females.

Demographic trends in joint symptoms site

My research also addressed the prevalence of joint symptom site across age-sex divided demographic groups. The prevalence of pain in various joints was proportionate across groups, although it is important to bear in mind that not all groups reported the same prevalence of joint pain originally. That is, although around 60% of people in all age-sex demographic groups reported their knees as a site at which they experienced joint symptoms, far more elderly people compared to young people reported joint symptoms to begin with. Nonetheless, the high prevalence of knee joint symptom citations was a predominant finding of my joint symptom mapping analysis. There is extensive research available on knee pain, and knee pain has been frequently reported as the most common site of joint pain, across time (Cushnaghan and Dieppe, 1991; Peat, McCarney and Croft, 2001). In the elderly, population-based research has estimated knee pain at 22.4% in Italy (Cecchi *et al.*, 2008), and up to 32.6% in the United Kingdom (Dawson *et al.*, 2004). Knee pain in the elderly, in particular, has been associated with high BMI, functional limitations such as reduced knee passive flexion and knee extension torque, as well as foot pain. Stair climbing and walking were cited as activities causing the most severe pain (Cecchi *et al.*, 2008). The consequences of knee pain are thus also important to consider as there is evidence to suggest that those with chronic knee pain are at increased risk of developing pain in multiple joints (Felson *et al.*, 2017). Given the high proportion of people who experience knee pain at the level of the population, the potential development of widespread pain, functional disabilities associated with knee pain, and pain is high. Given that the aforementioned variables affect overall health-related quality of life; knee joint symptoms can ultimately become very burdensome for the population.

My results showed that hip pain is reported more by females, particularly in younger females, and male citations of hip pain location catch up to female reports in later life, such that hip pain is cited around 25% of the time in those with some form of joint symptoms. Hip pain in the

elderly has been associated with poor self-rated health (Cecchi *et al.*, 2008), and yet has been reported at prevalences from 11.9% (Cecchi *et al.*, 2008) up to 19.2% (Cushnaghan and Dieppe, 1991; Dawson *et al.*, 2004). Research on young and middle-aged women (aged 18 to 40 years) has shown that hip abductor strength is significantly decreased in those with chronic hip joint pain, compared to matched asymptomatic controls (Mastenbrook *et al.*, 2017). Aside from the negative effect of abductor weakness on the hips themselves, hip abductor strength has also been associated with knee joint pathologies (Piva *et al.*, 2011; Chang *et al.*, 2019). In people with knee osteoarthritis, greater baseline hip abductor strength has been associated with reduced risk of medial patellofemoral and lateral tibiofemoral cartilage damage worsening, over a period of two years (Chang *et al.*, 2019). The preservation of hip joint integrity could therefore be an integral part of addressing knee joint symptoms too. Thus, by addressing hip joint symptoms, two joints with high numbers of joint symptom citations could be addressed, in turn affording the population greater functionality and health-related quality of life.

Joint symptoms were also reported in the ankles and feet, but more so in ankle joints. According to my results, ankle joint symptoms were mostly steady in prevalence, despite age. Given the level prevalence across demographic groups, the ankle joint symptoms reported are less likely due to age-induced diseases. Indeed, ankle osteoarthritis is rare: for perspective, patients are ten times more likely to be diagnosed with knee osteoarthritis than ankle osteoarthritis (Thomas *et al.*, 2017), which is likely why the prevalence of ankle symptom reports does not increase with age, which further begs the question of why ankle joint symptoms remain level across the population. Ankle injuries also account for approximately 20% of emergency department visits per year (Thomas *et al.*, 2017), indicating that they are still a burden in terms of joint symptoms, even if not predominantly as a form of arthritis. Research suggests that frequent ankle pain was 15%, while foot pain in older and middle-aged adults was 24% (Thomas *et al.*, 2011). In feet specifically, my results showed that the toes were cited as a location of joint symptoms more so in older women compared to older men. This demographic effect has also been shown in previous research, where foot pain had an age-related increase in women but not men (Thomas *et al.*, 2011). Although the prevalence of foot and ankle joint symptom reports seem moderate and constant in prevalence, they are still of concern when put into context of the burden on individuals and society. Recurrent ankle injuries can result in post-traumatic osteoarthritis (Thomas *et al.*, 2017; Herzog *et al.*, 2019), which could also explain why the prevalence of ankle

joint symptoms does not decrease in the elderly as they slow down and become less physically active and should, in theory, have fewer injuries. However, ankle and foot pain also have consequences in middle and older adults, where two thirds of cases of ankle and foot pain in older and middle-aged adults reported moderate disability (Thomas *et al.*, 2011).

The lower limb has been more frequently cited in osteoarthritic pain reports compared to the upper limb. Osteoarthritis pain reports show the most common sites of pain are the hip, knee, hand, and foot (excluding the spine, which is examined in greater detail in another section of this chapter) (O'Neill, McCabe and McBeth, 2018). As I have discussed, joint symptoms in the lower limb, particularly the knee and hip, are often also linked to each other. Hip and knee pain together have been associated with back pain, reduced hip abduction, and reduced muscle power (Cecchi *et al.*, 2008). Lower limb joint pain in the elderly specifically (the group with the highest prevalences of painful arthropathies) has been associated with poor balance (Eggermont *et al.*, 2009), and decrements in gait (Ogawa *et al.*, 2020). Both poor balance and gait decrements can have detrimental consequences for the elderly, as they can lead to dangers (such as falls), but also functional disabilities. Given that older people also tend to report widespread pain (Eggermont *et al.*, 2009), and that widespread pain in the elderly and pain severity were associated with lower limb function, lower limb joint symptoms need to be addressed to prevent greater repercussions in the long-run.

Upper limb joint symptoms should not be underestimated. Joint symptoms in the hands and wrists, shoulders, and elbows are not uncommon. Previous research shows that the hands are also a common location of joint pain. For example, a British study on osteoarthritis patients who were referred to a rheumatology unit found that around 30% had joint pain in their hands (Cushnaghan and Dieppe, 1991). My research showed that the prevalence of joint pain in the hands (fingers or thumb) increased with age, particularly in females. Work-related musculoskeletal disorders of the hands and wrists have been associated with longest work absences, and therefore lost productivity and wages compared to other anatomical regions (Barr, Barbe and Clark, 2004). In terms of the shoulders, my analyses found that, although present in both sexes and levelling out between the sexes in older age, shoulder joint symptoms were the only joint site more frequently reported slightly more by younger men compared to younger women. Research on shoulder pain has been estimated at 16% of musculoskeletal pain complaints amongst the population, and has also been associated with previous trauma in the shoulder in a sample of women (Khosravi *et al.*,

2019). American football involves collisions at high speeds, and high school football accounts for 480 000 shoulder injuries yearly, with 9.0% resulting in surgery (Gibbs *et al.*, 2015). I propose that the sex trend in shoulder pain may be to do with injuries related to American sports, for example American football. I recommend addressing potential intervention programmes for rehabilitation of shoulder joints after retiring from the sport to potentially attenuate the later effects of shoulder trauma, especially considering the association between joint injuries and post-traumatic arthritis. One other potential reason may be to do with employment, where men are more likely to be in manual employment positions, which may be contributing to reports of shoulder site symptoms in males.

Painful arthropathies and socioeconomic status

Previous research on joint symptoms and arthritis, and socioeconomic status has shown consistently that low socioeconomic status (in the form of employment, income, and education level) predicted joint pain and associated rheumatic disorders (Pincus and Castrejon, 2019; Putrik *et al.*, 2019), confirming my findings using population-based surveys. Employment was consistently associated with rheumatic disease diagnoses, joint symptoms, and arthritis diagnoses throughout all surveys, across all years, where unemployed people had significantly more rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses. Cross-sectional 2018 population-based research has also demonstrated this trend, where the prevalence of general chronic pain was 14.5% in employed people, was 15.9% in those unemployed who had also never worked, and was 31.5% in those who were unemployed but had previously worked. High-impact chronic pain showed similar results, where the prevalence of high-impact chronic pain in employed people was 3.4%, was 16.3% in those unemployed who had previously worked, and was 9.1% in those unemployed who had never worked (Dahlhamer *et al*., 2018). However, the trend may not only between employment groups, but *within* employment groups. An association between joint pain and employment status has been established, where being a farmer was a stronger predictor for joint pain compared to manual workers, entrepreneurs, lower white-collar workers, and upper white-collar workers, in that order (Leino-Arjas, Hänninen and Puska, 1998). Likewise, research has also established that those in non-managerial positions had significantly more pain reports compared to those in managerial positions (Cleveland *et al.*, 2013). Manuel

employees, assistant employees, and intermediate non-manual employees had significantly higher risk of developing rheumatoid arthritis compared to non-manual employees (Bengtsson *et al.*, 2005). Homemakers, for example, have a manual work role, and my results showed that homemakers do in fact have significantly more rheumatic disorder diagnoses compared to those categorised as employed.

Education level was also associated with rheumatic disorder diagnosis, where those who had less than college-level education reported more joint symptoms and rheumatic conditions compared to those who had graduated from college. Previous research also shows that people without a university degree had an increased risk of rheumatoid arthritis compared to those with a degree (Bengtsson *et al.*, 2005), and lower education also predicted decreased function in those with a rheumatic condition (Cleveland *et al.*, 2013; Putrik *et al.*, 2019). Education level has also predicted rheumatoid arthritis remission, where higher education level predicted disease remission (Yu *et al.*, 2019). Furthermore, some research has shown more specific trends in the association between education level and pain, where education level does not affect outcomes of total joint replacements in wealthy communities, but predicts increased pain and decreased function in poor communities (Goodman *et al.*, 2018). Cross-sectional population-based research from the US also demonstrated that the prevalence of general chronic pain, as well as high-impact chronic pain (both unadjusted for age), increased with decreasing education level. Those with less than a high school finishing qualification saw had a chronic pain prevalence of 26.1%, compared to 23.7% with a high school finishing/GED, 22.6% in those with some college, and 13.4% in those with a Bachelor's degree or higher (Dahlhamer *et al*., 2018). Furthermore, the prevalence of people with high-impact chronic pain was 13.6% in those with less than a high school finishing qualification, was 9.7% in those with a high school finishing/GED, was 8.6% in those with some college, and was 3.8% in those with a Bachelor's degree or higher (Dahlhamer *et al.*, 2018). Annual household income was associated with both rheumatic disorder diagnoses, and arthritis diagnoses in my analyses. The aforementioned association is supported by other research that has shown that annual household income was dependent on functional status of people (Wolfe *et al.*, 2005), which decreases with the worsening of rheumatic diseases. Furthermore, the corresponding loss of annual household income as a result of rheumatic conditions was approximately 11.8% (Wolfe *et al*., 2005). Low income has also been associated

with both higher rheumatic disease burden, and rates of rheumatic disease-associated work loss (Callhoff *et al.*, 2017).

Although directionality cannot be inferred from my results, the relationship between socioeconomic status and pain is often reciprocal. Firstly, as outlined by Wolfe *et al*. (2005), income is dependent on the functional status of people. If people have functional limitations as a result of pain, it could then limit their ability to earn. However, the second reciprocal relationship between socioeconomic status and pain demonstrates that those of lower socioeconomic status are more likely to develop pain than those who are socioeconomically comfortable. There could be a number of proxy variables that contribute to this second direction, namely other socioeconomic metrics such as education level or neighbourhood socioeconomic status, as well as individual factors such as physical activity levels, BMI, psychological ill-health and stress, and healthcare-seeking behaviour. Education level can often dictate the type of work that people do (such as whether they work a "desk job" or do manual labour), which can in turn predispose them to developing painful arthropathies (Cutler, Meara and Stewart, 2020). Neighbourhood socioeconomic status has also been associated with poorer pain outcomes and increased use of opioid prescriptions (Booher, 2019), where living circumstances may also contribute to developing or progressing chronic pain. Although I will discuss BMI and physical activity in more detail later in this thesis, these factors may also play a role in predisposing people of lower socioeconomic status to developing painful arthropathies. For example, people in manual labour positions may develop painful arthropathies if they overexert physically on a daily basis (Cutler, Meara and Stewart, 2020). On the other end of the spectrum, people who need to work for many hours in order to meet socioeconomic demands potentially have less time to participate in healthy levels of recreational physical activity, and decreased levels of recreational physical activity in turn increases the risk of painful arthropathies (CDC, 2011b).

Socioeconomic status also has the potential to dictate the type of nutrition choices that people make. If people are poorer, they may not have access to nutritious foods, which could affect their weight, and increased BMI is consistently associated with painful arthropathies, both generally as well as within the context of socioeconomic status (Reyes *et al*., 2016; Cutler, Meara and Stewart, 2020). Psychological ill-health and stress may also play a role, where those of lower socioeconomic status often have financial stress and less predictable living circumstances, which can in turn lead to the development or progression of chronic pain (Bonathan, Hearn and

Williams, 2013). Further to the aforementioned factors (socioeconomic impediments such as education and neighbourhood socioeconomic status, physical activity, BMI, and stress), people of low socioeconomic status also may also lack the means to get treatment for their conditions, which could result in disease progression. Furthermore, the trouble with the aforementioned factors is that they potentially compound into a vicious cycle that predisposes people of lower socioeconomic status to developing a health condition, which will then in turn limit their ability to ever change the circumstances that predisposed them to developing the condition to begin with. Indeed, the poverty rate (the percentage of households below the US Census Bureau poverty line), an indicator of community socioeconomic status, has also been associated with pain in people who have osteoarthritic symptoms (Cleveland *et al.*, 2013). It is not surprising, therefore, that developing arthritis increases the risk of falling into income and multidimensional poverty, and may well be an overlooked driver of poverty (Callander and Schofield, 2016).

Based on the literature I have presented so far; I have created a diagram of feedback loops. In the diagram, I have suggested relationships between variables and worse disease outcomes in poorer people and communities, and the potential consequences I foresee for society (Figure 5.8). Ultimately, the association between socioeconomic status can be detrimental for individuals and society, and can be further exacerbated by factors such as lack of healthcare access. Furthermore, the more the rheumatic disease affects one aspect of a person's socioeconomic prosperity (for example, education), the more other aspects of socioeconomic status are affected (for example, consequential employment, working position, and income). Combined, an overall poor socioeconomic status could then spiral into poorer disease outcomes and consequential burdens on society.

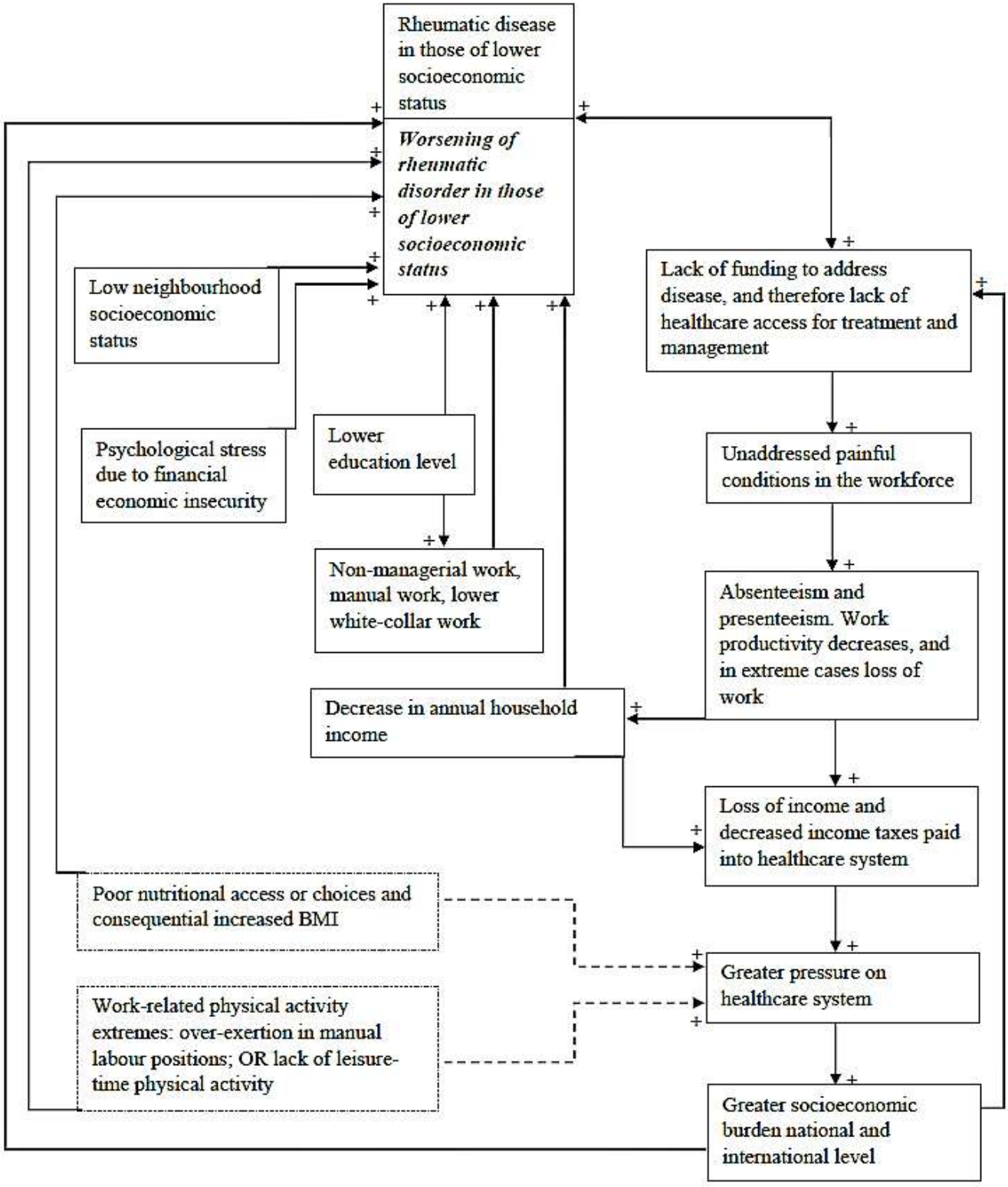


Figure 5.8: Schematic theoretical diagram of the potential positive feedback loops that show how the socioeconomic trends in rheumatic disease affect the burden on the individual and society

Dotted borders and arrows are factors that often correlate with pain in the context of socioeconomic status, but may not always present. When they do present, however, they amplify the effects on the feedback loops

Overall, socioeconomic status is an extremely important demographic factor to consider when examining the burden of painful arthropathies. It is sad to note that previous research found, when comparing socioeconomic statuses between participants in osteoarthritis management programs, and matched controls of the general population, socioeconomic status was in fact lower in the general population. Management program interventions may thus not be reaching people of lower socioeconomic status, where disease burden is also high (Gustafsson *et al.*, 2020). Furthermore, socioeconomic status may also be a surrogate marker for proactive patient self-management and also socioeconomic environment (for example, community poverty rate residence) in chronic disease pathogenesis, progression, and outcomes (Pincus and Castrejon, 2019). Re-examining the implementation of targeted interventions for painful arthropathies is essential if reaching the socioeconomically vulnerable population is to be effective.

A standout feature of my socioeconomic status trend results was that the lowest socioeconomic bracket in various socioeconomic indices (i.e. those with the lowest education level, and lowest annual household income) often was statistically similar in painful arthropathy reports to the highest group in the index. Firstly, the confidence intervals of the odds ratios on the lowest groups are very wide, indicating that the effect size is unstable. However, the surveys in question may not have accessed people of such low socioeconomic status, for example because people were sampled by telephone or home address, which those of such low socioeconomic status would not have. Increased BMI is associated with food insecurity in the US (Pan *et al.*, 2012), and BMI is associated with painful arthropathies, as will be extensively discussed in Chapter Six of this work. However, people with no education, and an annual household income of less than $5 000 are not likely to have much access to food, leading to normal or underweight BMI, therefore attenuating the effect of what is a usual driver of painful arthropathies in the US (Anandacoomarasamy *et al.*, 2008; Crowson *et al.*, 2013). One final suggestion is that if someone is living at such a low socioeconomic status level, it is unlikely that they are financing themselves. If they are in a shelter, or have much state-based or familial help, it is possible that they do not experience the normal stressors associated with low socioeconomic status, which could contribute to the lowest groups not associating with more painful arthropathy reports.

Limitations and conclusion

The research presented in this chapter was not without limitations. A statistical limitation in my methods included a potential inflation of a type I error rate, as a result of doing multiple comparisons across time, as well as multiple comparisons within groups. Furthermore, one demographic aspect that we were not able to investigate was race and/or ethnicity. Although the national population-based surveys I have used do over-sample minorities, upon analysis, I found that the confidence intervals and standard errors were very large, and many groups' painful arthropathy outcomes were inconclusive, although these errors improved in later years. I suggest addressing the large errors on minority groups as an area of future research. Furthermore, socioeconomic status indicators are self-reported, and people may not always be willing to be open about their income or education status. However, many options are given by the various surveys for income and education statuses, which would hopefully encourage people to be honest.

The Global Burden of Disease 2017 studies also found that, regionally, the age-standardised prevalence of arthritis was highest in North America (Safiri *et al.*, 2020). Furthermore, the Medical Expenditure Panel Survey (MEPS) national population-based survey was used to establish the costs of arthritis in the US, where estimated national costs in healthcare costs and lost wages amounted to $45 billion in people with osteoarthritis, compared to $1.7 billion in those without (Zhao *et al.*, 2019). This chapter of my work outlines demographic risk factors for developing painful arthropathies, and the potential consequences thereof. Demographic factors are often not controlled: we cannot control the fact that we get older, whether we are male or female, nor our socioeconomic status in many cases. My thesis has outlined direct demographic risk factors (being older, being female, having lower education status, having lower household income, being unemployed, unable to work, retired, or a homemaker) that could be targeted for attenuating an inevitable risk of developing an ailment that has potentially severe effects on quality of life.

SECTION 2: DEMOGRAPHIC TRENDS OF LOW BACK PAIN

In Chapter One, I discussed how low back pain has previously been associated with age, sex, and socioeconomic status. Older people were found to have higher prevalences of low back pain, and older age has been associated with having low back pain (Shmagel, Foley and Ibrahim, 2016; Wong, Karppinen and Samartzis, 2017). Sex too has been associated with low back pain, where females have higher prevalences of low back pain compared to males (Maher, Underwood and Buchbinder, 2017). Finally, socioeconomic status has been associated with low back pain, where unemployment is associated with low back pain. The unemployed also have higher prevalences of low back pain compared to the employed (Shmagel, Foley and Ibrahim, 2016; Ikeda *et al.*, 2019).

The National Health Interview Survey (NHIS) records self-reported data on age, sex, and employment status. I used complex survey design methods and appropriately weighted data to analyse self-reported data on low back pain. Using the aforementioned data, Section 2 of this chapter evaluates demographic trends of low back pain. I established the prevalence of low back pain within five-year age groups, and between the sexes. I also conducted logistic regressions between low back pain and age, sex, and employment status, respectively.

5.4 National Health Interview Survey (NHIS)

Using appropriately weighted NHIS data from 1997 until 2018 (with the exception of 2004, where stratum data was unavailable to create a design object), I calculated the prevalence of low back pain in US residents as those who answered "Yes" to the question, "DURING THE PAST THREE MONTHS, did you have low back pain?". I calculated the prevalence in various age groups and sexes. Thereafter, I conducted logistic regressions to assess whether a particular age, sex, or socioeconomic status predicted more reports of low back pain.

Tables consisting of all prevalence values (95% confidence intervals), odds ratios (95% confidence intervals) and p-values can be found in the appendices. Age-specific statistics can be found in Appendix H (Table IV). Sex-specific statistics can be found in Appendix I (Table IV). Employment-specific statistics can be found in Appendix J (Table IV).

5.4.1 Low back pain by age

The prevalence of low back pain was calculated from 1997 until 2018 in 11 age groups, namely: 18- to 24-year-olds, 25- to 29-year-olds, 30- to 34-year-olds, 35- to 39-year-olds, 40- to 44-year-olds, 45- to 49-year-olds, 50- to 54-year-olds, 55- to 59-year-olds, 60- to 64-year-olds, 65- to 69-year-olds, and 70-years-old and above. Thereafter, annual sex-adjusted logistic regressions were conducted, where the comparator group was the youngest age category, age 18 to 24 years.

In 18- to 24-year-olds, the prevalence of low back pain across all years that I analysed was between 16.2% and 25.8%, and the most recent prevalence (2018) was 16.5%. In those aged 25 to 29 years, the prevalence of low back pain was between 21.7% and 25.9%, and the most recent prevalence was 24.8%. In 30- to 34-year-olds, the prevalence of low back pain ranged between 23.0% and 27.6%, and the most recent prevalence was 26.3%. In those aged 35 to 39 years, the prevalence of low back pain was between 23.9% and 31.6%, and the most recent prevalence was 28.8%. In 40- to 44-year-olds, the prevalence of low back pain was between 20.3% and 31.7%, and the most recent prevalence was 29.1%. In those aged 45 to 49 years, the prevalence of low back pain was between 27.1% and 33.9%, and the most recent prevalence was 31.0%. In 50- to 54-year-olds, the prevalence of low back pain was between 27.3% and 35.6%, and the most recent prevalence was 31.2%. In 55- to 59-year-olds, the prevalence of low back pain was between 28.4% and 36.4%, and the most recent prevalence was 33.3%. In those aged 60 to 64 years, the prevalence of low back pain was between 27.9% and 37.2%, and the most recent prevalence was 36.4%. In 65- to 69-year-olds, the prevalence of low back pain was between 26.6% and 34.9%, where 34.9% was also the most recent prevalence. Finally, in those aged 70 years and above, the prevalence of low back pain was between 28.8% and 37.8%, where 37.8% was also the most recent prevalence. The prevalence of low back pain increases more steeply in youngest age categories, but by age 35 years, the prevalence increased by very small amounts or tapered off. These prevalence data therefore suggest that low back pain population prevalence is reached by approximately age 35. (Figure 5.9).

Sex-adjusted logistic regressions showed that the youngest age category (age 18 to 24 years) had significantly lower low back pain reports than did older age groups. In rare years, those aged 18 to 24 years had low back pain reports comparable to those aged 25 to 29 years (2000, 2001,

2002, 2008, and 2014) and those aged 30 to 34 years (2001), but significantly fewer low back pain reports than the remaining older age groups.

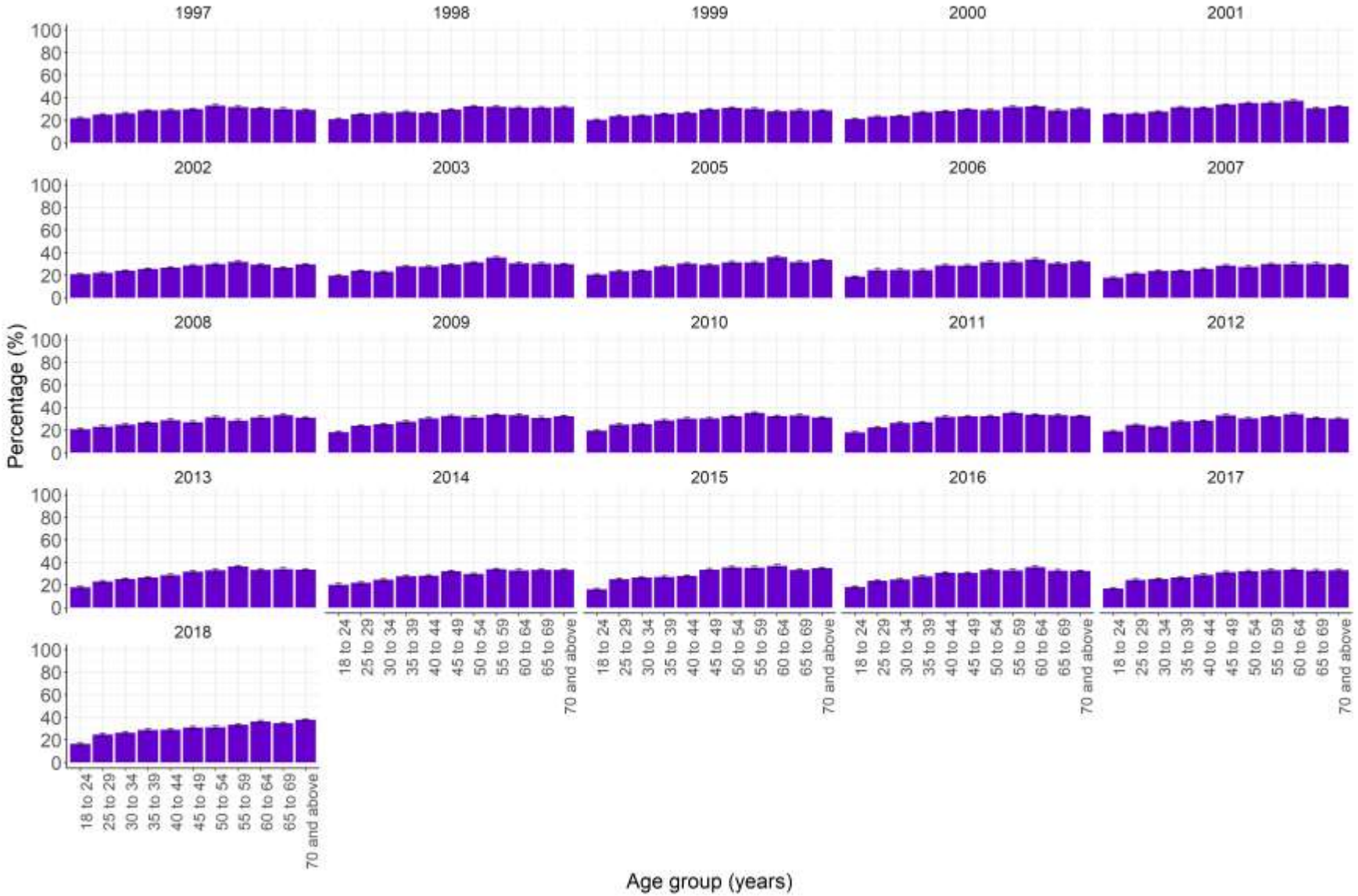


Figure 5.9: Prevalence (%) of US residents, by age group, who reported having had low back pain in the previous three months, according to the National Health Interview Survey (NHIS)[α], from 1997 until 2018

[α] Sample Adult Questionnaire

5.4.2 Low back pain by sex

Between 1997 and 2018, the prevalence of low back pain reports was calculated in males and females, and age-adjusted logistic regressions were conducted, where the comparator group was males. In males, the prevalence of low back pain was between 23.6% and 29.4%, and the most recent prevalence was 28.0%. In females, the prevalence of low back pain reports was between 27.5% and 32.7%, and the most recent prevalence was 31.6% (Figure 5.10). Age-adjusted logistic regressions showed that females reported statistically significantly more low back pain compared to males, across all survey years ($P < 0.001$).

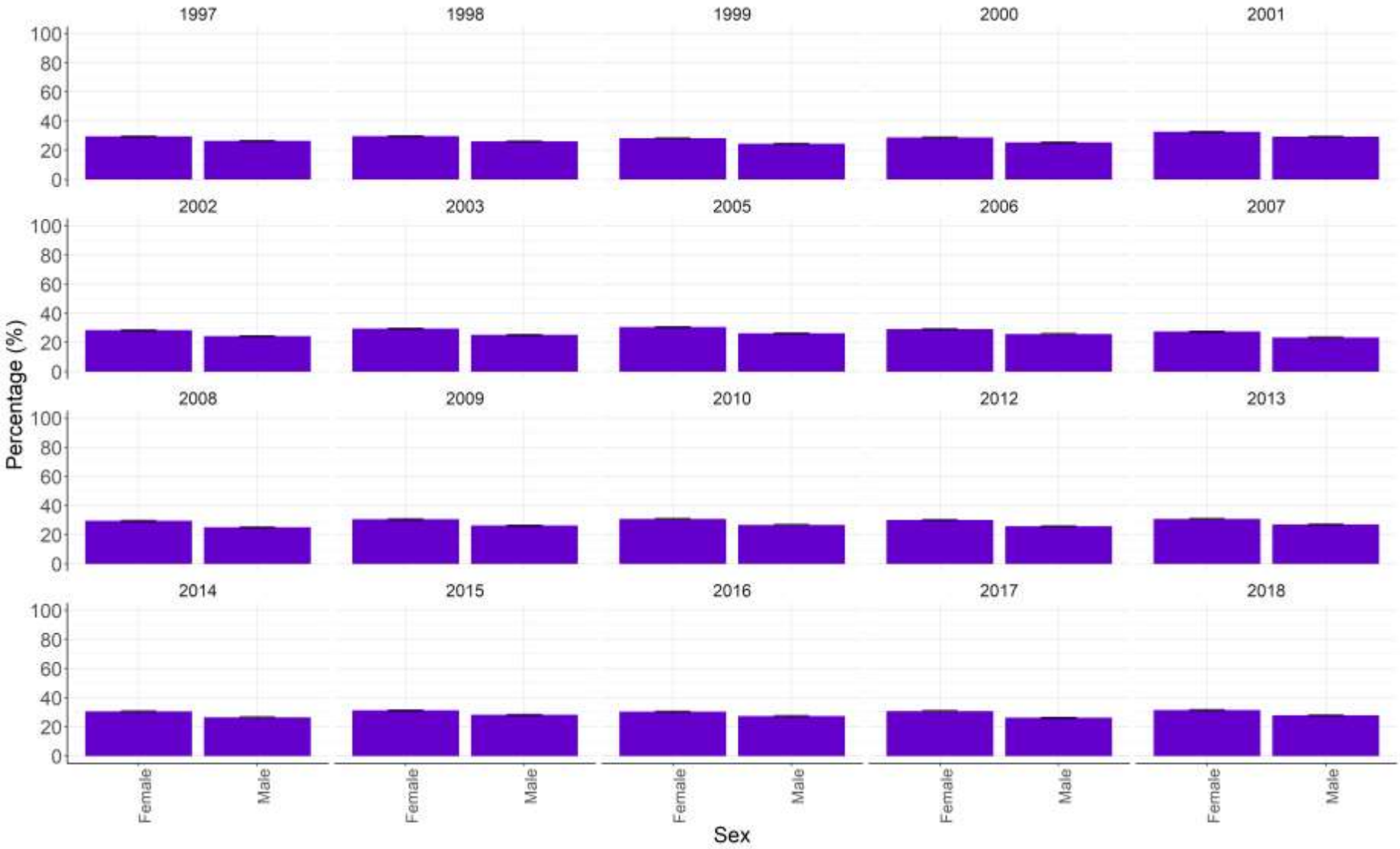


Figure 5.10: Prevalence (%) of US residents, by sex, who reported having had low back pain in the previous three months, according to the National Health Interview Survey (NHIS) [α], from 1997 until 2018

[α] Sample Adult Questionnaire

5.4.3 Low back pain by socioeconomic status

5.4.3.1 Employment status

Socioeconomic status was assessed using employment status, between 2002 and 2018, except for 2004. Annual age- and sex-adjusted logistic regressions were done to compare low back pain between individuals who were working for pay at a job/business, and those not working. Those who were not working reported significantly more low back pain than those who were working for pay, for every year of analysis (Table 5.4).

Table 5.4: Comparison of low back pain reports in different socioeconomic groups (indicated by employment status), according to the National Health Interview Survey (NHIS)[α], from 2002 to 2018

Year	Socioeconomic status indicator *Employment Status*	OR *(95% CI)*	P-value
2002	Working for pay at a job/business Not working	0.238 *(0.213, 0.266)* 1.55 *(1.44, 1.67)*	< 0.001*
2003	Working for pay at a job/business Not working	0.224 *(0.200, 0.251)* 1.53 *(1.42, 1.65)*	< 0.001*
2005	Working for pay at a job/business Not working	0.225 *(0.199, 0.254)* 1.60 *(1.49, 1.73)*	< 0.001*
2006	Working for pay at a job/business Not working	0.193 *(0.166, 0.223)* 1.67 *(1.53, 1.82)*	< 0.001*
2007	Working for pay at a job/business Not working	0.185 *(0.159, 0.215)* 1.66 *(1.52, 1.82)*	< 0.001*
2008	Working for pay at a job/business Not working	0.246 *(0.211, 0.287)* 1.48 *(1.35, 1.63)*	< 0.001*
2009	Working for pay at a job/business Not working	0.195 *(0.167, 0.226)* 1.64 *(1.51, 1.79)*	< 0.001*
2010	Working for pay at a job/business Not working	0.215 *(0.186, 0.249)* 1.64 *(1.51, 1.78)*	< 0.001*
2011	Working for pay at a job/business Not working	0.181 *(0.157, 0.207)* 1.81 *(1.68, 1.95)*	< 0.001*
2012	Working for pay at a job/business Not working	0.203 *(0.177, 0.233)* 1.78 *(1.64, 1.92)*	< 0.001*
2013	Working for pay at a job/business Not working	0.184 *(0.158, 0.214)* 1.78 *(1.65, 1.93)*	< 0.001*
2014	Working for pay at a job/business Not working	0.217 *(0.179, 0.263)* 1.72 *(1.58, 1.87)*	< 0.001*
2015	Working for pay at a job/business Not working	0.167 *(0.143, 0.196)* 1.62 *(1.49, 1.76)*	< 0.001*
2016	Working for pay at a job/business Not working	0.181 *(0.155, 0.212)* 1.81 *(1.66, 1.96)*	< 0.001*
2017	Working for pay at a job/business Not working	0.71 *(0.145, 0.201)* 1.74 *(1.60, 1.90)*	< 0.001*

2018	Working for pay at a job/business	0.175 *(0.148, 0.208)*	< 0.001*
	Not working	1.62 *(1.48, 1.75)*	

* P < 0.05: for a significant difference between those working for pay at a job/business (comparator group) and those without work, by logistic regression analysis

[α] Sample Adult Questionnaire

SECTION 2 DISCUSSION

Demographic trends in low back pain using the NHIS survey

I used the National Health Interview Survey (NHIS) to calculate the prevalence of low back pain during the three months prior to taking the Sample Adult Questionnaire, in various ages and the sexes. I also conducted logistic regressions to establish whether age, sex, and/or socioeconomic status were associated with low back pain. I conducted the age and sex analyses for survey cycles 1997 to 2018 (bar 2004), and I conducted the socioeconomic status analyses for survey cycles 2002 to 2018 (bar 2004). In age groups [ages (in years): 18 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, and 70 and above], the prevalence of low back pain ranged between 16.2% and 25.8% in the youngest age group, and reached a range of between 28.8% and 37.8% in those aged 70 years and above. Sex-adjusted logistic regressions showed that the youngest age group (age 18 to 24 years) reported significantly less low back pain compared to older groups. After the age of approximately 35-years-old, low back pain levelled off at a lifelong prevalence, with only very small increment (approximately 1%) increases per increasing five-year age group. The prevalence of low back pain in the sexes was different: low back pain prevalence reports in females were between 27.5% and 32.7%, while in males it was between 23.6% and 29.4%. Age-adjusted logistic regressions showed that females reported significantly more low back pain than males throughout the years I analysed. Finally, I conducted age- and sex-adjusted logistic regressions on employment status (employed for wages versus unemployed) to establish whether socioeconomic status was associated with low back pain. Individuals who were employed for pay at a job or business reported significantly less low back pain compared to those who were unemployed, across all years of analysis.

<u>Low back pain and age</u>

My analyses showed that low back pain was associated with age, but only in younger adult age groups. Low back pain reports were significantly lower in those aged 18 to 24 compared to older age groups. On occasion, age groups 25 to 29 years, and 30 to 35 years had statistically similar low back pain reports to the youngest group. Low back pain lifetime prevalence was reached by approximately age 35 years old. Meta-analyses have also previously shown that maximal low

back pain population prevalence was reached fairly early in life, growing steadily from childhood (approximately 6%) and adolescence (approximately 12%) to adult lifetime prevalence (approximately 39.9%) by 18 years old (Vlaeyen *et al.*, 2018; Mather *et al.*, 2019). Likewise, the risk of low back pain associated disability is also only reduced up until the age of approximately 30 years old (Mather *et al.*, 2019). Given that low back pain is prevalent in children (between 6% and 39.9% across various ages in childhood and adolescence until age 18 years (Vlaeyen *et al.*, 2018; Mather *et al.*, 2019)), I would suggest that a progressive increase in low back pain prevalence may actually begin before adulthood. Low back pain in childhood also predicts low back pain in adulthood (Swain *et al.*, 2014). Using the youngest age category of this research (age 18 to 24) as a childhood exit low back pain prevalence, the prevalence of those at risk of developing low back pain in the US is then already high, at between 16.2% and 25.8% of people. Previous research has however found low back pain to be associated with older age (Shmagel, Foley and Ibrahim, 2016). Furthermore, older age has been associated with chronic low back pain prevalence, and low back pain of higher pain intensity (Wong, Karppinen and Samartzis, 2017). The difference in the experience of low back pain by age then may not be in the prevalence, but in the aetiology, consequences, and experience of low back pain.

Although the aetiology of low back pain is often difficult to ascertain, recent research suggests that, in young and middle-aged adults, low back pain is more commonly as a result of internal disc disruption. In older adults, however, low back pain was associated with facet joint pain and sacroiliac joint pain (DePalma, Ketchum and Saullo, 2011; Wong, Karppinen and Samartzis, 2017). Other research suggests that in young adults, low back pain often had no definite pathology, while in older patients there is a higher prevalence of disc degeneration, and lumbar spine stenosis (Wong, Karppinen and Samartzis, 2017). In fact, prevalence of lumbar spine stenosis in younger adults (age 40 and below) was only 4% compared to 14.3% in older adults (Kamihara *et al.*, 2014). Furthermore, degenerative lumbar scoliosis in adults was estimated at 8.3% to 13.3% in the adult population, but was 68% in adults older than 60 years old (Schwab *et al.*, 2005). Therefore, although the prevalence of low back pain in middle-aged and older adults may be similar, the low back pain in the elderly was more chronic in nature due to long-term age-related changes. Moreover, the decreasing levels of physical activity in older adults (Cunningham et al., 2020) could result in decreased muscle strength. In turn, decreased muscle

strength could contribute to physical activity decline as movement becomes more difficult or limited, which could then further lead to low back pain.

As well as different aetiology, the consequences of low back pain are different in different age groups. Older adults with low back pain have cited limitations with "self-care", "mobility", and "walking", while younger patients have cited limitations in "transportation" (driving, using public transport, moving around using equipment) significantly more than older patients (Fehrmann *et al.*, 2019). Older and middle-aged adults also recognised more demand and dependency on health services and mobility-related social services compared to younger patients (Fehrmann *et al.*, 2019), which may be due to chronicity of low back pain or diversity of co-occurring limitations. Furthermore, older and middle-aged adults (ages 40 to 79 years old) with low back pain also had significantly higher depression scores compared to depressed age-matched age adults without low back pain (Calvo-Lobo *et al.*, 2017). When looking at the age-related socioeconomic experience of adults with low back pain, research showed that older workers were at greater risk of experiencing low back pain compared to younger workers, particularly when these older adults had non-standard work arrangements (Yang *et al.*, 2016). In younger workers, only those who reported working more than 60 hours per week had increased risk of low back pain (Yang *et al*., 2016). Therefore, I would recommend that future research consider psychosocial affect and socioeconomic status to establish whether these variables (such as depression, anxiety, stress, income and employment status) influence low back pain differently within different age groups.

Low back pain and sex

Sex has also been established as a low back pain risk factor in my research and elsewhere, where low back pain is more prevalent in females compared to males (Hoy *et al.*, 2010; Maher, Underwood and Buchbinder, 2017; Mather *et al.*, 2019). Furthermore, females have also been found to be at greater risk of developing chronic low back pain (Hoy *et al*., 2010). A systematic review found the global low back pain prevalence in females aged 20 to 29 years to be approximately 20% and age-matched males approximately 12%. By age 30 to 39 years, the prevalence of low back pain in females was approximately 33%, and 28% in age-matched males. By mid-adulthood, females had a low back pain prevalence of around 35%, and males around

30%. By older adulthood, the prevalence of low back pain was approximately 40% in females, and approximately 30% in age-matched males (Hoy *et al*., 2012). The results from this systematic review are similar to my own results, and show that, a) the prevalence of low back pain increases rapidly in early adulthood and then plateaus from middle adulthood, and b) females have a lifelong increased prevalence of low back pain compared to males.

As is the case with age, low back pain has different aetiology and consequences between the sexes. For example, evidence suggests that females have lower pain thresholds and tolerances and experience increased intensity when subjected to painful stimuli on a biological level (LeResche, 1999; Mills, Nicolson and Smith, 2019). Some research suggests that sex hormones may play a role in pain modulation (Craft, 2007). For example, postmenopausal women have decreased levels of oestrogen, which in turn leads to increased bone resorption and osteoporosis, and hence increased risk of fractures (Møller *et al*., 2020). Indeed, an estimated 25% of all postmenopausal women will suffer from vertebral fracture, and this prevalence increases with age to as much as 40% in women age 80 and above (Wong, Karppinen and Samartzis, 2017). Other proposed mechanisms for the sex-specific difference in pain prevalence include psychological aspects, for example, females are more likely to suffer with psychological illnesses such as anxiety and depression, and stress-related disorders (Altemus, Sarvaiya and Epperson, 2014); which, by proxy affect chronic outcomes in females (McWilliams, Goodwin and Cox, 2004; Altemus, Sarvaiya and Epperson, 2014). Secondly, research has shown that females may have used more maladaptive coping strategies, which led to poorer functional outcomes (El-Shormilisy, Strong and Meredith, 2015). Low back pain is largely related to occupation (which will be discussed in a later section in this discussion), and, in instances where low back pain is associated with professions requiring extensive manual labour and physical activity, it is more likely to be men in these roles than women (Unruh, 1996). One cannot, however, ignore the societal aspects of pain, where men are less willing to report pain than women due to societal expectations (Unruh, 1996).

Consequential behaviour is also different between the sexes. In terms of daily life, females have also cited low back pain-related restrictions in housework, which is a large concern for them compared to males. Young males in particular, however, have the highest concern for their impairment for social activities and recreation (Fehrmann *et al.*, 2019). Socioeconomic status will be covered more extensively later in this discussion; but socioeconomic status and

healthcare-seeking behaviour for low back pain is different between the sexes. Women are more likely to take time off work, and consult healthcare compared to men (Hoy *et al*., 2010). Therefore, as well as different prevalences of low back pain, the lived experience of low back pain is different between the sexes.

Low back pain and socioeconomic status

The socioeconomic index available in my low back pain analysis was employment status (employed versus unemployed). Unemployment was associated with having low back pain across all years of my analyses, and has also been associated with unemployment in other research. Low back pain was associated with unemployment rate in cross-sectional nationally representative samples (Shmagel, Foley and Ibrahim, 2016; Ikeda *et al.*, 2019). One study also estimated that 37% of unemployed research participants with low back pain cited their low back pain as the direct reason for their unemployment. When the sample was followed up, employment status statistics were stable, suggesting that those who were unemployed due to low back pain had not managed to re-enter employment (Wynne-Jones, Dunn and Main, 2008). Indeed, return-to-work rates are low, estimated at only 20% after one year of leave (Kool, Oesch and De Bie, 2002). Furthermore, having more than one risk factor associated with low back pain (for example higher pain intensity, sickness behaviour, and decreased physical function) predicted not returning to work more compared to having one or none of these risk factors (Kool, Oesch and De Bie, 2002).

The health-related quality of life in unemployed people with low back pain is in fact also worse than those unemployed for another reason. Unemployed people with low back pain reported worse self-rated health status compared to the unemployed who did not cite low back pain as the reason for their unemployment (Wynne-Jones, Dunn and Main, 2008). Furthermore, people with low back pain who were unemployed and receiving compensation reported higher disability scores compared to those employed (not receiving compensation) with low back pain. Even within the compensation-receiving group, disability was significantly worse in those unemployed compared to those employed (Sanderson *et al.*, 1995). The findings of the aforementioned research, along with that of Shmagel, Foley and Ibrahim (2016), where chronic low back pain was associated with income disability, implies that the unemployed with low back are at greater

risk of disability. Alternatively, the aforementioned research could imply that those of low socioeconomic status due to unemployment may have to rely on low back pain-related disability grants for survival, as a result of being unable to work due to their low back pain.

Although I have discussed the association of low back pain with unemployment, and its corresponding financial and social burden, low back pain is also burdensome within the workplace. In employed people with low back pain, 11% had undertaken reduced duties, and 22% reported sick leave. Thereafter, the further removed from full-time work someone with low back pain was (in the form of reduced duties, and more off-time), the worse their socioeconomic status, self-rated health, anxiety, depression and disability (Wynne-Jones, Dunn and Main, 2008). The burden of low back pain is thus prominent within the workplace. Low job demands and high job control were associated with lower risk of work disability (Mather *et al.*, 2019). The reduced load on employees with low back pain however means that the burden will simply fall onto the business and other employees.

Finally, although I have discussed low back pain specifically within the context of employment status, employment status is not the only socioeconomic index associated with low back pain. Having an education status of less than high school graduation has been associated with low back pain (Shmagel, Foley and Ibrahim, 2016). Likewise, lower education level has also predicted longer low back pain episode duration, and poorer corresponding low back pain outcomes (Dionne *et al.*, 2001). Income has also been associated with low back pain, where annual household income of less than $20 000, and disability grant income have also been associated with chronic low back pain (Shmagel, Foley and Ibrahim, 2016).

Research has shown that low back pain was associated with poor mental health (Hartvigsen *et al.*, 2018), such as stress, anxiety, and depression (Hoy *et al.*, 2010; Hartvigsen *et al.*, 2018). The association between low back pain and poor mental health also contributed to the transition from acute to chronic low back pain (Pincas *et al*., 2002). US-based nationally representative research has also shown the association of chronic low back pain with depression, and sleep disturbances (Shmagel, Foley and Ibrahim, 2016). Those of lower socioeconomic status often experience much stress, anxiety, sleep disturbance, and depression as a result of their circumstances. The association between socioeconomic status and poor psychological affect, as well as the

association between socioeconomic status and increased risk of chronic low back pain, leads to a double-edged sword for the poorer population.

Limitations and section conclusion

My research in this chapter does have some limitations. The NHIS is the only survey with low back pain data, and I was unable to compare demographic findings between surveys, as I did in Section 1 with painful arthropathies. Furthermore, socioeconomic status was only examined in terms of employment status (employed versus unemployed), and the NHIS Sample questionnaire did not include questions on annual household income or education level. Various other employment options (such as self-employment, manual labour and physical occupation work, and unable to work), education level, and annual household income should be explored in low back pain on a representative and nationwide, longitudinal level. Finally, a statistical limitation in my methods included a potential inflation of a type I error rate, as a result of doing multiple comparisons across time, as well as multiple comparisons within groups.

The association between various demographic groups (young adulthood, female sex, and low socioeconomic status in the form of unemployment) has been demonstrated in Section 2 of this chapter. Whilst these findings are not new, I have shown them collectively and within the context of an entire nationally represented population, across a period of approximately 20 years. The burden of low back pain on those affected is high, as low back pain is the leading cause of years lived with disability (Maher, Underwood and Buchbinder, 2017). The burden of low back pain is particularly challenging within the context of socioeconomic status, as low back pain is also the leading cause of work activity limitation and work absence (Hoy *et al.*, 2010), but likewise unemployment was also associated with low back pain over time. A biopsychosocial approach, encompassing targeting young adults and even adolescents, females, and the unemployed could be the best method for designing targeted interventions.

CHAPTER SIX

Lifestyle factors - the role of BMI and physical activity in musculoskeletal pain: painful arthropathies and low back pain

I discussed in Chapter One that previous research has shown that there is an association between lifestyle factors (such as BMI and physical activity levels) and musculoskeletal pain (Okifuji and Hare, 2015; Shemory, Pfefferle and Gradisar, 2016; Barbour *et al*., 2017b; Peng, Pérez and Gabriel, 2018; Zhang *et al.*, 2018). The US has a high prevalence of obesity amongst its population, with an age-standardised estimate of 39.6% of the population estimated to be obese, and 7.7% of the population being severely obese (Hales *et al*., 2018). Therefore, much of the US population could be at risk of musculoskeletal pain. The consequences of musculoskeletal conditions include pain and functional disability (Heo *et al.*, 2010; Arranz, Rafecas and Alegre, 2014; Wasser *et al.*, 2017), which in turn lead to reduced physical activity (Barbour *et al*., 2017a), and potentially obesity as a result of inactivity and functional limitations.

While the relationship between musculoskeletal pain and BMI, and physical activity, has been shown in previous research, the research to date is either cross-sectional, or geographically localised. In the case of low back pain, obtaining a standard measurement of low back pain across time is difficult and thus hampers the ability to evaluate corresponding lifestyle trends across time. Chapter Six of this thesis, therefore, aims to address my final objective: to describe the association between lifestyle-related factors (BMI, and physical activity) with having a painful arthropathy (Section 1), or low back pain (Section 2).

SECTION 1: LIFESTYLE (BMI AND PHYSICAL ACTIVITY) TRENDS OF PAINFUL ARTHROPATHIES

Obesity is common in people who suffer with rheumatic conditions, arthritis, and generalised joint pain (Okifuji and Hare, 2015; Vennu *et al.*, 2020). Given the high prevalence of obesity in the US (Hales *et al*., 2018), much of the US population could potentially be experiencing painful arthropathies. Furthermore, physical inactivity is also a risk factor for rheumatic conditions, and also correlates with pain severity once the painful arthropathy has developed. For example, physical inactivity was higher in people with severe pain (47.0%) compared to people with moderate (31.8%) or mild-to-no pain (22.6%) (Guglielmo *et al.*, 2019). Conversely, physical activity has been shown to be beneficial for people with rheumatic conditions, and improves functional outcomes and reduces pain (Villafañe *et al.*, 2019).

The Behavioural Risk Factor Surveillance System (BRFSS), and the National Health Interview Survey (NHIS) record self-reported height and weight data, and calculate BMI from that data. The National Health and Nutrition Examination Survey (NHANES) (Continuous) records self-reported height and weight data, as well as physically measured height and weight measurements, taken during the examination portion of the survey. Only the NHIS records data on physical activity habits (including intensity, frequency, and duration).

I used these three population-based surveys to describe the association between lifestyle-related factors (BMI, and physical activity) with having a painful arthropathy. Using logistic regressions, I addressed potential association between BMI and rheumatic disorder diagnoses, joint symptoms, and arthritis diagnoses, respectively. I then used the NHIS data to conduct logistic regressions in order to establish whether physical activity was associated with joint symptoms.

6.1 Behavioural Risk Factor Surveillance System (BRFSS)

Rheumatic disorder diagnosis and BMI

I used the BRFSS question, "Has a doctor, nurse, or other health professional ever told you that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?", to calculate BMI from self-reported height and weight in order to assess whether BMI associated with a rheumatic disorder diagnosis. I conducted appropriately weighted, and age- and sex- adjusted, logistic regressions for each year (1996 until 2018, except 2006 and 2008, where rheumatic disorder diagnosis data was unavailable, including module years 1996 to 2000, 2002, 2004, and 2010). Increased BMI was significantly associated with rheumatic disorder diagnosis across all survey cycles (Table 6.1).

6.2 National Health Interview Survey (NHIS)

Joint symptoms and BMI, and physical activity

6.2.1 Joint symptoms and BMI

Using appropriately weighted NHIS data from 2002 until 2018 (with the exception of 2004), I conducted appropriately weighted, age- and sex-adjusted, logistic regressions to assess whether BMI (calculated from self-reported height and weight) was associated with joint symptoms. Joint symptoms were defined according to the NHIS questionnaire as those who answered "Yes" to the question, "The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?". Increased BMI was significantly associated with joint symptoms across all survey cycles (Table 6.1).

6.2.2 Joint symptoms and physical activity

Using appropriately weighted NHIS data from 2002 until 2018 (with the exception of 2004), I conducted appropriately weighted age- and sex-adjusted, logistic regressions to assess whether physical activity was associated with joint symptoms. Joint symptoms were defined as those who answered "Yes" to the question, "The next questions refer to your joints. Please do NOT include the back or neck. DURING THE PAST 30 DAYS, have you had any symptoms of pain, aching, or stiffness in or around a joint?". Being physically active was defined as meeting the criteria of the *Healthy People 2010* objective, namely either light or moderate physical activity five or more times per week for a duration of 30 minutes or more, or vigorous exercise three or more times per week for a duration of 20 minutes or more. Any participants who did not meet these criteria were classed as physically inactive.

Not being physically active (physical inactivity) was significantly associated with joint symptom reports ($P < 0.05$) in 2005, 2007, and from 2009 across all years until the most recent analysis of 2018 data. The risk of joint symptoms in those physically inactive was higher compared to those physically active in these years. Physical activity levels were not associated with joint symptoms in 2002, 2003, 2006, or 2008 (Table 6.2).

6.3 National Health and Nutrition Examination Survey (NHANES) (Continuous)

Arthritis diagnosis and BMI

Using NHANES (Continuous) survey data, I conducted appropriately weighted, age- and sex-adjusted, logistic regressions to establish whether BMI (measured during the examination procedure of the NHANES survey, by a trained NHANES professional) was associated with an arthritis diagnosis (those who answered, "Yes" to the question, "Has a doctor or other health professional ever told you that you had arthritis?"). I conducted logistic regressions for each survey cycle, from 1999-2000 until 2017-2018. Increased BMI was significantly associated with an arthritis diagnosis across all survey cycles (Table 6.1).

Table 6.1: Association, shown by odds ratio (95% confidence interval) [OR (*95% CI*)] and p-value, between various painful arthropathies (rheumatic disorder diagnosis, BRFSS[ι]; joint symptoms, NHIS[ε]; and arthritis diagnosis, NHANES Continuous) and BMI, across all years analysed in each respective survey

Year	Survey					
	BRFSS		NHIS		NHANES (Continuous)	
	Rheumatic disorder diagnosis [ι]		Joint symptoms [ε]		Arthritis diagnosis	
	OR (95% CI)	*p-value*	*OR (95% CI)*	*p-value*	*OR (95% CI)*	*p-value*
1996	1.07 (1.05, 1.08)[α]	< 0.001*	--	--	--	--
1997	1.07 (1.05, 1.08)[α]	< 0.001*	--	--	--	--
1998	1.08 (1.06, 1.09)[α]	< 0.001*	--	--	--	--
1999	1.07 *(1.06, 1.07)*[α]	< 0.001*	--	--	1.05 (1.03, 1.07)	< 0.001*
2000	1.06 *(1.06, 1.07)*[α]	< 0.001*	--	--		
2001	1.07 *(1.06, 1.07*)	< 0.001*	--	--	1.05 (1.04, 1.07)	< 0.001*
2002	1.06 *(1.06, 1.07)*[α]	< 0.001*	1.06 *(1.05, 1.07)*	< 0.001*		
2003	1.06 *(1.06, 1.07)*	< 0.001*	1.06 *(1.05, 1.06)*	< 0.001*	1.04 (1.02, 1.05)	< 0.001*
2004	1.07 *(1.06, 1.08)*[α]	< 0.001*	--	--		
2005	1.06 *(1.06, 1.07)*	< 0.001*	1.06 *(1.05, 1.06)*	< 0.001*	1.06 (1.04, 1.07)	< 0.001*
2006	--	--	1.06 *(1.05, 1.07)*	< 0.001*		
2007	1.06 *(1.06, 1.07)*	< 0.001*	1.05 *(1.05, 1.06)*	< 0.001*	1.05 (1.04, 1.07)	< 0.001*
2008	--	--	1.05 *(1.05, 1.06)*	< 0.001*		
2009	1.06 *(1.06, 1.06)*	< 0.001*	1.05 *(1.04, 1.05)*	< 0.001*	1.05 (1.04, 1.06)	< 0.001*
2010	1.05 *(1.04, 1.06)*[α]	< 0.001*	1.05 *(1.05, 1.06)*	< 0.001*		
2011	1.06 *(1.06, 1.06)*	< 0.001*	1.06 *(1.05, 1.06)*	< 0.001*	1.05 (1.04, 1.07)	< 0.001*
2012	1.06 *(1.06, 1.07)*	< 0.001*	1.05 *(1.05, 1.06)*	< 0.001*		
2013	1.06 *(1.06, 1.06)*	< 0.001*	1.05 *(1.04, 1.05)*	< 0.001*	1.07 (1.05, 1.08)	< 0.001*
2014	1.06 *(1.06, 1.06)*	< 0.001*	2.29 *(1.76, 2.79)*	< 0.001*		
2015	1.05 *(1.05, 1.06)*	< 0.001*	1.05 *(1.05, 1.06)*	< 0.001*	1.06 (1.05, 1.08)	< 0.001*
2016	1.06 *(1.06, 1.06)*	< 0.001*	1.06 *(1.05, 1.06)*	< 0.001*		
2017	1.06 *(1.06, 1.06)*	< 0.001*	1.05 *(1.05, 1.06)*	< 0.001*	1.06 (1.04, 1.07)	< 0.001*
2018	1.06 *(1.05, 1.06)*	< 0.001*	1.05 *(1.05, 1.06)*	< 0.001*		

* P < 0.05: for a significant association between BMI and the respective painful arthropathy

[ι] Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[α] Module questionnaire years

[ε] Pain, aching, or stiffness in the 30 days prior to taking the NHIS Sample Adult Questionnaire

Table 6.2: Association, shown by odds ratio (95% confidence interval) [OR (95% CI)] and p-value, between joint symptoms[ε] (according to the NHIS) and physical inactivity, from 2002 until 2018

Year	OR *(95% CI)*	p-value
2002	1.01 *(0.948, 1.08)*	0.720
2003	0.982 *(0.921, 1.05)*	0.575
2005	1.07 *(1.00, 1.15)*	0.039*
2006	0.997 *(0.894, 1.05)*	0.399
2007	1.12 *(1.03, 1.21)*	0.007*
2008	1.08 *(0.999, 1.17)*	0.052
2009	1.26 *(1.17, 1.36)*	< 0.001*
2010	1.15 *(1.08, 1.24)*	< 0.001*
2011	1.31 *(1.23, 1.39)*	< 0.001*
2012	1.24 *(1.16, 1.33)*	< 0.001*
2013	1.23 *(1.15, 1.31)*	< 0.001*
2014	1.30 *(1.22, 1.39)*	< 0.001*
2015	1.29 *(1.20, 1.38)*	< 0.001*
2016	1.17 *(1.09, 1.25)*	< 0.001*
2017	1.18 *(1.10, 1.26)*	< 0.001*
2018	1.33 *(1.24, 1.43)*	< 0.001*

* $P < 0.05$: for a significant association between physical inactivity and joint symptoms

[ε] Pain, aching, or stiffness in the 30 days prior to taking the NHIS Sample Adult Questionnaire

SECTION 1 DISCUSSION

Lifestyle (BMI, and physical activity) trends in painful arthropathies

Summary of findings

I used the BRFSS to address whether BMI was associated with a diagnosis of a rheumatic disorder in US adult residents, by means of age- and sex-adjusted logistic regressions. I conducted analyses across a 23-year period, including module years. Increased BMI was significantly associated with a diagnosis for every year of analysis, including module years. Thereafter, I used the NHIS to establish whether BMI associated with joint symptoms in US adult residents, by using age- and sex-adjusted logistic regressions, across a 17-year period. Increased BMI significantly associated with joint symptoms for every year of analysis. I used the NHANES (Continuous) to establish whether BMI was significantly associated with an arthritis diagnosis in US adult residents, by means of age- and sex-adjusted logistic regressions. I conducted analyses across a 20-year period, which translated to 10 survey cycles. Increased BMI was significantly associated with an arthritis diagnosis for every survey cycle analysis.

Finally, I used the NHIS to establish whether physical activity was associated with joint symptoms in US adult residents by means of age- and sex-logistic regressions. In early survey years (2002 to 2008), physical activity oscillated between associating, and not associating, with joint symptoms. Since 2009, physical inactivity did significantly associate joint symptoms in every survey year cycle, where those who were categorised as physically inactive reported significantly more joint symptoms compared to those who were in the physically active group.

Painful arthropathies and obesity

Obesity is a massive public health burden and concern in the US, with an estimated 72.5 million adults being obese in 2011 (CDC, 2011c), and the prevalence of obesity and pre-obesity exceeding 60% of the US population in 2016 (De Lorenzo *et al.*, 2020). Obesity is also common in people with arthritis (Cheng, *et al.*, 2010; Barbour *et al.*, 2017b), with the prevalence of obese people with diagnosed arthritis cited as almost double that of non-obese people diagnosed with arthritis (31% as opposed to 16% respectively) (NCCDPHP, 2006). The prevalence of arthritis

diagnoses amongst the obese population is high, ranging between 40.3% and 42.6%, compared to arthritis diagnoses in the overall population of between 20.6% and 22.0% in the same year (Barbour *et al.*, 2017b). Even within the obese population, there are clear arthritis-based trends. Within obesity subclasses, the prevalence of the obese population diagnosed with arthritis compared to obese people without an arthritis diagnosis was 20.1% compared to 16.4% (subclass I, 30 to <35kg.m^{-2}), 10.4% compared to 6.2% (subclass II, 35 to <40 kg.m^{-2}), and 9.8% compared to 3.6% (subclass III, ≥40kg.m^{-2}), respectively (Barbour *et al.*, 2017b). From these prevalence data, as well as my own findings on the significant association between increased BMI and all painful arthropathy types, there is a clear association between obesity and painful arthropathies.

Longitudinal research over a period of two years found that the obese with early rheumatoid arthritis had significantly worse outcomes (pain, functional impairment, and disease activity) compared to non-obese early rheumatoid arthritis patients (Levitsky *et al.*, 2017). Obesity, therefore, is a predictor for worse disease-related outcomes in people who already have painful arthropathies. Furthermore, the relationship may be bidirectional. People with painful arthropathies often have disease-attributable physical inactivity, and the prevalence thereof is rising (Barbour *et al.*, 2017a). Physical inactivity in these people could thus also be contributing to the high prevalence of obesity in the population with a painful arthropathy, which could in turn be worsening their disease outcomes. My analysis was only able to show an association between increased BMI and painful arthropathies at continuous points across time (as opposed to a longitudinal study on the same individuals). My findings, however, have shown that the association emerges at the level of the population, and has done so for over two decades.

Obesity has been identified as a risk factor for developing both osteoarthritis (Anandacoomarasamy *et al.*, 2008) and rheumatoid arthritis (Crowson *et al.*, 2013). Moreover, not only is there a clear link between obesity and arthritis, but there are also corresponding detrimental effects on many areas of health and health-related quality of life. Obesity in those with arthritis is associated with the progression of arthritis, activity limitation, disability, and overall reduced quality of life (Anandacoomarasamy *et al.*, 2008). Furthermore, both arthritis and obesity have been significantly associated with longer years of disability in older adulthood (Reynolds and McIlvane, 2009). By addressing the obesity epidemic within the US population,

the detrimental effects of painful arthropathies may be attenuated or improved. Attenuating the detrimental effects of painful arthropathies could in turn decrease financial and social burdens on individuals who suffer with painful arthropathies, as well as the structures (ranging from familial support to federal government) that have to support them.

One of the interesting results from this thesis was that US residents, irrespective of demographic group, largely cited their knees as a location of joint symptoms (Chapter Five). Indeed, there has been a positive relation between obesity and reported pain in the lower limbs (hips, knees, and feet) (Adamson *et al.*, 2006). Obesity was also a risk factor for developing symptomatic knee osteoarthritis specifically (Anandacoomarasamy *et al.*, 2008). Furthermore, research on life-course body mass index (at ages 20, 30, 40, and 50) found that obesity in early adulthood increased the risk of unilateral knee pain by 38% and functional limitations by 27%, while developing severe obesity increased the risk of knee pain by 80% and functional limitations by 93% (Frilander *et al.*, 2016). Also linking with our joint symptom site maps from the previous chapter, research has shown that obesity was significantly associated with lower limb weakness in people with multisite joint symptoms (Raja *et al.*, 2016). Obesity is particularly detrimental for lower limb joints due to increased weight bearing and consequential strain on the joints. Given the high prevalence of obesity in the US, as well as the association between obesity and painful arthropathies, there may be a link between the obesity prevalence and the high citation rate of the knees in those who report joint symptoms.

Obesity is treatable, and is therefore a risk factor most definitely worth addressing and tackling in the population living with arthritis. Some US-based research has however found that, although the prevalence of obesity was higher in people with arthritis, less than half (46%) of adults with arthritis had attempted to lose weight (Mehrotra, Chudy and Thomas, 2003). Nutrition and dietary choices are problematic in the US, as healthier food is often more expensive than the average US diet, which is higher in fats, sugars, and sodium; and lower in fibre, nutrients, minerals, and vitamins (Fulgoni and Drewnowski, 2019). Nutrition-related intervention, therefore, is possible but does have limitations associated with it, particularly for poorer people. Other interventions, such as surgical joint replacement, is possible, however the obesity effect is often not entirely mitigated (Haebich *et al.*, 2020). Obese patients following total hip arthroplasty had poorer walking capacity, were more likely to use walking aids, and were less satisfied at 10-

year follow-up compared to non-obese individuals who had total hip arthroplasty surgery (Haebich *et al.*, 2020). Research on bariatric surgery and joint symptoms, however, has shown that joint pain, impaired physical function, and impaired health-related quality of life improve significantly after bariatric surgery and consequential weight loss (King *et al.*, 2016; Springer *et al.*, 2017), as well as gait biomechanics (Springer *et al.*, 2017). Therefore, without addressing the obesity problem (as the bariatric surgery route does), even surgical intervention directed at the joint itself may not be enough to attenuate the effects of obesity on the joint. The long-term success of bariatric surgery is 50% to 60% (Elder and Wolfe, 2007; O'Brien *et al*., 2013), and has also led to a 59% reduction in musculoskeletal problems in matched controls without bariatric surgery intervention (Elder and Wolfe, 2007), thus proving a promising avenue for musculoskeletal pain treatment. However, the success rates of bariatric surgery also indicate that almost half of all bariatric surgery candidates regain enough weight to be categorised as at least overweight. Given the criteria for bariatric surgery (morbid obesity), these candidates would still receive some benefits to their surgery, however, without lifestyle modifications, these benefits may never translate to improving musculoskeletal pain outcomes. Furthermore, the number of people who meet the criteria for bariatric surgery far outweighs the number of people who could realistically receive this treatment. In 2008, only 1% of eligible morbidly obese people were treated with bariatric surgery in the US, despite the number of people receiving bariatric surgery increasing by 13 times since 16 years' prior (Dumon and Murayama, 2011). Additionally, not all US residents have the financial means to have surgical intervention. In fact, population-based national survey research has suggested that obesity rates were often higher in food insecure socioeconomic status groups, in those with less annual household income, and lower education (Pan *et al.*, 2012; Ogden *et al.*, 2017; Heo *et al.*, 2018). Furthermore, my previous chapter showed that low socioeconomic status was associated joint symptoms, as well as rheumatic disorders, and arthritis diagnoses. Low socioeconomic status and obesity could thus combine to cause severe pain and functional limitations in population groups less able to seek intervention, leading to a greater burden on the individuals and society.

Painful arthropathies and physical activity

My findings showed that physical inactivity was associated with reporting joint symptoms, particularly in more recent years of analysis, the reason for which was not clear. In addition to physical inactivity being associated with rheumatic disorders (including arthritis), the prevalence of arthritis-attributable activity limitation is high and increasing over time (Barbour *et al*., 2017a). For example, those with osteoarthritis have been shown to be less active, more sedentary, have more comorbidities, and more barriers to physical activities compared to the overall population (Gay *et al.*, 2019). There have been increases in the number of people seeking care from health professionals, where the prevalence of counselling by healthcare professionals for exercise has increased from 17.6% to 51.9% between 2002 and 2014. Around 40% of adults with arthritis are, however, not receiving exercise advice from healthcare providers (Hootman *et al.*, 2018). Furthermore, reduced physical activity (be it moderate or vigorous) is associated with more painful sites in musculoskeletal pain (Pan *et al.*, 2019), particularly in older people (Murata *et al.*, 2019), who are also at the greatest risk of developing painful musculoskeletal conditions due to age. Patient education on the necessity of physical activity as a lifestyle habit is thus essential to address, not only the burden of painful arthropathies, but also its associated consequences.

Physical activity is a potential avenue for mitigating the development of painful arthropathies. Likewise, physical activity is an avenue for mitigating symptoms in those who already have rheumatic disorder diagnoses, particularly in those of lower socioeconomic status, who often cannot afford other healthcare and are reliant on lifestyle-related interventions only. Direct advice on intervention strategies were drawn up in order to assist clinicians in designing treatment plans for patients. The 2019 American College of Rheumatology/Arthritis Foundation Guideline for the Management of the Hand, Hip, and Knee made strong recommendations for tai chi, and conditional recommendations for balance exercises such as yoga (Kolasinski *et al.*, 2020). Not all groups affected by painful arthropathies have the means to seek healthcare though, and thus may be unintentionally excluded from advice. One way around this might be to disseminate advice into communities through outreach programmes, and not only via clinicians.

The role of physical activity is critical in addressing the burden of painful arthropathies. Physical activity itself is associated with attenuating the burden of painful arthropathies. Physical activity

is also a crucial element of attenuating obesity and being overweight, which in turn also addresses the burden of painful arthropathies. Increasing the physical activity levels in the obese and obese-arthritic populations, through interventions such as physical activity-based self-management education (Barbour *et al*., 2017a) and physical activity initiatives within communities is thus critical. Such interventions would hopefully address a treatable and preventable risk factor for developing arthritis, and attenuate the burden of diagnosed arthritis.

Limitations and section conclusion

My research had limitations. The BRFSS, being a telephonic interview, and the NHIS, being a sample questionnaire, rely on people reporting truthful weight and height variables. Due to the sensitive nature of weight in society, many people (particularly women) have been known to under-report weight, therefore underestimating the corresponding BMI, and the obesity burden in the US (Scribani *et al.*, 2014). The NHANES (Continuous) data however was measured by a trained professional as part of the examination portion of the survey. Results across all three surveys are strikingly similar and conclusive. It is therefore my belief that, within the context of painful arthropathies, the effect of having an increased BMI (being overweight or obese) most definitely predicts rheumatic disorder diagnosis, joint symptoms, and arthritis diagnosis. A further limitation was the fact that we could only assess the risks of physical inactivity and painful arthropathies using the NHIS. The NHIS was the only survey with one standard set of physical activity questions across all years of our analyses. It would have been beneficial to compare results between surveys in this regard, particularly as physical inactivity only emerged as a risk factor from the late 2000s. The physical activity variable that I used was binary (physically active, or physically inactive, based on the *Healthy People 2010* criteria). Future research should address whether there is a "sweet spot" of physical activity that best addresses painful arthropathies and its associated symptoms. One statistical limitation I faced was that there is a potential inflation of a type I error rate due to conducting multiple comparisons across time.

The prevalence of arthritis, obesity, and arthritis and obesity in combination, are high. The results presented in this chapter showed that obesity, and physical activity were both associated with all painful arthropathy types, across time. Despite physical activity as a potential avenue for

treatment, arthritis-attributable physical inactivity is high and increasing (Barbour *et al*., 2017a). Arthritis, physical inactivity, and obesity also worsen the disease progression of each other: arthritic symptoms result in arthritis-related physical inactivity, and in turn physical inactivity contributes to obesity in the arthritic population. Obesity then potentially worsens arthritic symptoms, particularly in lower limb joints due to weight-bearing, leading to more arthritis-attributable inactivity. Lower socioeconomic status can further complicate matters as groups of lower socioeconomic status have been found to have greater levels of obesity (Pan *et al.*, 2012; Ogden *et al.*, 2017; Heo *et al.*, 2018), as well as more reports of joint symptoms, rheumatic disorders and arthritis, according to my own findings. Purchasing foods that are healthier also cost more money, putting those most pre-disposed to painful arthropathies have even greater difficulty in addressing the obesity-physical activity-socioeconomic status problem. Therefore, individuals of lower socioeconomic status could be at even greater risk of the arthritis-obesity conundrum, particularly when they do not have access to intervention programmes or healthcare. I strongly recommend community-based intervention, such that advice given to clinicians to disseminate to patients is also disseminated to local communities. Health drives within communities should also aim to instil programs that monitor compliance, through follow-up initiatives. Arthritis-attributable inactivity is at the core of the problem and at the core of the solution. Physical activity could potentially lead to healthy weight loss and thus attenuate many of the negative effects of lack of physical activity and obesity in those with painful arthropathies.

SECTION 2: LIFESTYLE (BMI AND PHYSICAL ACTIVITY) TRENDS OF LOW BACK PAIN

Obesity is common in people with low back pain (Shemory, Pfefferle and Gradisar, 2016; Peng, Pérez and Gabriel, 2018; Zhang *et al.*, 2018). The prevalence of obesity is high in the US (approximately 39.6% of the population) (Hales *et al.*, 2018). If the prevalence of obesity is high, and obesity frequently occurs in people with low back pain, then much of the US population could be vulnerable to low back pain.

Physical activity has previously been associated with musculoskeletal pain, including low back pain (Alzahrani *et al.*, 2020), where physical inactivity often leads to worse outcomes related to low back pain, including functional disability and pain (Heo *et al.*, 2010; Arranz, Rafecas and Alegre, 2014; Wasser *et al.*, 2017). People with low back pain also have high levels of physical inactivity, commonly as a result of fear-avoidance and pain (Antunes *et al.*, 2013), and thus unknowingly potentially worsen their own low back pain outcomes.

The NHIS is the only survey to record data on low back pain. The survey also records self-reported height and weight data, as well as physical activity habits (including intensity, frequency, and duration). I used the NHIS to address my fourth thesis objective within the context of low back pain: to describe the association between lifestyle-related factors (BMI and physical activity) with having low back pain, by means of logistic regressions.

6.4 National Health Interview Survey (NHIS)

6.4.1 Low back pain and BMI

Using appropriately weighted NHIS data from 1997 to 2018 (with the exception of 2004), I conducted age- and sex-adjusted logistic regressions to establish whether BMI was associated with low back pain, which was taken as those who answered “Yes” to the question, “DURING THE PAST THREE MONTHS, did you have low back pain?”. Increased BMI was significantly associated with low back pain across all survey cycles (Table 6.3).

6.4.2 Low back pain and physical activity

Using appropriately weighted NHIS data from 1997 until 2018 (with the exception of 2004), I conducted appropriately weighted, age- and sex-adjusted, logistic regressions to assess whether physical activity associated with low back pain. Low back pain was defined as those who answered "Yes" to the question, "DURING THE PAST THREE MONTHS, did you have low back pain?". Being physically active was defined as meeting the criteria of the *Healthy People 2010* objective, namely either light or moderate physical activity five or more times per week for a duration of 30 minutes or more, or vigorous exercise three or more times per week for a duration of 20 minutes or more. Any participants who did not meet these criteria were classed as physically inactive.

Physical inactivity significantly associated with low back pain across all survey cycle analyses between 1997 and 2018. Those who were physically inactive consistently reported significantly more low back pain compared to those classed as physically active, and the odds ratio thereof has increased gradually in the last decade (Table 6.3).

Table 6.3: Association, shown by odds ratio (95% confidence interval) [OR (95% CI)] and p-value between low back pain and two lifestyle indicators, BMI and physical inactivity, according to the NHIS[ε], from 1997 until 2018

Year	Lifestyle Indicator			
	BMI		*Physical inactivity*	
	OR *(95% CI)*	p-value	OR *(95% CI)*	p-value
1997	1.03 (1.03, 1.04)	< 0.001*	1.20 (1.11, 1.31)	< 0.001*
1998	1.03 (1.03, 1.04)	< 0.001*	1.10 (1.03, 1.17)	0.003*
1999	1.03 (1.03, 1.04)	< 0.001*	1.13 (1.05, 1.20)	< 0.001*
2000	1.04 (1.03, 1.04)	< 0.001*	1.11 (1.04, 1.18)	0.001*
2001	1.03 (1.02, 1.03)	< 0.001*	1.12 (1.06, 1.19)	< 0.001*
2002	1.04 (1.03, 1.04)	< 0.001*	1.13 (1.06, 1.21)	< 0.001*
.2003	1.03 (1.03, 1.04)	< 0.001*	1.12 (1.05, 1.20)	< 0.001*
2005	1.04 (1.03, 1.04)	< 0.001*	1.23 (1.16, 1.32)	< 0.001*
2006	1.04 (1.03, 1.04)	< 0.001*	1.08 (1.00, 1.17)	< 0.048*
2007	1.04 (1.03, 1.04)	< 0.001*	1.30 (1.20, 1.41)	< 0.001*
2008	1.03 (1.03, 1.04)	< 0.001*	1.26 (1.16, 1.37)	< 0.001*
2009	1.03 (1.03, 1.04)	< 0.001*	1.34 (1.25, 1.45)	< 0.001*
2010	1.03 (1.03, 1.04)	< 0.001*	1.31 (1.22, 1.41)	< 0.001*
2011	1.04 (1.04, 1.05)	< 0.001*	1.47 (1.38, 1.57)	< 0.001*
2012	1.03 (1.03, 1.04)	< 0.001*	1.34 (1.25, 1.45)	< 0.001*
2013	1.04 (1.03, 1.04)	< 0.001*	1.35 (1.26, 1.44)	< 0.001*
2014	1.97 (1.63, 2.40)	< 0.001*	1.43 (1.33, 1.53)	< 0.001*
2015	1.03 (1.03, 1.04)	< 0.001*	1.36 (1.27, 1.46)	< 0.001*
2016	1.04 (1.04, 1.05)	< 0.001*	1.39 (1.30, 1.48)	< 0.001*
2017	1.04 (1.03, 1.04)	< 0.001*	1.45 (1.35, 1.56)	< 0.001*
2018	1.04 (1.03, 1.04)	< 0.001*	1.50 (1.40, 1.60)	< 0.001*

* P < 0.05: for a significant association between physical inactivity and BMI, and physical inactivity and low back pain

[ε] Low back pain in the three months prior to taking the NHIS Sample Adult Questionnaire

SECTION 2 DISCUSSION

Lifestyle (BMI, and physical activity) trends in low back pain

Summary of findings

I used the NHIS to establish whether increased BMI, and physical activity could independently associate with low back pain in adult US residents, across a 22-year period, using age- and sex-adjusted logistic regressions. Increased BMI was significantly associated with low back pain for every year of analysis. Furthermore, physical activity was also significantly associated with low back pain across all years, where those who were not physically active reported significantly more low back pain compared to those who were physically active.

Low back pain and obesity

There is a consensus amongst research that obesity is a risk factor for low back pain (Shemory, Pfefferle and Gradisar, 2016; Peng, Pérez and Gabriel, 2018; Zhang *et al.*, 2018), with research suggesting a relative risk of six for having low back pain in those with obesity compared to those not obese. Data from the Osteoarthritis Initiative showed that around 47.4% of people with normal or underweight BMI reported low back pain, compared to 72.8% of patients who were morbidly obese (Su *et al.*, 2018). Furthermore, the same consensus has been reached when assessing obesity as a risk factor in males and females separately (Zhang *et al.*, 2018), indicating that the link between obesity and low back pain transcends demographic grouping. Low back pain intensity and low back pain-related disability are also independently positively associated with overweight- and obesity-related variables, including waist circumference, body fat percentage, and fat mass (Hussain *et al.*, 2017). My research showed that there has been a significant positive association between low back pain reports and increased BMI. My analysis further showed that this association has remained over more than two decades, and that the association is present at the level of the population, thereby confirming and elaborating already-existing associations between low back pain and overweight and obesity.

My results showed that increased BMI (on a continuous spectrum) was associated with low back pain. Indeed, as BMI increases and gets further away from normal weight BMI values, so too

does the risk of having low back increase. People in the overweight category have had a greater risk of having low back pain compared to those of healthy weight. Those in the obese category had greater risk of having low back pain compared to those in the overweight category, and an even greater risk of having low back pain compared to the healthy weight category (Shiri *et al.*, 2010). Greater risk of having low back pain as a result of increased BMI has also been associated with low back pain-related disability. Preliminary findings from an outpatient physical therapy registry suggest that, although low back pain-related disability improved after treatment in overweight patients, it did not improve in patients of obesity class II (BMI 35 to <40kg.m^{-2}) and III (BMI ≥40kg.m^{-2}) (Wertli *et al.*, 2016). The risk of developing low back pain, and its associated disability, as well as the chances of improvement of health outcomes with treatment, therefore appear to worsen as BMI rises in a continuous manner.

The worsening of low back pain and its associated health outcomes may have to do with anatomical structural changes that occur within the obese and overweight. Obese and overweight people have had significantly higher mean lumbar lordosis angle, lumbosacral angle, sacral inclination, and lumbosacral disc angle, compared to people in the healthy weight category (Onyemaechi *et al.*, 2016). Spinal segments from cadaveric donors have also anatomically been analysed to evaluate whether obesity affects biomechanics of the spine. The findings indicated that lumbar spines behave differently during axial rotation, and compression, with the effect in fact more pronounced in females (Rodriguez-Martinez *et al.*, 2016). Radiological imaging suggested that the discrepancy in spinal behaviour may be due to greater facet degeneration and increased disc herniation in obese people (Rodriguez-Martinez *et al.*, 2016). Simulations have also shown that as body weight increases, compression in flexed positions, and spinal loads increase (Hajihosseinali, Arimand and Shirazi-Adl, 2015). Hence, biomechanical research indicates that raised BMI could result in changes to the spine, potentially increasing the risk of associated low back pain.

Low back pain and physical activity

Meta-analysis and systematic review research has shown that there is an inverse association between low back pain and physical activity (Alzahrani *et al.*, 2020). Furthermore, the University of California Los Angeles (UCLA) Low Back Pain Study established that

participation in recreational physical activity was associated inversely with low back pain, both in cross-sectional and longitudinal analyses (Hurwitz, Morgenstern and Chiao, 2005). My findings found that the risk of low back pain was significantly higher in those who were physically inactive compared to those physically active, thus aligning with the trends found in the literature. My research showed that the association between low back pain and physical activity is in fact present at the level of the population, consistently over the last two decades.

Some evidence suggests that physical activity and low back pain may have a U-shaped relationship, indicating that both inactivity and excessive activity can be detrimental for low back pain (Heneweer, Vanhees and Picavet, 2009). The type of activity may also contribute. For instance, recreational physical activity appears to reduce the risk of low back pain, however, occupational physical activity appears not to. In fact, occupational physical activity has even been cited as a potential risk factor for low back pain. People with low back pain more often had low leisure-time physical activity but high occupational physical activity (Björck-van Dijken, Fjellman-Wiklund and Hildingsson, 2008). I would suggest that excessive physical activity in those with low back pain (such as that required in a manual labour occupation) may be attributable to the U-shaped trend, whereas leisure time physical activity is more likely to fall into the physical activity "sweet spot" of the U-shaped trend, as people are unlikely to be active for the same amount of time as a full work day. Stress may also be contributing to manual occupations being associated with low back pain, as the level of psychological demands has been significantly associated with low back in machine operators and manual workers, according to national cross-sectional research (Hagen, Magnus and Vetlesen, 1998).

Indeed, psychological factors may influence low back pain and physical activity, particularly as the duration of low back pain increases. Patients with acute or subacute low back pain have exhibited varied physical activity levels, and those with chronic low back pain were likely to have low physical activity levels (Lin *et al.*, 2011). Psychological factors such as exercise-related fear-avoidance and kinesiophobia, are common in people with low back pain and can be worse in patients with depression (Antunes *et al.*, 2013), a common comorbidity of low back pain (Fernandez *et al.*, 2017; Marshall, Schabrun and Knox, 2017). Addressing the anxieties around physical activity in people with low back pain is an important treatment outcome (Bailey *et al.*, 2010) in those that seek healthcare.

The combination of obesity and physical inactivity in patients with low back pain can be very problematic for people with low back pain. Furthermore, low back pain itself is a disabling condition. Overweight and obese individuals with chronic low back pain have difficulties engaging in physical activity due to the physical challenges of exercise for these individuals (Wasser *et al.*, 2017), there is an increase in perceived disability and a perceived decrease in self-efficacy. The increase in perceived functional disability could exacerbate apprehension towards physical activity, resulting in more low back pain (either in intensity or chronicity), and more consequential disability and loss of function. Therefore, people who are inactive and have a BMI above the normal range could be targeted as a special intervention group.

Research on people with low back pain's wants regarding healthcare for their low back pain has found that low back pain patients want a diagnosis, clear and personalised information on prognosis and potential treatment, and management strategies (Lim *et al.*, 2019). Providing physical activity-based programs optimised for low back pain, physical activity could be used to reduce low back pain burden without the need for grand-scale medical intervention. It may be necessary to look at personalised interventions by demographic groups (such as age, sex, race, socioeconomic status, and county residence), as well as the involvement of healthcare professionals instilling community reach intervention programmes. For example, I identified that low back pain is significantly associated with low socioeconomic status, namely unemployment. Furthermore, groups of lower socioeconomic status have greater levels of obesity (Pan *et al.*, 2012; Ogden *et al.*, 2017; Heo *et al.*, 2018). Individuals with low socioeconomic status, high BMI, and low physical activity could be prioritised for such programmes.

Limitations and section conclusion

As I pointed out in the discussion of Section 1 of this chapter, the NHIS is reliant upon self-reported weight and height, which can sometimes result in reporting decreased weight values (Scribani *et al.*, 2014). The low back pain section relies solely on the NHIS survey, and is not supplemented with the physically measured BMI NHANES data in the way that the data in Section 1 of this chapter are. However, I think that the similarity in the results in BMI between all three surveys in Section 1 of this chapter means that the potential discrepancy is addressed and negated. Furthermore, low back pain prevalences differ by age (in young adults only), sex,

and socioeconomic status. Within these various demographics, with their heterogeneous low back pain burdens, the effects of BMI and physical activity may be different, where some groups may have greater risk of developing low back pain than others. I, therefore, suggest a future area of research to be the effect of BMI and physical activity on low back pain in various demographic groups, using population-based analyses. Similar to Section 1, one statistical limitation that I faced in my methods was that there is a potential inflation of a type I error rate due to conducting multiple comparisons across time. As mentioned in my discussion on painful arthropathies, the physical activity variable was a binary variable of physically active or not physically active, based on the *Healthy People 2010* objective criteria. Therefore, our analysis could only examine physical activity in a binary manner, and did not consider that "physically active" means a large range of potential activity. Analysis on the intensity and duration of physical activity is therefore an area of research that could be investigated in the future to establish the ideal physical activity, including intensity and duration, in various demographic groups, to attenuate the risk of low back pain.

The burden of low back pain is costly for individuals and society. My analysis showed that increased BMI was significantly associated with low back pain in the US population, and has been consistently for over 20 years. Furthermore, I showed that physical activity was associated with low back pain, where people who were physically inactive had significantly more low back pain compared to physically active people, across time and at the level of the US population. Physical inactivity and increased BMI have the potential to greatly impact the population due to their risks associated with low back pain. However, both factors are modifiable. Physical activity and healthy weight loss are, therefore, a means of addressing the low back pain burden in the US. I think that these lifestyle-related interventions would not only improve functional abilities in patients with low back pain, but also overall health-related quality of life. Physical activity and weight loss interventions could be particularly helpful in groups already high in low back pain, particularly low socioeconomic status, where access to healthcare and clinical interventions may not always be available.

CHAPTER SEVEN

Conclusion

SECTION 1: THESIS FINDINGS AND CONTEXUALISATION

7.1 Summary of findings

At the onset of my research, I recognised that the vast majority of pain research is cross-sectional and geographically localised. Hence, I aimed to establish musculoskeletal pain trajectories across time and space. I also aimed to establish the potential association of factors previously associated with pain, at the level of the national population, and over time. In order to address these objectives, I used nationally representative population-based surveys from the US, incorporating appropriate analyses for complex survey designs, accounting for strata, clusters, and design weights. Using three such surveys, I was able to address my objectives on musculoskeletal pain in the population within the context of painful arthropathies, including rheumatic disorder diagnoses (BRFSS), joint symptoms (NHIS), and arthritis (NHANES (Continuous)); and low back pain (NHIS).

This thesis was written in South Africa, which does not have surveys of this nature that have run over enough time to address my objectives. My hope was that, by determining the answers to my main research questions, and by gaining a good understanding for these population-based surveys, that I could potentially make suggestions for the South African context. These suggestions would be both in terms of my findings on musculoskeletal pain trends, such that policy makers and economists would have an awareness of patterns of musculoskeletal pain; as well as how best to capture information about pain within the population in long-running surveys.

In addressing my first objective of establishing temporal trends of musculoskeletal pain, I showed that neither painful arthropathies nor low back pain have changed in their prevalence trajectory over the last 20 years, within the overall US population (Chapter Three). Approximately 25 to 30% of all non-institutionalised US residents have some kind of painful arthropathy, and approximately 30% of all non-institutionalised US residents have low back pain (these two groups are not necessarily mutually exclusive). In light of the growing and aging population, there has been a large growth in the number of people affected by musculoskeletal pain over the last 20 years. There has been an increase of 27.5 million people with joint symptoms, and an increase of over 23 million people with low back pain. The prevalence of rheumatic disorder diagnoses has increased by upward of 10 million people. I also analysed the

trajectory of musculoskeletal pain within different demographic groups individually (age, sex, and employment status). Majority of the demographic groups in the age and sex analyses tended to have stable musculoskeletal pain trajectories, and the differences in prevalences between demographic groups also remained steady over time. However, the aging population results in a translation of over 10 million more US residents aged 65 years and older having reported joint symptoms and rheumatic disorder diagnoses compared to 20 years ago. There was a small increase in the prevalence of joint symptoms (NHIS) in males. Arthritis diagnoses (NHANES (Continuous)) increased slightly across time in adults between the ages of 25 and 29 years, and in both sexes. The only group that had an increase in all three types of painful arthropathies across time was the unemployed. Given the consensus between surveys on the trends of painful arthropathies in the unemployed, there is strong evidence to suggest that the prevalence of painful arthropathies is indeed slowly increasing in the unemployed, reaching a prevalence of almost half of all unemployed people. Low back pain trends, however, are strikingly stable across time, and the only groups to have any temporal change (albeit small) were the youngest group (where it decreased slightly) and in the oldest age group (where it increased slightly). The prevalence of low back pain was temporally stable in both sexes, and both the employed and unemployed.

In addressing my second objective of establishing spatial trends, I showed that inter-state differences in painful rheumatic disorder diagnoses (BRFSS) were present, and were consistent across time (Chapter Four). I showed that there was a spatial correlation between state residence and rheumatic disorder diagnoses, where the closer in proximity states were, the more similar their rheumatic disorder diagnosis prevalences. Moreover, the states at either limit of the state-based prevalence data were similar across all years and demographic groups. West Virginia consistently had the highest prevalence of rheumatic disorder diagnoses, and other states with high prevalences included Kentucky, Alabama, Mississippi, Tennessee, Michigan, and Arkansas. Appalachia and the Mississippi Valley area were identified as geographical hotspots for rheumatic disorder diagnoses across time. Conversely, states or territories consistently at the lower limit of rheumatic disorder diagnoses prevalence reports included California, Arizona, Hawaii, Utah, Texas, Minnesota, Puerto Rico, and the District of Columbia.

I also showed that, although spatial disparities are clear on a state level, regional trends are not always so (Chapter Four). In the overall US population, Midwestern residents reported significantly more joint symptoms compared to Northeastern, Southern, and Western residents, and this stayed true across time. Male and female Midwestern residents also reported significantly more joint symptoms compared to the other three regions within each sex group, across time. When the population was divided into age groups, Midwestern residents reported significantly more joint symptoms compared to those in the Northeast, but less consistently with the South and West, which often oscillated in and out of the significance set-point ($P < 0.05$) across time. Low back pain, however, yielded no consistent spatial trend on a regional level. It is my opinion, based on my findings, that regions are too large an area to use to establish spatial disparities in musculoskeletal pain, but that state-sized spatial analyses are useful for musculoskeletal pain studies.

I established that there was a long-term association between having a painful arthropathy of any sub-type (rheumatic disorder diagnosis, joint symptoms, or arthritis diagnosis) with older age, female sex, and lower socioeconomic status (in the form of unemployment, lower annual household income, and lower education level) (Chapter Five). Using age-sex divided demographic groups, I also established that knees were the most reported site of joint symptoms, indeed up to 60% of the time, irrespective of demographic profile. Young females reported their hips as a site of joint symptoms more frequently than did age-matched males, while younger and middle-aged males reported their shoulders as a site of joint symptoms more than age-matched females. Older people reported their hands and fingers as affected more than younger people, irrespective of sex. In the case of low back pain, there was an association between having low back pain and female sex, and unemployment. The age profile of low back pain, however, was different from painful arthropathies. Low back pain reports were significantly lower in the young adult groups compared to middle-aged and older-aged adults. The prevalence of low back pain increased from a starting prevalence of approximately 16% in the 18- to 24-year-old population, up to approximately 25% in those 25- to 30-years old, but was thereafter fairly stable at a prevalence of around 30% to 35% of the population. Finally, I established that lifestyle factors also affect musculoskeletal pain outcomes. Increased BMI and physical inactivity were both associated with having painful arthropathies, and low back pain (Chapter Six). Furthermore, all

the associations that I identified all stood the test of time, where they were repeatedly associated for over 20 years.

7.2 Contextualisation with the Global Burden of Disease research

The Global Burden of Disease research uses all three of the surveys that I used in this thesis to produce its US-based statistics on musculoskeletal pain-types. The musculoskeletal disorder statistics (in particular, the prevalence statistics) that I have determined for the US in this thesis do, therefore, align well with the results determined by the GBD research (GBD and Injury Incidence and Prevalence collaborators, 2016; GBD 2016 DALYs and HALE collaborators, 2017; Wu *et al*., 2020). However, given the scope of what the GBD research has to do (the sheer number of countries, diseases, and disability-related consequences of those diseases), describing and presenting finer details of one type of disorder in one country would not be possible, nor would it be a responsible distribution of financial resources (as they deliver global data).

I would hope that my research, therefore, acts as a strut in the framework of GBD research in a number of ways. Firstly, I have used three large nationally representative data sources used in GBD studies for the US, and conducted separate analyses across time (similar to those done in GBD work), and shown consistency amongst the findings across the three surveys as well as with GBD findings also across time. Secondly, because my whole thesis focussed only on the US, I was able to more deeply dissect variables that are perhaps too involved for the scope of the GBD research outputs. For example, I conducted extensive geospatial analyses across both painful arthropathies and low back pain within the context of the US. Furthermore, for both my temporal analyses as well as my geospatial analyses, I looked at how these broad analyses (temporal and geospatial analyses) interplayed with demographic variables (such as age, sex, and socioeconomic status). Finally, I assessed the associations between musculoskeletal pain types with demographic variables (age, sex, employment status, annual household income, and education level), as well as lifestyle variables (including BMI, and physical activity) in the US population over time across all three surveys. Through the aforementioned analyses, I was able to demonstrate robust and well-rounded population trends in musculoskeletal pain within the context of the US. Indeed, I would recommend that other research using country-specific available national surveys also be done to expand findings of GBD research.

SECTION 2: FUTURE RECOMMENDATIONS

Although I have addressed specific limitations within the discussion sections of each results chapter, there are a few over-arching limitations that I would like to address in order to highlight recommendations for improvement of future longitudinal research on pain within national populations. Based on my findings, I will also then address the potential improvement of pain questions in population-based surveys, and public health policy recommendations.

7.3 Recommendations based on my research limitations

One of the major limitations that I faced was the changing of questions within population-based surveys, as well as the major change in weighting methodology in the case of the BRFSS. As a consequence of the changing of questions, I was only able to analyse data for a period of approximately 20 years, and not the full lifetimes of the surveys. Furthermore, in the case of the BRFSS, weighting methodology changed from poststratification to raking, resulting in a limitation in the comparison of data from before 2011 with data from 2011 onwards. Although changing questions and weighting methods did pose a limitation in the comparison of data across time within the context of this thesis, it is important for surveys to stay relevant. It is thus a necessary consequence of population-based surveys to update questions and weighting methodology. As the world shifts to the digital realm, one such update could be the addition of online components of national surveys, which would save money and manpower, but will require the re-examination of weighting methodology.

One limitation to my statistical analysis methods was that the results I have presented could have an inflation of the type I error rate due to conducting multiple comparisons across many years. However, after assessing the temporal trends in Chapter Three and seeing that the prevalence of musculoskeletal pain was in fact fairly steady over time, I chose to assess each year individually, rather than look at time-dependent changes across years.

I noted in my introduction that many researchers have collapsed data from various years and analysed all the datasets together. I suggested that this methodology may not be appropriate as pain prevalence may well have changed over time. However, I have shown in this thesis that musculoskeletal pain (both painful arthropathies and low back pain) is, in fact, fairly steady over

time in the overall population. Given the flat trajectory of musculoskeletal pain prevalence, collapsing multiple years of data would be reasonable. Therefore, future research on big data sets could continue to combine data sets, provided they follow the specific instructions on combining datasets on the survey websites, such that appropriate weightings for appropriate years are used.

I faced limitations in my spatial analysis. The prevalence of rheumatic disorder diagnoses (BRFSS) was done by state, where there was a consistent spatial association, and the states had consistent prevalences across time. The NHIS, however, made use of region-based spatial data for both joint symptoms, and low back pain. The regional analysis was either inconclusive (low back pain), or less consistent (joint symptoms) than state-based analyses. My state-based analysis showed that the states are heterogeneous in the prevalence of rheumatic disorder diagnoses (a painful arthropathy), and it is then possible that regional analysis is too broad to yield conclusive spatial trends. For example, West Virginia, Kentucky, Mississippi, Alabama, and Arkansas are all in the South, but all rank amongst the states with the highest prevalence of rheumatic disorder diagnosis. Texas, however, is also in the South, but is one of the states with the lowest ranking prevalences of painful rheumatic disorder diagnoses. It is also possible that the large population in Texas perhaps skewed the regional data outcomes due to its relative weight in comparison to other states in the South. Hence, the higher representative weight of Texans (low in painful arthropathies, as well as generally young) may lower the prevalence of painful arthropathies in the South, despite the high prevalences of high-ranking states with fewer people. Furthermore, it was the Midwest that, according to the NHIS data, emerged as having the overall highest prevalence of joint symptoms in my analysis, despite not consisting of the majority of states most frequently at the upper limit of rheumatic disorder prevalences. Whilst I acknowledge that joint symptoms and painful rheumatic disorders are not equivalent, it is reasonable to assume that those who have a rheumatic disorder diagnosis would experience some joint symptoms. Therefore, I strongly recommend incorporating state-based analyses on joint symptoms, but also particularly on low back pain, for which spatial analysis in this thesis was inconclusive. Future research could therefore examine whether low back pain is simply more evenly dispersed across space, or whether regional analyses are too broad to detect the spatial trends.

A second recommendation I would make is the incorporation of a spatial correlation function in the *Survey* package in R. The Global Moran's I that I conducted is limited as I assigned

established weighted prevalences to states. Therefore, each state only had one data point. Based on my own results as a starting point, I feel that a spatial correlation tool that can be used for design objects (which considers strata, clusters, nesting, and weighting) would be extremely beneficial for survey data analysis. Given that survey data is often sampled using geography as part of sampling methodology, spatial data is often available within population-based datasets, and thus frequently available and, in my opinion, really useful as part of an analysis.

7.4 Refining data from population-based surveys

One of the first things that I established about the survey questionnaires was that there were no questions that asked directly about chronic pain to the whole sample (as opposed to a module only, for example), and/or asked over a timeframe longer than 10 years. The surveys I used consisted of questions that I could use as a proxy for pain, such as whether someone had been diagnosed with a rheumatic disorder (including arthritis); been diagnosed with arthritis; had experienced pain, aching, or stiffness in or around a joint; or whether they had experienced low back pain within the past three months. It must, however, be acknowledged that not everyone who has received a rheumatic disorder diagnosis experiences pain. Indeed, the lack of a gold standard chronic pain question has been cited as a limitation of epidemiological research on pain previously (Steingrímsdóttir *et al.*, 2017). Epidemiological research on chronic pain itself even tends to be specific to the type of pain experienced, such as only musculoskeletal pain (Cimas *et al.*, 2018) or neuropathic pain (Van Hecke *et al.*, 2014).

Neuropathic pain specifically was not directly screened for in the population-based surveys that I used, and nor were proxy questions available on neuropathic pain. Previous research has shown that the prevalence of neuropathic pain ranges from 1% to 17.9% across the literature, but more likely ranges between 6.9% and 10% (Van Hecke *et al.*, 2014). It must be considered that diseases which often result in painful neuropathies are increasing. One such disease is diabetes mellitus, which is particularly relevant for the context of the US. The prevalence of diabetes worldwide was 2.8% in 2000 (Wild *et al.*, 2004), was 8.8% in 2017 (Cho *et al.*, 2018), and had reached 9.3% by 2019 (Saeedi *et al.*, 2019). The US, in particular, has a high diabetes prevalence (data from 2011 until 2016 suggests between 10.9% (Guariguata *et al.*, 2014) and 12.1% (Cheng *et al.*, 2019)), and also has the highest expenditure per person with diabetes (Cho *et al.*, 2018).

Roughly 15% of individuals with diabetes have painful neuropathy (Sadosky *et al.*, 2008), which equates to about 4.6 million adult Americans. Screening for neuropathic pain within a population with such statistics is strongly recommended. Research on neuropathic pain has acknowledged that it is often difficult to assess whether someone has neuropathic pain however (Van Hecke *et al.*, 2014; Smith, Hébert and Veluchamy, 2020). Diagnostics often rely on history of positive or negative sensory signs (Smith, Hébert and Veluchamy, 2020), which require time and training, both of which would be challenges to large surveys, but particular wording of questions could help to indicate neuropathic pain in respondents. However, without nationally representative screening longitudinally, it is difficult to assess the trajectory of neuropathic pain in the population, and the risk factors for developing it. Therefore, I strongly recommend the addition of questions that directly ask about neuropathic pain.

Based the lack of questions directly pertaining to chronic pain and chronic pain types in population-based surveys, I recommend the following question sequence as a potential chronic pain screening tool for population-based surveys (Figure 7.1).

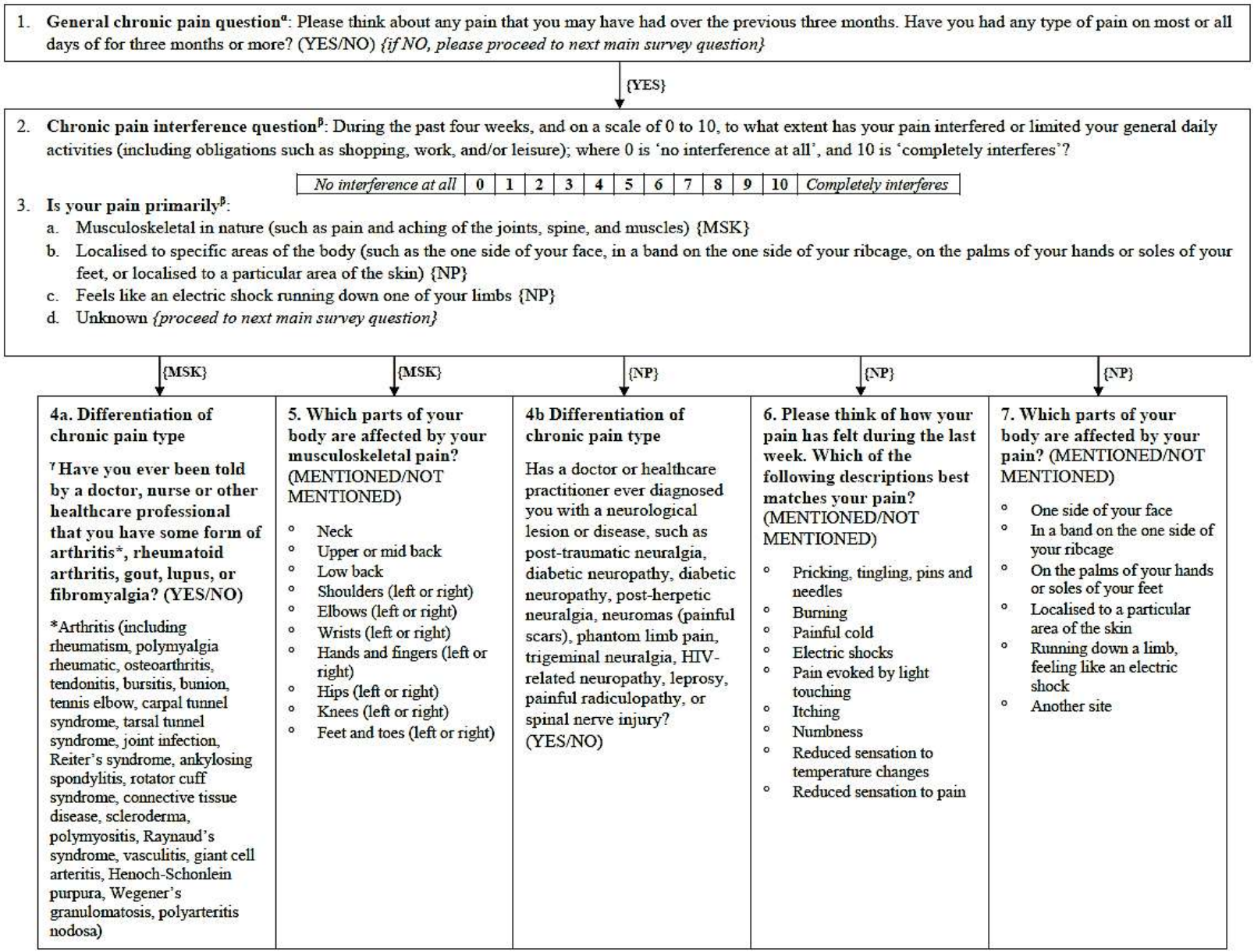


Figure 7.1: Potential recommendations** for future chronic pain assessment in population-based surveys

[α] Asked to the entire adult sample in the survey

[β] Asked to those who have answered "Yes" to "1. General chronic pain question"

[γ] BRFSS question on painful rheumatic disorders

** Potential recommendations based on the updated Graded Chronic Pain Scale (von Korff *et al.*, 2020), the survey questionnaire for low resource settings developed by the Global Alliance for Musculoskeletal Health Surveillance Taskforce (G-MUSC, 2019) neuropathic pain assessment and anatomical distribution (Colloca *et al.*, 2017), the LANSS (Bennett, 2001), the DN4 (Bouhassira *et al.*, 2005), the IASP definition for chronic pain (IASP, 2020), and existing questions on painful conditions in national surveys (CDC, 2018)

After screening for chronic pain in the population using the aforementioned potential sequence of questions, a possible cyclical question (asked every two years, or as a module) could be used to investigate the experience of pain within the population. For example, pain intensity could be assessed using a numerical rating scale, in which case future research could look at a potential association with disability in the overall population, as well as within various demographic groups. Another area I suggest be included in the potential module is a question on the extent of functional disability in those with chronic pain, as well as pain interference in those with chronic pain. Assessing functional disability and interference would assist in quantifying the burden of pain on individuals, as well as assist in calculating indirect cost of pain, which is often difficult to assess as pain is frequently associated with disability, which can in turn be costly to individuals and society. Finally, given the extensive over-prescription and addiction problem of opioids in the US, as well as the general desire of people with pain to undergo imaging (for example, MRI scans, despite contrary advice in clinical guidelines (Qaseem *et al.*, 2017)), a question on management strategies received by people with chronic pain could be added. An additional benefit to assessing management strategies would be the potential link to routinely collected data in clinical practice. Previous research has illustrated that there are often administrative boundaries in analysing routinely collected data (and, hence, designing health policies using such data) due to inconsistencies in diagnostic coding (Nicholls, Langan and Benchimol, 2017). Whilst not all jurisdictions would be able to administer optional module survey questionnaires, having management strategy questions in selected optional survey modules could not only improve routine screening for musculoskeletal pain in clinical practice, but also offer a streamlined process for establishing improvements to diagnostic codes. Together, population surveillance and routinely collected data could offer robust data on musculoskeletal pain at various levels of the population.

7.5 Public health recommendations for musculoskeletal pain in the population

7.5.1 Potential intervention for musculoskeletal pain in the context of physical inactivity and obesity

My analyses yielded a number of demographic associations with having painful arthropathies, and low back pain. Many of these factors are uncontrollable (for example, age, sex, and, to a

large extent, socioeconomic status). Two lifestyle-related variables that I showed to be associated with painful arthropathies, and low back pain were physical inactivity, and increased BMI. Although each of these variables associated with both types of musculoskeletal pain within their own right, physical inactivity and increased BMI are related to each other as well. Longitudinal population-based research has shown that physical activity predicted lower waist circumferences as well as lower waist circumference increases in people who were physically active over time, compared to those who were not (Bauman. *et al.*, 2017). Hence, it is imperative to address physical inactivity and increased BMI in the population, as musculoskeletal pain, physical inactivity, and increased BMI have the potential to compound into a positive feedback loop, yielding worse and worse outcomes for people with musculoskeletal pain.

The role of diet and nutrition also cannot be ignored in the burden of obesity in the US. Although the US Department of Agriculture has identified official food patterns that could assist US residents in making better decisions in their diet (including foods that are higher in protein, fibre, minerals and vitamins; as well as lower in solid fats, sugars, and sodium), these diets are more expensive than average dietary costs. According to nationally representative research, the average cost of consumption in the US is currently $5.47 per day (for a 2000-kcal-per-day diet), whereas the suggested healthy patterns range are between $8.73 and $8.73 per day ($5.90 per day for vegetarians) (Fulgoni and Drewnowski, 2019). Furthermore, research shows that merely the *belief* amongst consumers in the US that healthy food is more expensive has a large influence on consumer habits (Haws, Reczek and Sample, 2017). Consumers are more likely to buy less healthy options purely based on their predisposition and pre-existing beliefs about food choices. Without addressing both these matters (the actual cost of healthier food costing more, as well as consumer attitudes when purchasing food), the burden of obesity can never hope to be addressed.

Indeed, even within the context of spatial research, physical inactivity and obesity prevalence data aligned well with my findings on rheumatic disorder diagnoses. The prevalence of self-reported physical inactivity in the US between 2015 and 2018 differed by state, and ranged between 15% and 47% of US residents. States where 30% or more of all residents were physically inactive included Tennessee, Oklahoma, Louisiana, Alabama, Kentucky, Arkansas, and Mississippi (Figure 7.2.1) (CDC, 2020a). It is perhaps not a coincidence that the prevalence of obesity is over 35% in states Tennessee, Oklahoma, Louisiana, Alabama, Kentucky, Arkansas,

Mississippi, West Virginia, Indiana, Kansas, Michigan, and South Carolina (Figure 7.2.2) (CDC, 2019b). Notably, the majority of these states were also amongst those with a continually high prevalence of rheumatic disorder diagnoses, according to my own findings. States at the opposite limit, with the lowest prevalence of physical inactivity (between 15% and 20%) included Washington, Oregon, Utah, Colorado, and the District of Columbia (Figure 7.2.1) (CDC, 2020a). Only Colorado and the District of Columbia had lower obesity prevalences of between 20% and 25%; the remaining states all have higher prevalences (Figure 7.2.2) (CDC, 2019b). The District of Columbia ranked amongst the territories with the lowest prevalence of rheumatic disorder diagnoses, and Colorado was also low in rheumatic disorder diagnoses, but was not always at the lower limit. States at the upper limit of obesity and physical inactivity statistics could, therefore, benefit from state-targeted physical activity interventions to potentially address the musculoskeletal pain burden. These states include Tennessee, Oklahoma, Louisiana, Alabama, Kentucky, Arkansas, West Virginia, and Mississippi.

US public health policy has largely failed to address the 'obesity epidemic' within the country. The prevalence of obesity and overweight are in fact increasing in the US (Hales *et al*., 2018; Hales *et al*., 2020) Unfortunately, given that I have shown that obesity and physical inactivity are key risk factors for multiple musculoskeletal pain-types, there can be no doubt that the lack of progress in public health spheres of obesity and physical activity are perpetuating the musculoskeletal pain burden. It is not, however, that there is a lack of policy to address obesity and overweight. In reality, it is quite the contrary: the CDC alone has a number of programmes to attempt to address the burden of obesity, and these begin from childhood and extend throughout US residents' lifetimes. The programmes are also administered at state and local levels (CDC, 2020c). It is difficult for public health policy makers to navigate the detrimental lifestyle-related behaviours of US residents, particularly as the conventional public health policy in isolation (such as education programmes) are not enough to attenuate the statistics on obesity and overweight, particularly in the Appalachian region and the South region (Figure 7.2.2) (CDC, 2019b). It is not to say that musculoskeletal pain public health policy should be ignored, however. The prevalence of musculoskeletal pain conditions is steady, unlike the associated risk factors of physical inactivity and increased BMI. It is clear, therefore, that "unconventional" methods (or, at the very least, lateral re-thinking of the types of policies that are put in place) will

be necessary to address these two (obesity and physical inactivity) key factors in the health of the US, including musculoskeletal health.

Research suggests that, although there have been numerous trials for physical activity intervention programmes, these programmes have not become embedded in the real-world system after trials have ended (Reis et al., 2016). Reasons for this include only reaching already-active populations, or not reaching across all cultures, socioeconomic statuses, or geography (Reis et al., 2016). One approach that I would suggest is the incorporation of mobile games. Novel mobile phone games could offer a potential way to increase the physical activity of the population. Research on Pokémon Go users, for example, saw a significant increase in users' physical activity levels over the 30-day data collection period, and an increase in their daily step count by over 25%, compared to their physical activity levels before engaging in the game. Notably, the increase in physical activity occurred across both sexes, all ages, weight statuses, and physical activity levels (including previously low activity populations) (Althoff, White and Horvitz, 2016). Therefore, mobile gaming applications that involve physical activity with in-game rewards appear to be an avenue to get the population active, irrespective of the factors originally cited as barriers to increasing physical activity.

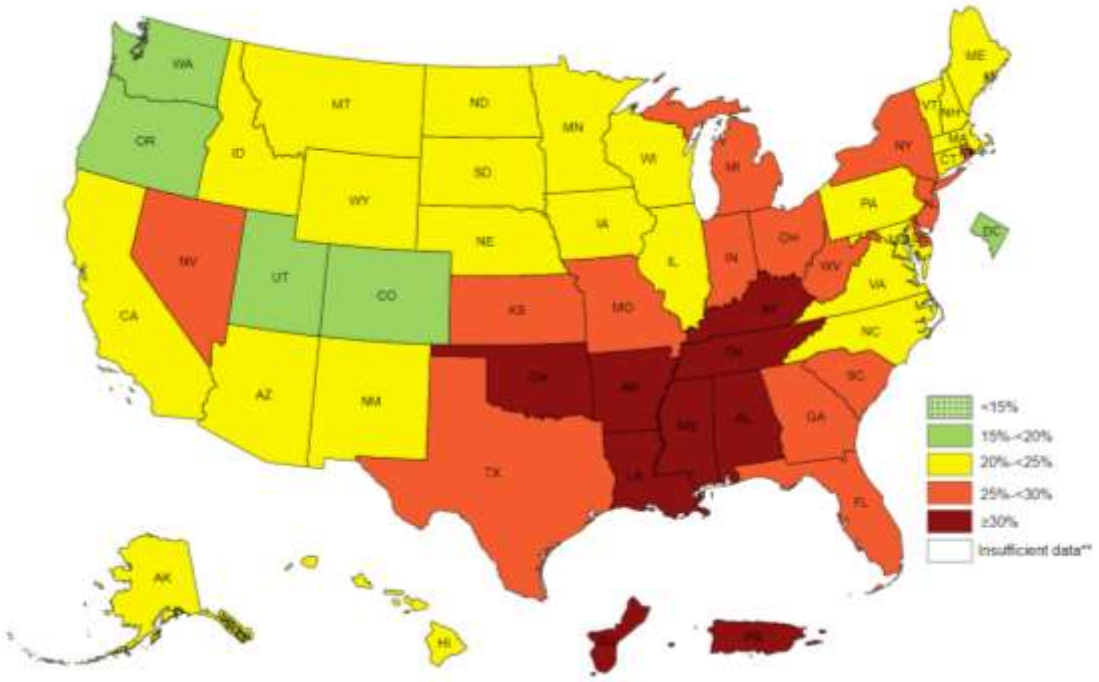


Figure 7.2.1: Prevalence of self-reported physical inactivity by state or territory between 2015 and 2018, according to the BRFSS*
* (CDC, 2020a)

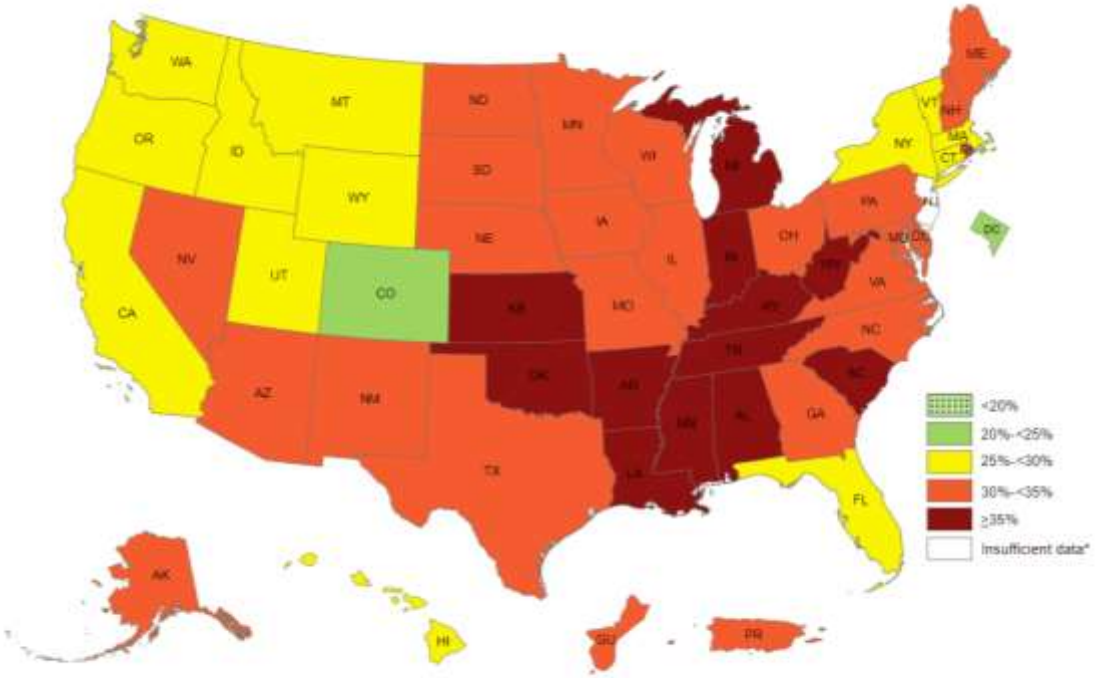


Figure 7.2.2: Prevalence of self-reported obesity by state or territory in 2019, according to the BRFSS*
* (CDC, 2019b)

7.5.2 Potential intervention for musculoskeletal pain in the context of low socioeconomic status

Many US residents have difficulty in accessing good quality healthcare, where 18% of US adults cited financial affordability barriers, and 21% of US adults cited nonfinancial barriers in accessing healthcare (Butkus *et al.*, 2020). Many Americans cannot afford health insurance, and an estimated 30 million Americans are completely uninsured. Furthermore, employer-sponsored health insurance has decreased by almost 10% over approximately the last 20 years (Crowley *et al.*, 2020). Low socioeconomic status, within the context of a number of factors (including fiscal unaffordability) is associated with reduced access to healthcare, poorer health outcomes, and increased mortality and morbidity with age. Furthermore, low socioeconomic status is also associated with poor health-related quality of life (McMaughan, Oloruntoba and Smith, 2020). The association between socioeconomic status and reduced healthcare, and health-related quality of life poses a conundrum generally, as the less able people are to afford healthcare, the worse their overall health-related quality of life, which in turn could affect their ability to work and earn money to obtain healthcare, and the cycle continues. Within the context of this thesis, the conundrum I described is also appropriate as low socioeconomic status was associated with having painful arthropathies (unemployment, low household income, and low education status), as well as low back pain (unemployment). I also found that painful arthropathies have increased in the unemployed. These findings were supported by other research too, and notably that by Dahlhamer *et al*. (2018), who demonstrated that the prevalence of chronic pain as well as high-impact chronic pain increases incrementally in decreasing socioeconomic status, both in the form of employment status as well as in the form of highest education level obtained. In turn, these findings also beg the question: how are people to better themselves socioeconomically (and address a key risk factor in their pain condition) if their socioeconomic status and chronic pain and the reciprocal relationship is in fact the hindrance in addressing the other piece of the puzzle? Given that other research has found that musculoskeletal pain is associated with disability, loss of work, and less chance of re-employment (Kool, Oesch and De Bie, 2002; Wynne-Jones, Dunn and Main, 2008; Callhoff *et al.*, 2017; Maher, Underwood and Buchbinder, 2017; Ikeda *et al.*, 2019), people with musculoskeletal pain may be at risk of being unable to improve their health-related quality of life as well as their socioeconomic status, and the burden thereof may also continue to rise.

Crucially, the marked socioeconomic disparities in healthcare occur largely at primary care level (Wright and Perry, 2010), which is where musculoskeletal pains would potentially be addressed. Longitudinal research on neighbourhood socioeconomic status and primary healthcare showed that residents from low-income neighbourhoods relied less on physician offices, and more on safety net health centres and outpatient clinics, such as community health centres (Hussein, Roux and Field, 2016). These settings could thus offer a platform to screen and educate people who have painful arthropathies and/or low back pain (particularly those who positively identify with factors frequently associated with musculoskeletal pain, including those who are older, females, those with increased BMI, and those physically inactive). Furthermore, community health centres could screen patients with known musculoskeletal pain conditions for other common co-occurring conditions, such as mental ill-health and disability (CDC, 2020b). The US safety net system is heterogeneous, however, and some community health centres are able to offer less than others (Nguyen, Makam and Halm, 2016). Whilst these centres do not all have specialists on hand, by increasing screening and primary care, musculoskeletal pain could be attended to in the low socioeconomic category before the need for a specialist arises, and hopefully attenuate the need for a specialist, or extend the time before a specialist is required.

One of the most marked features of the low back pain intervention literature was on highlighting the over-treatment of the condition medically (Qaseem *et al.*, 2017; Traeger *et al.*, 2019). An estimated 32% of healthcare interventions or treatment plans for low back pain in the US conflicted with clinical guidelines, where the 32% statistic is likely an underestimation (Traeger *et al.*, 2019). The cumulative costs of unnecessary imaging, unnecessary surgeries, and unnecessary long-term opioid prescriptions are an enormous social burden. The movement towards lifestyle-related interventions (such as physical activity, patient education, stress reduction and mindfulness, and patient reassurance by clinicians) is, in fact, a very positive outcome for groups who may have traits frequently associated with low back pain. For example, people who are inactive and have increased BMI will be able to benefit from treatment programmes as these treatment plans directly confront multiple health issues at a time. Moreover, those of low socioeconomic status (which is associated with worse health outcomes) are not excluded from treatment regimens as they would be if treatment was largely medical (and thus expensive). Safety net community health centres would be ideal in this regard, as they could

screen, and offer people of low socioeconomic status who have low back pain real solutions to their pain, without financial constraints.

SECTION 3: SOUTH AFRICAN CONTEXT

Musculoskeletal pain is not only a problem and burden for developed countries like the US; residents of the developing world too report high prevalences of musculoskeletal pain (Hoy *et al.*, 2014). Musculoskeletal conditions accounted for 19.2% of years lost to disability in developing countries, with low back pain specifically ranked highest for years lost to disability (Hoy *et al.*, 2014). Reports of chronic pain in South Africa, specifically, are also high, at almost one in five people, according to recent cross-sectional population-based research (Kamerman *et al.*, 2020). In Chapter One of this thesis, I cited that large population-based surveys, where data have been collected over many years, are unavailable in South Africa. However, South Africa's trends in diseases (for example diabetes, and cardiovascular disease) follow US trends (GBD, 2019a). I used the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease data to plot the prevalence of cardiovascular disease, diabetes, musculoskeletal disorders, and low back pain in South Africa and the US, from 1990 until 2019 (Figure 7.3). Although the prevalence of the aforementioned diseases are still higher in the US, they are rising in South Africa in a similar pattern as the US. Thus, the US-based findings in this thesis may, to an extent, be applicable to the South African context, but only in conjunction with available local research, such that South Africa can use American statistics to try to better predict future disease and cost burdens.

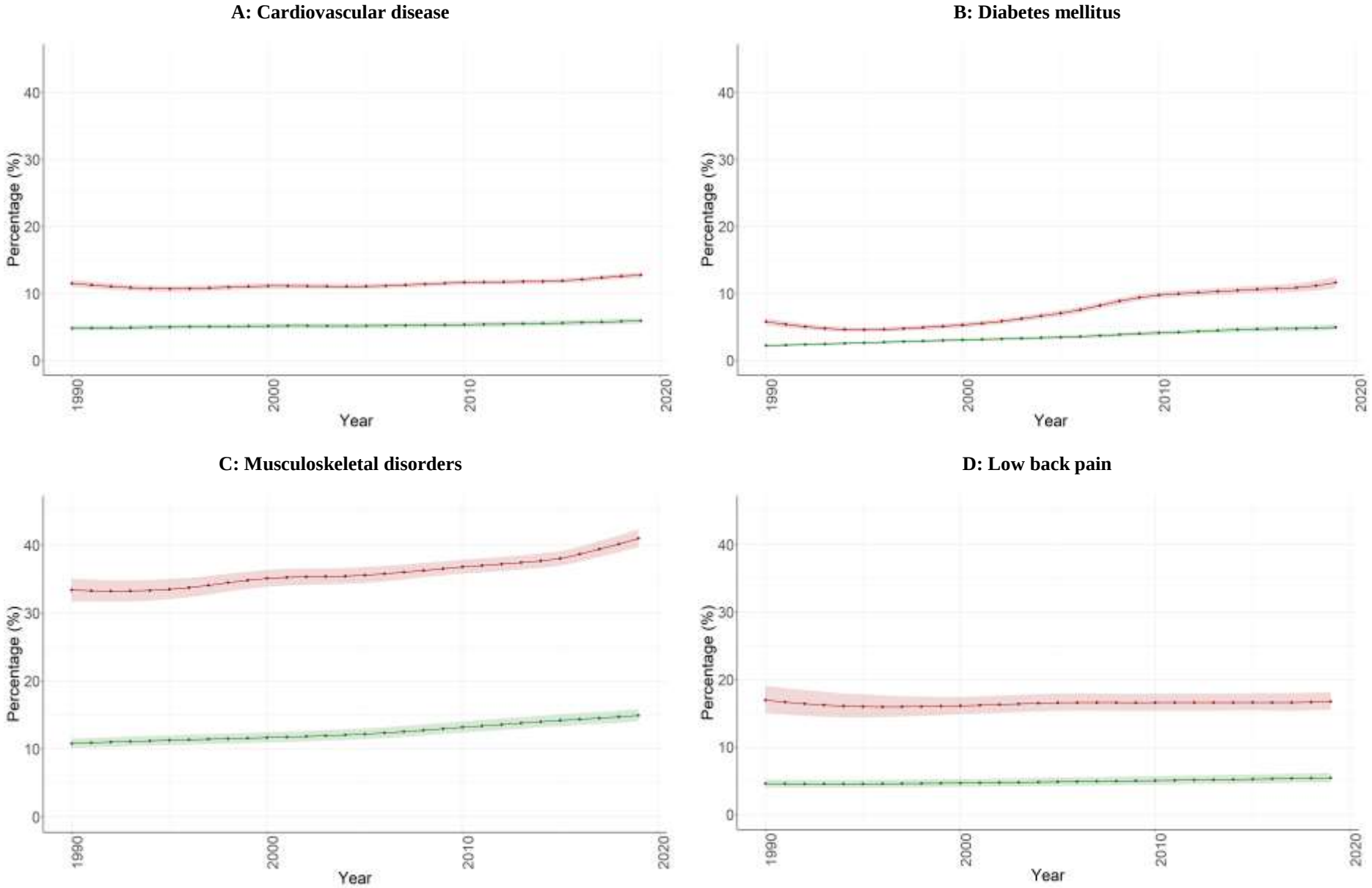


Figure 7.3: Prevalence (%) of cardiovascular disease (A), diabetes mellitus (B), musculoskeletal disorders (C), and low back pain (D) in the US (red) and South Africa (green), between 1990 and 2019, using the Global Burden of Disease data, from the Institute for Health Metrics and Evaluation*

*(GBD, 2019a)

One of the main findings of this thesis that is particularly relevant to the South African context is the robust association between having musculoskeletal pain (either as a painful arthropathy, or low back pain) and low socioeconomic status. Only one in four South Africans may be regarded either as stably middle-class or elite, and unemployment is not only high, but it is also a driving force of fiscal vulnerability in South African citizens (Schotte, Zizzamia and Leibbrandt, 2018). Indeed, the most recent unemployment statistics indicated that South Africa's unemployment rate was 32.5% in the final quarter of 2020 (Stats SA, 2021a). Low socioeconomic status, including low income as well as unemployment, has been associated with musculoskeletal pain (Wolfe *et al.*, 2005; Callhoff *et al.*, 2017). Indeed, cross-sectional surveys on poor older sub-Saharan African slum dwellers indicated that past two-week arthritis symptom prevalence was 42%, and activity-limiting joint symptom prevalence was 22.7%. Furthermore, 42.6% of these slum residents with a current health problem rated musculoskeletal pain as their most severe health problem (Aboderin and Nanyonjo, 2017). My US-based results showed that, indeed, low socioeconomic status (unemployment, low annual household income, and low education level) was associated with all musculoskeletal pain types, across all years of research. All of these low socioeconomic statuses indices are relevant for many South Africans, and have the potential to thus affect large proportions (up to 75%, given that only one in four South Africans are fiscally stable) of the South African population.

South Africans also face healthcare-related vulnerability as the South African public health system, which is relied upon by at least 84% of the South African population (Naidoo, 2012), faces many large challenges. Amongst others, some highlighted issues include prolonged waiting time because of a shortage of human resources, adverse events (such as being turned away from hospital), poor hygiene and poor infection control measures, increased litigation because of avoidable errors, a shortage of resources in medicine and equipment, and poor record-keeping (Maphumulo and Bhengu, 2019). The robust association between low socioeconomic status and musculoskeletal pain established in this thesis has the potential to put much pressure on many South Africans, and the health structures on which they have to rely. Much like the US, South Africa does have community health centres and clinics. Staff at these facilities could be trained to screen, and offer management advice to South Africans who attend these clinics, particularly as these clinics are the only source of care for many South Africans of low socioeconomic status. As catchment facilities, they have the potential to intercept and address the population's

musculoskeletal pain burden. Training would, however, be essential, and would require governmental funding.

Research has also estimated that the burden of musculoskeletal conditions is increasing in developing countries, where the burden thereof increased by 60% between 1990 and 2010 (Hoy *et al.*, 2014). The increased burden has been attributed to a growing population and aging, which is expected to continue (and more rapidly so than it did in developed countries) in the coming years, despite developing countries' economies being ill-equipped to deal with the rapid changes (Hoy *et al.*, 2014). A further risk factor cited as increasing the burden of musculoskeletal pain in developing countries is that of labour-intensive industries in developing countries (Hoy *et al.*, 2014). South Africa too has a large manual labour workforce because much of the workforce is in agriculture, mining, construction, or the informal sector (including street vendors, craftsmen, gardeners, and domestic workers, who spend many hours on their feet), which are large industries in the country (Stats SA, 2021b). Therefore, high musculoskeletal pain prevalence reports in poor people residing in developing countries not only supports the findings of my own analysis, but they also highlight the burden that musculoskeletal pain is placing on societies in the developing world.

Two lifestyle-related factors that associated with having musculoskeletal pain in US-based results were increased BMI, and physical inactivity. Although there is food insecurity of between 19% and 32.8% of people in South Africa (HSRC, 2013), there is still a high number of BMI values that fall into overweight and obese categories. In 2016, the mean prevalence of obesity ($BMI > 30 kg.m^{-2}$) in South Africa was 40% in females, and 20% in males; the prevalence of being overweight ($25 kg.m^{-2} < BMI < 30 kg.m^{-2}$) was approximately 25% in both males and females; and the prevalence of being underweight ($BMI < 18.5 kg.m^{-2}$) was approximately 4% in females, and 8% in males (NCD-RisC collaborators, 2017). Despite the already-high prevalence of obesity, the obesity statistics are still increasing in South Africa. Age-standardised mean BMI in adult females increased from approximately $27 kg.m^{-2}$ in 1975 to approximately $30 kg.m^{-2}$ in 2016, and from approximately $22 kg.m^{-2}$ to approximately $24 kg.m^{-2}$ in adult males over the same timeframe (NCD-RisC collaborators, 2017). Given the high prevalence of South African residents with increased BMIs, a substantial proportion of the population could in fact be at risk of musculoskeletal pain. Furthermore, given the growing number of people in South Africa in the

overweight and obesity BMI categories, the burden of musculoskeletal pain in the population may well rise. Obesity is expected to rise in developing nations over the coming 20 years, and has been cited as a potential driver of an expected increase in the burden of musculoskeletal pain (Hoy *et al.*, 2014), which could also increase the burden of corresponding disability. Therefore, early population-based screening, monitoring, intervention, and management is therefore crucial if musculoskeletal pain is to be addressed and managed at community clinic level, which is all that many South Africans can afford.

BMI and nutrition status are interwoven with factors such as socioeconomic status, sex, and area of residence (HSRC, 2013; Alaba and Chola, 2014; Cois and Day, 2015). Higher socioeconomic status was associated with increased likelihood of obesity in both South African men and women (Alaba and Chola, 2014; Cois and Day, 2015; Ramsay *et al.*, 2018; Koupil *et al.*, 2019). There is greater inequality in men, where wealthier men were significantly more likely to be obese compared to poorer men (Alaba and Chola, 2014), however, the obesity disparity in females across socioeconomic groups was not as stark. The double-edged sword of low socioeconomic status combined with inappropriate extremes of BMI and physical activity looks different in South Africa compared to the US. South Africa has a far more delicate and difficult socioeconomic circumstance. On the one hand, poor education in nutrition as well as large consumption of inexpensive staple food (maize meal) leads to large numbers of the poorer population being overweight or obese (NCD-RisC collaborators, 2017) (this pattern aligns with the double-edged sword of low socioeconomic status combined with increased BMI and physical inactivity, as is the case in the US). On the other hand, many South African residents are at the absolute extreme of food insecurity and are underweight (4% of females and 8% of males (NCD-RisC collaborators, 2017)). These individuals may therefore experience musculoskeletal pain due to malnutrition. It is also possible, as per the evidence in Alaba and Chola (2014), that the prevalence of obesity is more evenly distributed and more similar across different socioeconomic statuses in the South African population (particularly in women) and so the double-edged sword of low socioeconomic status combined with increased BMI and physical inactivity may not be so rigidly applied to some groups of the population who still fall into low socioeconomic status categories. In turn, it could mean that the burden of musculoskeletal pain conditions could be more dispersed and affect more people, as opposed to being very burdensome on one particular group comprising all the risk factors. There is also a very strong association between BMI and

sex in South Africa, where females were shown to have significantly higher BMIs than males (Alaba and Chola, 2014; Micklesfield *et al.*, 2018), even in lower socioeconomic groups (although this trend in females of all socioeconomic statuses does not negate the high socioeconomic status-obesity association). My own research on US data showed that female sex is significantly associated with both painful arthropathies, and low back pain. A large burden of musculoskeletal pain in obese females could develop on society in South Africa. I would strongly recommend screening South African females, and instilling community intervention programmes to attenuate the large prevalence of obesity in the group in attempt to address the corresponding potential risk of musculoskeletal pain.

The prevalence of physical inactivity (measured in a binary manner, where exercising twice per week was marked as physically active) in South Africans is high, estimated at 72% of the population, and was particularly high in females at 80% (compared to 60% in males) (Alaba and Chola, 2014). Other research, however, suggests that 46.6% of women and 43% of men are categorised as inactive (Guthold *et al.*, 2008). Within the context of South Africa, where people often walk long distances to work, the definition of "physical activity" requires clarification on whether it refers to leisure-time or sport pattern physical activity, or physical activity that would include transport or occupation-related physical activity. For example, the 2019 General Household Survey in South Africa indicated that the percentage of learners whose primary transport to school was walking was 62.1%, and the percentage of workers whose primary transport to work was walking was 21.5% (Stats SA, 2020). The percentage of disabled workers who walk all the way to work was estimated at 29% (Stats SA, 2014). National survey data also indicated that the mean number of minutes walked to work in South Africa by those who do walk is 34 minutes. Furthermore, almost 10% of those who walk to work have to work for over one hour to get to work (Stats SA, 2014). It is important to bear in mind that a roundtrip to and from work would double these times.

As I mentioned in Chapter Six, there is evidence that physical activity and musculoskeletal pain have a U-shaped relationship (where too little and too much physical activity can lead to negative outcomes for musculoskeletal pain) (Heneweer, Vanhees and Picavet, 2009). Similarly, research suggests that people with low back pain, for example, more often had low leisure-time physical activity but high occupational activity (Björck-van Dijken, Fjellman-Wiklund and

Hildingsson, 2008). Clarification should thus be established on the effect of physical activity on the pain outcomes of South Africans, who often walk long distances to work, and who may have physically demanding occupations. It is possible that, despite being physically active, their physical activity levels are so far to the upper limit that it begins to detriment their musculoskeletal pain outcomes.

One final area that I feel South Africa stands to benefit from investigating is the longitudinal spatial trends of chronic pain across the country. Despite the decades of available spatial and pain data for me to analyse within the context of the US, only one study has to date conducted spatial analyses on chronic pain in South Africa. Cross-sectional population-based research has shown spatial disparities in chronic pain between South African provinces, where chronic pain prevalence ranged from 12% to 27% (Kamerman *et al.*, 2020). The prevalence of chronic pain was highest in the Northern Cape, which is where much of South Africa's mining industry is found. Given that US-based statistics also showed high prevalences of pain around mining regions (Appalachia), I would suggest that an area of future research could be whether there is in fact an association between pain in the population, and residing in an area with major mining industry. Mining is a hugely important part of the South African economy, contributing R351 billion and employing 456 438 people in 2018 (Minerals Council, 2018). As an important driver of the economy, addressing mining's potential "side effects" needs to be investigated and addressed through geographically-specific management programmes and health budgets.

I must address that US-based results do have limitations to the South African context. Whilst they serve as a starting block for future research and health and cost projections, extrapolating the data fully would not be appropriate. The South African population has a different sociodemographic make-up than the US population, where the population has different racial proportions, socioeconomic proportions and conditions, different lifestyles (including non-recreational physical activity through walking to work or school, as well as diet), and even public health system differences. Therefore, I strongly suggest that South Africa implement pain-related questions into a longitudinal health-related population-based survey. The surveys that I used in my thesis could, in fact, be used as templates to streamline the process of implementing such a survey. For example, many South Africans do not have access to healthcare, either due to socioeconomic status or geographical location, resulting in a shortage of official diagnoses.

Therefore, I would recommend that painful arthropathies be assessed in a manner similar to the NHIS, which asked about whether the participant had experienced pain, aching, or stiffness in the previous 30 days. It is my opinion that only asking whether a South African resident has received a diagnosis for a painful rheumatic disorder would severely underestimate the prevalence of arthritic pain in the country. Asking South African residents whether they have received a disease diagnosis would only be useful *in conjunction* with symptomatic reports. Pain-related disease diagnosis reports could rather be compared to pain-related symptom reports as an indicator of the gap between people receiving a diagnosis, and people who experience pain symptoms. Reports on diagnoses would thus be inappropriate as the primary indicator of the societal burden.

Another aspect in which US-based data may not be entirely applicable to the South African framework is within the context of HIV/AIDS. From doing my thesis on pain data from population-based surveys, I found that knowing the types of pains the population is experiencing is important, but the data are not always available. This lack of data was problematic, in the American context, in that there was no screening of neuropathic pain despite the burden of diabetes in the US (Cho *et al.*, 2018; Cheng *et al.*, 2019). Within the South African context, sensory neuropathy is a common problem faced by those living with HIV. An estimated 20.4% of South African adults are HIV-positive (UNAIDS, 2019), and a systematic review found that the point prevalence of pain in people living with HIV was 54%. The prevalence of pain in people living with HIV ranged between 55% and 83%, across various studies' pooled data that used recall periods of between one week and six months (Parker, Stein and Jelsma, 2014). Therefore, I suggest screening for neuropathic pain in the South African population due to the high prevalence of HIV in the population, and its potential associated painful neuropathy.

There is research into South African musculoskeletal disorders included in the Global Burden of Disease (GBD) research (including the data that I have shown in Figure 7.3). The GBD are, however, restricted to data that are currently available, which (unlike many large national US databases) are different data sources collected over different time points and are not always the same. For example, two such data sources include cross-sectional population-based surveys administered once, as well as a few longitudinal household interviews (not nationally representative and administered over the course of two years). The statistics that the GBD

produces are, therefore, very impressive considering the heterogeneity in the South African data sources available. It is, however, a pity that the GBD studies do not have access to data sources that collect temporally consistent data (including nationally representative samples, and consistent question phrasing) because such data do not exist presently for South Africa (GBD, 2021). In the US, surveys such as the BRFSS, NHIS and NHANES Continuous US data sources ask the same questions, phrased the same and asked to the same samples, over time and so the statistics from these surveys can be validated against previous years; whereas this would not be possible in South Africa. Ideally, South African annual cross-sectional population-based surveys that are nationally representative and consistent in their data collection over time should be administered to the South African population from within South Africa, which would in turn increase the robustness of local as well GBD studies.

A recently published strategy guide published by the Global Alliance for Musculoskeletal Health (G-MUSC), highlighted not only the importance of addressing the global burden of musculoskeletal conditions, but also suggested a guide on how to address this burden. The guide was inclusive of numerous countries worldwide (both in the developed and developing world, including South Africa), as well as inclusive of various views of musculoskeletal pain (such as including people across multiple clinical disciplines who work with pain) (Briggs et al., 2021). Critically, the strategies outlined by G-MUSC were designed with the idea that they could be adapted and applied across many countries, irrespective of how different the socioeconomic circumstances. The strategy includes a number of "pillars", which are aspects of the strategy that countries could follow to best address the burden of musculoskeletal pain within their borders. Pillar 7 directly addresses the power and necessity of population health surveillance in the context of musculoskeletal pain (Briggs et al., 2021). However, for Pillar 7 to be fully recognized, Pillar 2 (integrating musculoskeletal health as a priority condition at top levels of society including governments) needs to be adequately addressed within the context of South Africa. This would include government-sponsored care, strategic responses aligned with global initiatives, legislature, and inter-disciplinary teams within countries to extend strategic obligations from government to grassroots level (Briggs et al., 2021). Nationally surveillance (Pillar 7) should be prioritized in the context of South Africa in order to assess the scope of the musculoskeletal pain problem appropriately, and in turn to therefore best assess how the G-MUSC strategies can be applied and streamlined in South Africa.

The current prevalence of chronic pain in the South African population was estimated at 18.3% (Kamerman *et al.*, 2020). The prevalence of painful arthropathies in the US was approximately between 25% and 30%, and low back pain approximately 30% of US residents. If, indeed, the trends in pain (including painful arthropathies, and low back pain) follow the US trajectories, the prevalence of musculoskeletal pain could well increase in South Africa. The growing population, aging, low socioeconomic status and growing fiscal insecurity, and obesity and physical inactivity in South Africans are all factors that could contribute to this increase. The value of this thesis in the South African context then could be in early screening and intervention programmes for South Africans, particularly residents who encompass variables that were associated with pain in this US-based analyses (older age, female sex, unemployment, low education level, low annual household income, increased BMI, and physical inactivity). In doing so, early intervention or prevention programmes could be put in place in an attempt to blunt the growth of musculoskeletal pain, and its corresponding burden. Health budgets could also be addressed in order to prepare for the burden of musculoskeletal pain on South African society.

SECTION 4: NOVEL CONTRIBUTION AND POTENTIAL IMPACT

Pain research has previously been cross-sectional and geographically localised in nature. This thesis adds to the existing body of knowledge by showing a nationally-representative temporal trajectory of musculoskeletal pain (including arthritic pain, and low back pain), as well as a spatial trajectory thereof. I showed that, although the musculoskeletal pain trajectory remains steady in prevalence, the number of people affected by musculoskeletal pain has increased. I also showed that not all geographic locations are affected evenly, where Appalachia and the Mississippi Valley have disproportionately high prevalences of rheumatic disorder diagnoses compared to other states, across time. This thesis has also shown, with long-term data analysis, that painful arthropathies were associated with older age, being female, low socioeconomic status, being physically inactive, and having an increased BMI, over the last 20 years. Furthermore, this thesis showed that low back pain was associated with being female, being unemployed, being physically inactive, and having an increased BMI, over the last 20 years. Age was associated with low back pain in young adults (increasing in age between ages 18 to approximately 30 years), but the prevalence of low back pain reached lifetime prevalence by between 30 and 35 years old.

Knowledge on the temporal and spatial trajectories, and demographic and lifestyle factors associated with musculoskeletal pain are crucial for cost prediction, particularly going forward as the population grows and continues to age. Low back pain and neck pain were amongst the conditions with the highest increase in US national spending estimates, increasing by $57.2 billion from 1996 until 2013 (Dieleman *et al.*, 2016). The estimated direct healthcare cost of arthritis in the US by 2013 was between $1 862 to $14 021 per person, per year (Lo *et al.*, 2016). Collectively, back pain and arthritis affect more than 100 million individuals in the US per year, costing over $200 billion annually due to being highly prevalent and causing disability (Ma, Chan and Carruthers, 2014). Research has even shown that the cost of persistent pain in the US exceeds the costs of the major disease diagnoses, including cardiovascular disease, neoplasms, injury and poisoning, endocrine, nutritional and metabolic diseases, digestive diseases, and respiratory diseases (Gaskin and Richard, 2012). Pain also affects four times the number of people with heart disease and diabetes, and nine times the number of people with cancer (Gaskin and Richard, 2012). My findings (which showed nationally-representative trends on painful

arthropathies, and low back pain) demonstrate a trajectory for musculoskeletal conditions. Potential health-related costs could be calculated for the overall population, as well as for various states and regions, and various demographic groups within the population.

Targeting groups at greater risk of musculoskeletal pain for intervention will in turn address and attenuate the burden of musculoskeletal pain in these vulnerable groups, thereby reducing costs and the burden on society in the long run. Older age and female sex are both associated with musculoskeletal pain, but one cannot change age or biological sex. In the case of these fixed variables, societies could prepare for the potential associated cost, as well as support for these groups from healthcare practitioners to try to preserve independence and functional abilities. In the case of socioeconomic status, screening and associated patient education and support at community health centres can help to treat those with musculoskeletal pain. By addressing the burden of pain within the low socioeconomic status group in the population, the burden of pain on these individuals as well as the broader society could be reduced. Finally, addressing lifestyle-related predictors (physical inactivity, and increased BMI) would also attenuate the burden of musculoskeletal pain on individuals and society, and be a cheaper option for those of low socioeconomic status. Given the high unnecessary costs (according to clinical guidelines) of imaging, surgery, and opioid prescriptions in the US, costs could be better prioritised to supporting those at risk of musculoskeletal pain, and to interventions that attenuate the effect of modifiable risk factors, such as education on living a healthy lifestyle (for example, physical activity, and wise nutritional choices).

Finally, there is growing recognition of data analytics in pain research, as evidenced by the inclusion of a workshop on pain analytics for the first time at the 2018 World Congress on Pain, Boston. Pain is affected by an array of variables, as demonstrated by this thesis, as well as other variables that were not within the scope of this work (for example, sleep, disability, mental health, healthcare-seeking behaviour, and health-related quality of life (Koleck *et al.*, 2006; Gerrits *et al.*, 2012; Shmagel, Foley and Ibrahim, 2016)). My thesis presents a new methodology for evaluating pain, using nationally-representative population-based survey data to assess factors frequently associated with pain, and crucially its time and space trajectories. There can be no doubt that pain is a hugely complex phenomenon, and the risk factors for pain interact between themselves, as well as with pain itself. It is my personal opinion that no human-made model will ever be able to

capture the intricacies of the pain experience. Therefore, whilst my own methodology was simple in comparison to the potential artificial intelligence and machine learning methods that exist, I would hope that my work, in some small way, has shown that the potential and scope for modelling big data in pain medicine is not only enormous, but imperative.

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333 Fuming Zheng, Weihui Xiao, Jiajia Yang, Shufeng Liu et al. "Effect of Self-Compassion Training Combined With Core Stability Exercise For Patients With Non-Specific Chronic Low Back Pain: Study Protocol For A Randomized Controlled Trial", Research Square Platform LLC, 2021 <1%
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346 Jennifer M. Hootman, Wendy Y. Cheng. "Psychological distress and fair/poor health among adults with arthritis: state-specific prevalence and correlates of general health status, United States, 2007", International Journal of Public Health, 2009 <1%
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347 Mayank Singh, Ravi Prakash Jha, Neha Shri, Krittika Bhattacharyya, Priyanka Patel, Deepak Dhamnetiya. "Secular Trends in Incidence and <1%

Mortality of Cervical Cancer in India and its States, 1990- 2019: Data from the Global Burden of Disease 2019 Study", Research Square Platform LLC, 2021
Publication

348 Rivinoja, A. E., M. V. Paananen, S. P. Taimela, S. Solovieva, A. Okuloff, P. Zitting, M.-R. Jarvelin, P. Leino-Arjas, and J. I. Karppinen. "Sports, Smoking, and Overweight During Adolescence as Predictors of Sciatica in Adulthood: A 28-Year Follow-up Study of a Birth Cohort", American Journal of Epidemiology, 2011.
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APPENDIX B

Ethics waiver certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL

Human Research Ethics Committee (Medical)

Research Office Secretariat:
Faculty of Health Sciences, Phillip Tobias Building, 3rd Floor, Office 301/2/4, 29 Princess of Wales Terrace, Parktown, 2193
Tel +27 (0)11-717-1252 /1234/2656/2700
Private Bag 3, Wits 2050
Office email: HREC-Medical.ResearchOffice@wits.ac.za
Website: www.wits.ac.za/research/about-our-research/ethics-and-research-integrity/

Ref: W-CBP-180917-4 17/09/2018

TO WHOM IT MAY CONCERN:

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)

Investigator: Miss Anne Elizabeth Ioannides et al (student no. 731507)

Supervisor: Prof Peter Kamerman

Department: Physiology

Project title: Long-term trends and risk factors for arthritic and low back pain, using population-based surveys from the USA

Reason: Study solely involves secondary analysis of de-identified, public domain data. No human participants will be involved in the study.

Dr CB Penny

Chairperson: Human Research Ethics Committee (Medical)

Copy – HREC (Medical) Secretariat: Zanele Ndlovu, Charmaine Khumalo and Rhulani Mkansi.

APPENDIX C

BRFSS sampling information: 1996 to 2018

Table I: Sampling information, response rates, weighting information, and additional sampling information for each BRFSS survey year used in this thesis

Year	Data quality report and sampling information	RR[a] (%)	State-specific RR (%)	Additional weighting or sampling information
1996	https://www.cdc.gov/brfss/annual_data/1996/pdf/1996SummaryDataQualityReport.pdf	63.2	*Available in Data Quality Report*	Information available from the other link listed for 1996, or at <https://www.cdc.gov/brfss/annual_data/1996/files/OVERVU96.TXT> ◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Rheumatic disorder diagnosis question was part of the module questionnaire
1997	https://www.cdc.gov/brfss/annual_data/1997/pdf/1997SummaryDataQualityReport.pdf	62.1	*Available in Data Quality Report*	Information available from the other link listed for 1997, or at <https://www.cdc.gov/brfss/annual_data/1997/files/OVERVU97.TXT> ◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Rheumatic disorder diagnosis question was part of the module questionnaire
1998	https://www.cdc.gov/brfss/annual_data/1998/pdf/1998SummaryDataQualityReport.pdf	59.1	*Available in Data Quality Report*	Information available from the other link listed for 1998, or at <https://www.cdc.gov/brfss/annual_data/1998/pdf/Overview_98.pdf> ◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Rheumatic disorder diagnosis question was part of the module questionnaire
1999	https://www.cdc.gov/brfss/annual_data/1999/pdf/1999SummaryDataQualityReport.pdf	55.2	*Available in Data Quality Report*	Information available from the other link listed for 1999, or at <https://www.cdc.gov/brfss/annual_data/1999/pdf/Overview_99.pdf> ◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Rheumatic disorder diagnosis question was part of the module questionnaire
2000	https://www.cdc.gov/brfss/annual_data/2000/pdf/2000SummaryDataQualityReport.pdf	48.9	*Available in Data Quality Report*	Information available from the other link listed for 2000, or at <https://www.cdc.gov/brfss/annual_data/2000/pdf/Overview_00.pdf> ◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Rheumatic disorder diagnosis question was part of the module questionnaire

2001	https://www.cdc.gov/brfss/annual_data/2001/pdf/2001SummaryDataQualityReport.pdf	52.7	*Available in Data Quality Report*	Information available from the other link listed for 2001, or at <https://www.cdc.gov/brfss/annual_data/2001/pdf/overview_01.pdf> ° Poststratification weighting methods ° Inclusion of landlines only
2002	https://www.cdc.gov/brfss/annual_data/2002/pdf/2002SummaryDataQualityReport.pdf	44.5	*Available in Data Quality Report*	Information available from the other link listed for 2002, or at <https://www.cdc.gov/brfss/annual_data/2002/pdf/overview_02.pdf> ° Poststratification weighting methods ° Inclusion of landlines only ° Rheumatic disorder diagnosis question was part of the module questionnaire
2003	https://www.cdc.gov/brfss/annual_data/2003/pdf/2003SummaryDataQualityReport.pdf	53.2	*Available in Data Quality Report*	Information available from the other link listed for 2003, or at <https://www.cdc.gov/brfss/annual_data/2003/pdf/overview_03.pdf> ° Poststratification weighting methods ° Inclusion of landlines only
2004	https://www.cdc.gov/brfss/annual_data/2004/pdf/2004SummaryDataQualityReport.pdf	52.7	*Available in Data Quality Report*	Information available from the other link listed for 2004, or at <https://www.cdc.gov/brfss/annual_data/2004/pdf/overview_04.pdf > ° Poststratification weighting methods ° Inclusion of landlines only ° Rheumatic disorder diagnosis question was part of the module questionnaire
2005	https://www.cdc.gov/brfss/annual_data/annual_2005.htm	51.1	*Available in Data Quality Report*	Information available from the other link listed for 2005, or at <https://www.cdc.gov/brfss/annual_data/2005/pdf/overview_05.pdf > ° Poststratification weighting methods ° Inclusion of landlines only ° Response rate excludes Guam, Puerto Rico, and Virgin Islands
2007	https://www.cdc.gov/brfss/annual_data/2007/pdf/2007SummaryDataQualityReport.pdf	50.6	*Available in Data Quality Report*	Information available from the other link listed for 2007, or at <https://www.cdc.gov/brfss/annual_data/2007/pdf/overview_07.pdf> ° Poststratification weighting methods ° Inclusion of landlines only ° Response rate excludes Guam, Puerto Rico, and Virgin Islands
2009	https://www.cdc.gov/brfss/annual_data/2009/pdf/2009_Summary_Data_Quality_Report.pdf	52.5	*Available in Data Quality Report*	Information available from the other link listed for 2009, or at <https://www.cdc.gov/brfss/annual_data/2009/pdf/overview_09.pdf>

				◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Response rate excludes Guam, Puerto Rico, and Virgin Islands
2010	https://www.cdc.gov/brfss/annual_data/2010/pdf/2010_Summary_Data_Quality_Report.pdf	54.6	*Available in Data Quality Report*	Information available from the other link listed for 2010, or at < https://www.cdc.gov/brfss/annual_data/2010/pdf/overview_10.pdf> ◦ Poststratification weighting methods ◦ Inclusion of landlines only ◦ Response rate excludes Guam, Puerto Rico, and Virgin Islands ◦ Rheumatic disorder diagnosis question was part of the module questionnaire
2011	https://www.cdc.gov/brfss/annual_data/2011/pdf/2011_Summary_Data_Quality_Report.pdf	49.7	https://www.cdc.gov/brfss/annual_data/2011/response_rates_11.htm	Information available from the other two links listed for 2011, or at <https://www.cdc.gov/brfss/annual_data/2011/pdf/overview_11.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights ◦ Weight trimming to increase the value of very low weights and decrease the value of very high weights ◦ Response rate excludes Guam, Puerto Rico, and Virgin Islands
2012	https://www.cdc.gov/brfss/annual_data/2012/pdf/SummaryDataQualityReport2012_20130712.pdf	45.2	https://www.cdc.gov/brfss/annual_data/2012/response_rates_12.htm	Information available from the other two links listed for 2012, or at <https://www.cdc.gov/brfss/annual_data/2012/pdf/Overview_2012.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights ◦ Weight trimming to increase the value of very low weights and decrease the value of very high weights
2013	https://www.cdc.gov/brfss/annual_data/2013/pdf/2013_DQR.pdf	46.4	https://www.cdc.gov/brfss/annual_data/2013/response_rates_13.htm	Information available from the other two links listed for 2013, or at <https://www.cdc.gov/brfss/annual_data/2013/pdf/Overview_2013.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights ◦ Weight trimming to increase the value of very low weights and decrease the value of very high weights
2014	https://www.cdc.gov/brfss/annual_data/2014/pdf/2014_dqr.pdf	47.0	https://www.cdc.gov/brfss/annual_data/2014/2014_ResponseRates.html	Information available from the other two links listed for 2014, or at <https://www.cdc.gov/brfss/annual_data/2014/pdf/Overview_2014.pdf>

				◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights ◦ Weight trimming to increase the value of very low weights and decrease the value of very high weights
2015	https://www.cdc.gov/brfss/annual_data/2015/pdf/2015-sdqr.pdf	47.2	https://www.cdc.gov/brfss/annual_data/2015/2015_ResponseRates.html	Information available from the other two links listed for 2015, or at <https://www.cdc.gov/brfss/annual_data/2015/pdf/overview_2015.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights ◦ Weight trimming to increase the value of very low weights and decrease the value of very high weights
2016	https://www.cdc.gov/brfss/annual_data/2016/pdf/2016-sdqr.pdf	47.1	https://www.cdc.gov/brfss/annual_data/2016/pdf/2016_ResponseRates_Table.pdf	Information available from the other two links listed for 2016, or at <https://www.cdc.gov/brfss/annual_data/2016/pdf/overview_2016.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights
2017	https://www.cdc.gov/brfss/annual_data/2017/pdf/2017-sdqr-508.pdf	45.9	https://www.cdc.gov/brfss/annual_data/2017/pdf/2017-response-rates-table-508.pdf	Information available from the other two links listed for 2017, or at <https://www.cdc.gov/brfss/annual_data/2017/pdf/overview-2017-508.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights
2018	https://www.cdc.gov/brfss/annual_data/2018/pdf/2018-sdqr-508.pdf	49.9	https://www.cdc.gov/brfss/annual_data/2018/pdf/2018-response-rates-table-508.pdf	Information available from the other two links listed for 2018, or at <https://www.cdc.gov/brfss/annual_data/2018/pdf/overview-2018-508.pdf> ◦ Comparable to data from 2011 onwards ◦ Inclusion of cell-phones and landlines ◦ Iterative proportional fitting (raking) to obtain design weights

[α] RR: median (by state) response rate

Additional Information

Additional information on weighting for each year can be found within each year's data files at https://www.cdc.gov/brfss/annual_data/annual_data.htm.

APPENDIX D

NHIS sampling information: 1997 to 2018

Table I: Sampling information, response rates, weighting information, and additional sampling information for each NHIS survey year used in this thesis

Year	Survey description[β]	RR[α] (%)	Field guide and manual	Design and weighting information
1997	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/1997/srvydesc.pdf ° Sample adult file begins on page 32	80.4	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1997/frmanual.pdf	New design implemented from 1995, as outlined in https://www.cdc.gov/nchs/data/series/sr_02/sr02_130.pdf; thus, the below features apply to this timeframe ° All area sampling (from 1985) ° State stratification and increased PSU's ° Oversampling black and Hispanic persons
1998	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/1998/srvydesc.pdf ° Sample adult file begins on page 36	73.9	*Part A:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1998/frmanu_a.pdf *Part B:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1998/frmanu_b.pdf *Part C:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1998/frmanu_c.pdf *Part D:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1998/frmanu_d.pdf	
1999	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/1999/Srvydesc.pdf ° Sample adult file begins on page 40	69.6	*Part A:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1999/frmanu_a.pdf *Part B:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1999/frmanu_b.pdf *Part C:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1999/frmanu_c.pdf *Part D:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/1999/frmanu_d.pdf	
2000	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2000/srvydesc.pdf	72.1	*Part A:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2000/frmanu_a.pdf	

	◦ Sample adult file begins on page 42		*Part B:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2000/frmanu_b.pdf *Part C:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2000/frmanu_c.pdf *Part D:* ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2000/frmanu_d.pdf	
2001	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2001/Srvydesc.pdf ◦ Sample adult file begins on page 44	73.8	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2001/frmanual.pdf	
2002	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2002/srvydesc.pdf ◦ Sample adult file begins on page 46	74.3	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2002/frmanual.pdf	
2003	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2003/Srvydesc.pdf\ ◦ Sample adult file begins on page 44	74.2	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2003/frmanual.pdf	
2005	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2005/srvydesc.pdf ◦ Sample adult file begins on page 51	69.0	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2005/frmanual.pdf	
2006	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2006/srvydesc.pdf ◦ Sample adult file begins on page 51	70.8	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2006/frmanual.pdf	New design implemented, as outlined in <https://www.cdc.gov/nchs/data/series/sr_02/sr02_165.pdf> ◦ All area sampling (continued) ◦ State stratification
2007	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2007/srvydesc.pdf	67.8	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2007/frmanual.pdf	

	◦ Sample adult file begins on page 57			◦ Oversampling of black, Hispanic, and Asian persons
2008	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2008/srvydesc.pdf ◦ Sample adult file begins on page	62.6	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2008/frmanual.pdf	
2009	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2009/srvydesc.pdf ◦ Sample adult file begins on page 57	65.4	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2009/frmanual.pdf	
2010	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2010/srvydesc.pdf ◦ Sample adult file begins on page 60	60.8	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2010/frmanual.pdf	
2011	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2011/srvydesc.pdf ◦ Sample adult file begins on page 62	66.3	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2011/frmanual.pdf	
2012	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2012/srvydesc.pdf ◦ Sample adult file begins on page 63	61.2	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2012/frmanual.pdf	
2013	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2013/srvydesc.pdf ◦ Sample adult file begins on page 53	61.2	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2013/frmanual.pdf	
2014	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2014/srvydesc.pdf ◦ Sample adult file begins on page 55	58.9	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2014/frmanual.pdf	

2015	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2015/srvydesc.pdf ° Sample adult file begins on page 57	55.2	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2015/frmanual.pdf	
2016	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2016/srvydesc.pdf ° Sample adult file begins on page 58	54.3	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2016/frmanual.pdf	New design implemented, as outlined in <ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2016/srvydesc.pdf>, found on **page 8**. ° Changed US population distribution considered ° Oversampling of black, Hispanic, and Asian persons no longer required ° State stratification ° Commercial address lists used as main source of addresses
2017	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2017/srvydesc.pdf ° Sample adult file begins on page 56	53.0	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2017/frmanual.pdf	
2018	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2018/srvydesc.pdf ° Sample adult file begins on page 51	53.1	ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2018/frmanual.pdf	

[α] RR: Response rate is the unconditional response rate, and accounts for household and family survey sections non-response

[β] Annual new additions, sample design, questionnaire, interviewing procedures, sample sizes and response rates, weighting, and other mathematical specifics

APPENDIX E

NHANES (Continuous) sampling information: 1999-2000 to 2017-18

Table I: Sampling information, response rates, weighting information, and additional sampling information for each NHANES (Continuous) survey cycle used in this thesis

Survey Cycle	Sampling information link	Unweighted response rate[α] (%) I^{α}	E^{α}	Response rate and population information link	Notes/annotations
1999-2000	https://www.cdc.gov/nchs/data/series/sr_02/sr02_155.pdf	82.0	76.0	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/RRT0102MF.pdf	Oversampled groups: ° Mexican Americans ° Black people ° White/'other' people below 130% of the federal poverty level ° White/'other' people over 70 ° Adolescents aged 12 to 19 (not relevant for this study) Only survey cycle for which a representative population was based on 1990 government census
2001-02		84.0	80.0	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/RRT0102MF.pdf	Oversampled groups: ° Mexican Americans ° Black people ° White/'other' people below 130% of the federal poverty level ° White/'other' people over 70 ° Adolescents aged 12 to 19 (not relevant for this study) Representative population based on 2000 census
2003-04		79.0	76.0	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/RRT0304MF.pdf	Oversampled groups: ° Mexican Americans ° Black people ° White/'other' people below 130% of the federal poverty level ° White/'other' people over 70 ° Adolescents aged 12 to 19 (not relevant for this study) Representative population based on 2000 census
2005-06		80.5	77.4	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/RRT0506MF.pdf	Oversampled groups: ° Mexican Americans ° Black people ° White/'other' people below 130% of the federal poverty level ° White/'other' people over 70 ° Adolescents aged 12 to 19 (not relevant for this study) Representative population based on 2000 census

2007-08	https://www.cdc.gov/nchs/data/series/sr_02/sr02_160.pdf	78.4 75.4	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/RRT0708MF.pdf	Over sampled groups: ° Hispanic people ° Non-Hispanic black people ° Non-Hispanic white/'other' people below 130% of the federal poverty line ° Non-Hispanic white/'other' people aged 80 or above Representative population based on 2000 census
2009-10		79.4 77.3	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/RRT0910.pdf	Over sampled groups: ° Hispanic people ° Non-Hispanic black people ° Non-Hispanic white/'other' people below 130% of the federal poverty line ° Non-Hispanic white/'other' people aged 80 or above Representative population based on 2000 census
2011-12	https://www.cdc.gov/nchs/data/series/sr_02/sr02_162.pdf	72.6 69.5	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/rrt1112.pdf	Oversampled groups: ° Hispanic people ° Non-Hispanic black people ° Non-Hispanic, non-black Asian people ° Non-Hispanic white/'other' people below 130% of the deferral poverty level ° Non-Hispanic white/'other' people aged 80 and over Representative population based on 2000 census
2013-14		71.0 68.5	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/2013_2014_response_rates.pdf	Oversampled groups: ° Hispanic people ° Non-Hispanic black people ° Non-Hispanic, non-black Asian people ° Non-Hispanic white/'other' people below 130% of the deferral poverty level ° Non-Hispanic white/'other' people aged 80 and over Representative population based on 2000 census

2015-16	https://www.cdc.gov/nchs/data/series/sr_02/sr02-184-508.pdf	61.3	58.7	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/2015-2016_response_rates.pdf	Oversampled groups: ° Hispanic people ° Non-Hispanics black people ° Non-Hispanic, non-black Asians ° Non-Hispanic white/'other' people below 185% of federal poverty level ° Non-Hispanic white/'other' people aged 0 to 11, and 80 and above Representative population based on 2000 census
2017-18		51.9	48.8	https://wwwn.cdc.gov/nchs/data/nhanes3/ResponseRates/NHANES-2017-2018-Response-Rates-508.pdf	Oversampled groups: ° Hispanic people ° Non-Hispanics black people ° Non-Hispanic, non-black Asians ° Non-Hispanic white/'other' people below 185% of federal poverty level ° Non-Hispanic white/'other' people aged 0 to 11, and 80 and above Representative population based on 2000 census

[a]Response rate for people who were interviewed (I) and people who were examined (E)

Additional information

Although I described the sampling methodology used by NHANES (Continuous) within Chapter 2 (Methods) of this thesis, specific information can be found on the NHANES (Continuous) portion of the CDC website. Additional sampling information on specific weighting mathematics and analysis specifications can be found in *National Health and Nutrition Examination Survey: Analytic Guidelines, 1999-2010* (at https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/99-10-analytic-guidelines.pdf), and in *National Health and Nutrition Examination Survey: Analytic Guidelines, 2011-2014 and 2015-2016* https://wwwn.cdc.gov/nchs/data/nhanes/analyticguidelines/11-16-analytic-guidelines.pdf . In addition, additional specific information on the operational methods used for NHANES (Continuous) data collection is available in the *National Health and Nutrition Examination Survey: Plan and Operations, 1999-2010* document (at https://www.cdc.gov/nchs/data/series/sr_01/sr01_056.pdf).

APPENDIX F

Annual unweighted sample size for each type of musculoskeletal pain and respective survey

Table I: Unweighted sample size of surveyed participants for whom rheumatic disorder diagnosis datasets were complete*, per year from 1996 until 2018 (except 2006 and 2008), from the Behavioral Risk Factor Surveillance System (BRFSS)

Year	Sample																					
	Age 18 to 24		*Age 25 to 29*		*Age 30 to 34*		*Age 35 to 39*		*Age 40 to 44*		*Age 45 to 49*		*Age 50 to 54*		*Age 55 to 59*		*Age 60 to 64*		*Age 65 to 69*		*Age 70 and above*		*TOTAL PER YEAR*
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
1996	450	567	477	508	530	700	621	826	462	741	502	635	350	534	308	409	284	401	332	505	628	1298	**12068**
1997	388	528	369	521	412	595	502	731	442	643	423	544	335	454	258	378	220	323	222	346	462	925	**10021**
1998	341	424	381	523	428	552	407	629	399	578	361	499	325	480	288	346	211	311	208	365	467	946	**9469**
1999	878	1109	758	1069	786	1192	929	1396	948	1309	876	1198	711	1075	615	938	525	834	528	942	1001	2141	**21758**
2000	4792	5821	4261	5922	4667	6745	5597	7751	5671	7715	5191	7018	4556	6089	3512	4919	2842	4100	2566	3973	5077	10241	**119026**
2001	8154	10156	7086	9932	8088	11681	9195	12749	9639	13243	9129	12188	8198	11613	6234	8686	5045	7412	4596	6952	9437	18361	**207774**
2002	4184	5472	3744	5583	4593	6734	4970	7372	5660	8151	5636	7991	5275	7385	4304	6341	3482	5206	3195	4954	6611	13225	**130068**
2003	7615	10329	6933	10789	8657	12991	9636	14091	11148	16099	11024	16019	10693	15257	8983	13372	7357	11374	6487	9881	13172	25318	**257225**
2004	1263	1781	1268	2046	1502	2581	1700	2669	1951	3074	2024	3183	1989	3075	1837	2889	1515	2431	1317	2240	2833	5480	**50648**
2005	7311	10689	7473	12794	9682	15925	11469	17890	12902	20156	14320	21458	14493	21929	13964	20638	11486	17405	9679	15414	20545	40021	**347643**
2007	6643	8923	6556	12096	8775	16240	11561	19643	13421	21766	15840	25210	17478	28043	17585	27282	16167	25445	13446	21898	28687	55743	**418448**
2009	5796	6862	5220	9312	7650	13686	10169	16811	11995	18870	15288	23269	17803	27608	18404	28251	18024	27750	15186	23918	31493	60656	**414021**
2010	424	557	358	674	556	1039	724	1264	893	1475	1031	1859	1346	2203	1564	2537	1661	2582	1413	2418	2779	5737	**35094**
2011	10952	11823	9361	12352	10924	16396	11849	17821	14156	20656	16572	23950	20063	30164	21993	32621	22532	33842	18771	28676	38255	73477	**497206**
2012	12156	12634	9669	11750	11041	15140	11463	16048	13545	18418	15395	21020	19064	27494	20677	29582	21286	30735	18707	28135	36406	68330	**468695**
2013	13535	13538	10692	12107	11712	15399	11754	16220	13625	17704	15371	20613	19512	27386	21550	30648	21908	31400	20097	29637	38733	71057	**484198**
2014	12311	11792	9342	10470	10278	13289	10764	14589	12219	16242	13996	18522	18322	24837	20849	28344	22119	30222	20921	29534	38941	68683	**456586**
2015	12414	11685	9446	10216	10299	12525	10730	13696	11283	14527	13349	16756	17076	22569	19434	26497	21287	28217	20498	28452	38034	64465	**433455**
2016	14088	12443	11301	11628	11839	13479	12273	14817	12152	14903	14748	18111	18357	23226	21836	27686	23515	31019	23819	31764	43218	71023	**477245**
2017	14031	12061	11165	11106	11837	12854	12177	13981	11480	13669	13648	16326	16443	20472	20030	24830	21959	27709	21529	28133	40793	64835	**441068**
2018	13953	11871	11266	10878	11749	12352	12158	13802	11805	13618	13340	15325	16018	18779	19050	22839	21142	25541	21172	25849	41439	61958	**425904**

*Complete datasets included all participants for whom there was an answered question on rheumatic disorder diagnosis, as well as PSU, stratum, and weighting data

Table II: Unweighted sample size of surveyed participants for whom joint symptoms datasets were complete*, per year from 2002 until 2018 (except 2004), from the National Health Interview Survey

Year	Sample																						
	Age 18 to 24		*Age 25 to 29*		*Age 30 to 34*		*Age 35 to 39*		*Age 40 to 44*		*Age 45 to 49*		*Age 50 to 54*		*Age 55 to 59*		*Age 60 to 64*		*Age 65 to 69*		*Age 70 and above*		*TOTAL PER YEAR*
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
2002	1491	1868	1195	1472	1387	1811	1459	1771	1502	1751	1322	1617	1183	1349	981	1243	783	960	676	856	1494	2802	**30973**
2003	1513	1746	1194	1492	1390	1736	1388	1681	1474	1728	1330	1607	1176	1500	1008	1268	791	1029	667	869	1465	2735	**30787**
2005	1407	1694	1184	1539	1306	1661	1371	1639	1405	1702	1372	1652	1267	1557	1151	1382	901	1130	711	921	1666	2766	**31384**
2006	1253	1415	1001	1205	917	1300	1059	1256	1022	1303	1111	1213	980	1142	854	1084	702	778	596	747	1199	2088	**24225**
2007	1132	1360	913	1136	991	1155	957	1213	980	1190	1030	1223	938	1171	826	963	746	872	627	737	1224	1980	**23364**
2008	982	1147	877	1102	884	1081	894	1099	901	1052	903	1135	869	1062	833	1006	647	858	605	700	1117	2019	**21773**
2009	1344	1476	1108	1349	1051	1471	1094	1380	1130	1366	1179	1410	1184	1376	976	1281	989	1059	698	922	1496	2367	**27706**
2010	1314	1486	1107	1365	1140	1361	1097	1327	1107	1271	1093	1346	1099	1315	976	1215	908	1170	719	896	1412	2412	**27136**
2011	1555	1734	1345	1686	1407	1629	1253	1578	1332	1510	1375	1531	1333	1515	1263	1426	1172	1452	930	1180	1838	2943	**32987**
2012	1507	1908	1335	1666	1322	1786	1320	1583	1327	1525	1348	1527	1390	1690	1423	1586	1294	1592	1028	1276	1972	3101	**34506**
2013	1556	1732	1440	1677	1425	1749	1216	1594	1384	1490	1288	1497	1418	1567	1383	1670	1207	1519	1091	1388	2015	3219	**34525**
2014	1640	1710	1472	1732	1438	1788	1308	1630	1394	1611	1307	1548	1536	1720	1459	1759	1355	1627	1225	1575	2249	3579	**36662**
2015	1374	1516	1319	1483	1313	1668	1219	1451	1218	1393	1189	1469	1366	1541	1343	1620	1246	1551	1202	1474	2270	3421	**33646**
2016	1453	1571	1102	1397	1150	1424	1167	1389	1069	1199	1194	1284	1339	1455	1390	1550	1363	1616	1368	1642	2387	3496	**33005**
2017	1129	1198	974	1070	982	1152	936	1120	857	981	984	1043	992	1220	1054	1262	1130	1313	1039	1293	2013	2981	**26723**
2018	934	923	889	923	921	1117	920	1073	869	1041	875	983	931	1034	1045	1205	1111	1262	1075	1281	1966	2964	**25342**

*Complete datasets included all participants for whom there was an answered question on joint symptoms, as well as PSU, stratum, and weighting data

Table III: Unweighted sample size of surveyed participants for whom arthritis diagnosis datasets were complete*, per survey cyce from 1999-2000 until 2017-18, from the National Health and Nutrition Examination Survey (NHANES) (Continuous)

Year	Sample																					
	Age 20 to 24		*Age 25 to 29*		*Age 30 to 34*		*Age 35 to 39*		*Age 40 to 44*		*Age 45 to 49*		*Age 50 to 54*		*Age 55 to 59*		*Age 60 to 64*		*Age 65 to 69*		*Age 70 and above*		*TOTAL PER YEAR*
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
1999-2000	165	247	161	224	167	230	177	196	197	196	143	182	146	173	116	115	204	206	176	172	420	425	**4438**
2001-02	217	297	188	270	181	249	199	242	233	233	222	202	205	187	138	134	187	199	148	161	466	465	**5023**
2003-04	209	248	201	214	194	235	163	189	200	202	175	180	170	174	111	120	170	205	173	170	503	522	**4728**
2005-06	212	302	198	309	187	241	205	183	202	216	199	195	189	182	127	131	178	185	156	141	427	398	**4763**
2007-08	212	234	219	202	220	245	253	257	214	241	222	249	272	233	181	205	281	293	193	193	523	556	**5698**
2009-10	253	279	220	270	231	265	246	265	253	297	250	284	266	248	223	194	257	287	211	190	510	544	**6043**
2011-12	276	248	212	218	237	233	222	230	214	235	202	223	223	263	194	197	258	263	184	162	393	423	**5310**
2013-14	248	245	205	221	251	250	210	249	237	296	226	246	220	245	222	228	253	263	187	209	404	460	**5575**
2015-16	204	216	232	278	230	247	220	234	196	264	206	245	229	245	208	205	255	251	193	216	448	442	**5464**
2017-18	190	192	187	207	200	221	165	226	175	210	191	199	196	212	212	256	315	310	220	210	485	471	**5250**

*Complete datasets included all participants for whom there was an answered question on joint symptoms, as well as PSU, stratum, and weighting data

Table IV: Unweighted sample size of surveyed participants for whom low back pain datasets were complete*, per year from 1997 until 2018 (except 2004), from the National Health Interview Survey

Year	Sample																						
	Age 18 to 24		*Age 25 to 29*		*Age 30 to 34*		*Age 35 to 39*		*Age 40 to 44*		*Age 45 to 49*		*Age 50 to 54*		*Age 55 to 59*		*Age 60 to 64*		*Age 65 to 69*		*Age 70 and above*		*TOTAL PER YEAR*
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
1997	1584	2111	1568	2027	1809	2218	1830	2355	1721	2055	1451	1783	1190	1440	920	1162	852	1000	788	1146	1746	3272	**36028**
1998	1493	1742	1397	1686	1513	1921	1670	2004	1552	1799	1378	1641	1116	1436	866	1118	768	976	762	1006	1672	2877	**32393**
1999	1455	1724	1214	1635	1301	1799	1497	1914	1476	1805	1260	1489	1113	1348	855	1184	751	967	653	933	1616	2785	**30774**
2000	1597	1880	1303	1707	1441	1809	1542	1990	1514	1859	1362	1675	1159	1455	950	1156	783	983	691	942	1625	2908	**32331**
2001	1599	1906	1383	1740	1544	1817	1556	1990	1606	1952	1392	1753	1297	1531	1021	1235	773	1040	659	980	1636	2847	**33257**
2002	1491	1866	1196	1472	1385	1810	1462	1771	1500	1750	1325	1617	1182	1350	984	1241	783	958	678	856	1496	2807	**30980**
2003	1513	1746	1197	1493	1390	1736	1388	1681	1474	1732	1328	1610	1176	1499	1008	1266	792	1030	668	869	1464	2729	**30789**
2005	1409	1691	1183	1539	1306	1662	1369	1639	1404	1702	1372	1652	1266	1556	1150	1381	902	1129	710	920	1667	2766	**31375**
2006	1254	1415	1001	1206	918	1300	1256	1056	1023	1302	1110	1212	979	1142	854	1086	701	781	595	747	1201	2087	**24226**
2007	1132	1360	913	1135	989	1156	957	1213	980	1191	1030	1223	937	1171	825	964	746	872	627	739	1222	1984	**23366**
2008	982	1148	876	1102	884	1081	894	1099	900	1052	903	1135	869	1060	831	1006	647	858	605	699	1115	2021	**21767**
2009	1345	1476	1107	1349	1051	1472	1094	1380	1131	1366	1179	1411	1185	1377	975	1281	989	1059	697	922	1498	2369	**27713**
2010	1314	1486	1108	1565	1139	1361	1097	1327	1106	1271	1093	1347	1098	1315	977	1215	909	1170	720	896	1413	2413	**27340**
2011	1555	1734	1345	1686	1408	1629	1251	1579	1511	1330	1374	1531	1333	1515	1264	1426	1172	1453	930	1180	1838	2943	**32987**
2012	1507	1908	1335	1666	1323	1786	1320	1583	1327	1527	1348	1526	1390	1688	1423	1586	1294	1592	1028	1276	1970	3102	**34505**
2013	1556	1732	1440	1676	1425	1748	1216	1593	1384	1490	1289	1497	1417	1567	1383	1670	1208	1520	1092	1392	2016	3219	**34530**
2014	1642	1710	1472	1732	1439	1788	1307	1632	1394	1611	1307	1548	1536	1721	1460	1759	1355	1626	1225	1576	2251	3580	**36671**
2015	1374	1516	1319	1483	1313	1668	1219	1451	1218	1393	1188	1469	1365	1541	1344	1620	1246	1551	1202	1474	2269	3418	**33641**
2016	1453	1571	1102	1397	1151	1423	1167	1389	1070	1198	1194	1284	1338	1455	1388	1550	1363	1616	1368	1641	2388	3493	**32999**
2017	1129	1198	974	1070	982	1153	936	1122	856	981	984	1043	992	1220	1054	1261	1129	1314	1039	1294	2015	2981	**26727**
2018	933	923	889	978	921	1117	921	1073	869	1041	875	983	931	1031	1046	1205	1111	1262	1076	1281	1968	2963	**25397**

*Complete datasets included all participants for whom there was an answered question on low back pain, as well as PSU, stratum, and weighting data

APPENDIX G

Annual prevalence of each musculoskeletal pain type

Table I: Prevalence of musculoskeletal pain type for the overall US population, by year and survey**

Year	Prevalence (95% confidence interval)			
	Rheumatic disorder diagnoses *BRFSS*	*Joint Symptoms NHIS Sample Adult Questionnaire*	*Arthritis diagnoses* *NHANES (Continuous)*	*Low back pain NHIS Sample Adult Questionnaire*
1996	27.66* *(26.63, 28.69)*	--	--	--
1997	22.53* *(21.47, 23.60)*	--	--	28.08 *(27.56, 28.61)*
1998	22.29* *(21.22, 23.36)*	--	--	27.96 *(27.40, 28.52)*
1999	23.21* *(22.47, 23.95)*	--	20.23 *(18.77, 21.68)*	26.53 *(25.96, 27.09)*
2000	23.12* *(22.71, 23.52)*	--		27.25 *(26.69, 27.81)*
2001	23.00 *(22.70, 23.30)*	--	20.31 *(19.01, 21.62)*	31.09 *(30.52, 31.67)*
2002	26.79* *(26.35, 27.22)*	29.53 *(28.95, 30.11)*		26.45 *(25.88, 27.02)*
2003	27.07 *(26.77, 27.37)*	31.75 *(31.16, 32.35)*	24.29 *(22.83, 25.75)*	27.48 *(26.90, 28.05)*
2004	29.24* *(28.58, 29.90)*	--		--
2005	26.63 *(26.36, 26.89)*	31.12 *(30.53, 31.71)*	24.57 *(23.10, 26.04)*	28.50 *(27.92, 29.08)*
2006	--	29.73 *(29.04, 30.41)*		27.57 *(26.89, 28.25)*
2007	27.02 *(26.76, 27.27)*	27.63 *(26.94, 28.31)*	25.68 *(24.29, 27.07)*	25.60 *(24.93, 26.27)*
2008	--	31.29 *(30.56, 32.03)*		27.42 *(26.71, 28.13)*
2009	25.92 *(25.68, 26.17)*	33.03 *(32.32, 33.74)*	24.09 *(22.79, 25.39)*	28.52 *(27.83, 29.20)*
2010	30.28* *(29.56, 31.01)*	33.29 *(32.62, 33.96)*		28.82 *(28.18, 29.47)*
2011	24.78 *(24.56, 25.00)*	33.62 *(33.00, 34.23)*	23.01 *(21.44, 24.59)*	28.95 *(28.36, 29.54)*
2012	25.62 *(25.38, 25.85)*	30.43 *(29.81, 31.04)*		28.04 *(27.43, 28.65)*
2013	25.00 *(24.77, 25.23)*	32.15 *(31.52, 32.79)*	26.67 *(25.19, 28.14)*	29.03 *(28.41, 29.66)*
2014	25.61 *(25.38, 25.84)*	32.78 *(32.11, 33.45)*		28.64 *(27.99, 29.30)*
2015	24.68 *(24.45, 24.91)*	33.83 *(33.15, 34.51)*	26.96 *(25.29, 28.63)*	29.83 *(29.17, 30.49)*
2016	25.35 *(25.12, 25.58)*	33.79 *(33.12, 34.47)*		29.01 *(28.36, 29.67)*
2017	24.54 *(24.28, 24.79)*	34.28 *(33.59, 34.98)*	27.85 *(26.03, 29.68)*	28.63 *(27.96, 29.30)*
2018	25.80 *(25.54, 26.055)*	34.30 *(33.59, 35.00)*		29.85 *(29.16, 30.54)*

**Musculoskeletal pain types include rheumatic disorder diagnosis (BRFSS), joint symptoms (NHIS), arthritis diagnosis (NHANES Continuous), and low back pain (NHIS)

*Module year questionnaire

APPENDIX H

Annual age-specific trends of each musculoskeletal pain type

Table I: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing rheumatic disorder diagnoses in various age groups, across years 1996 until 2018 (except for 2006 and 2008), according to the Behavioural Risk Factor Surveillance System (BRFSS)**

Year	Measurement	Age group (years)										
		Age 18 to 24	*Age 25 to 29*	*Age 30 to 34*	*Age 35 to 39*	*Age 40 to 44*	*Age 45 to 49*	*Age 50 to 54*	*Age 55 to 59*	*Age 60 to 64*	*Age 65 to 69*	*Age 70 & above*
1996[α]	Prevalence *(95% CI)* (%)	4.2 *(2.7, 5.7)*	8.7 *(5.5, 12.0)*	8.3 *(6.4, 10.3)*	13.3 *(11.0, 15.6)*	20.3 *(17.3, 23.4)*	24.1 *(20.7, 27.4)*	33.5 *(29.3, 37.8)*	42.1 *(37.4, 46.9)*	47.4 *(42.6, 52.2)*	50.5 *(46.1, 54.9)*	58.8 *(56.0, 61.6)*
	OR[α] *(95% CI)*	0.055 *(0.037, 0.080)*	2.20 *(1.26, 3.83)*	2.02 *(1.30, 3.15)*	3.42 *(2.25, 5.22)*	5.80 *(3.82, 8.81)*	7.19 *(4.74, 10.9)*	11.2 *(7.40, 17.0)*	16.5 *(10.9, 25.2)*	20.3 *(13.4, 30.8)*	22.8 *(15.1, 34.5)*	31.2 *(21.1, 46.1)*
	P-value		0.005*	0.002*	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
1997[α]	Prevalence *(95% CI)* (%)	3.4 *(1.9, 4.8)*	8.4 *(5.9, 10.8)*	7.3 *(5.0, 9.7)*	10.2 *(8.1, 12.3)*	14.3 *(11.7, 17.0)*	23.3 *(19.4, 27.1)*	34.4 *(30.1, 38.7)*	34.9 *(29.9, 39.9)*	37.3 *(32.1, 42.6)*	47.0 *(41.7, 52.2)*	51.8 *(48.3, 55.2)*
	OR[α] *(95% CI)*	0.044 *(0.028, 0.070)*	2.61 *(1.51, 4.53)*	2.26 *(1.28, 4.00)*	3.22 *(1.94, 5.33)*	4.78 *(2.89, 7.89)*	8.81 *(5.35, 14.5)*	15.0 *(9.27, 24.4)*	15.4 *(9.33, 25.4)*	17.1 *(10.3, 28.3)*	24.8 *(15.1, 40.9)*	29.8 *(18.6, 47.7)*
	P-value		<0.001*	0.005*	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
1998[α]	Prevalence *(95% CI)* (%)	4.4 *(2.2, 6.5)*	5.4 *(3.6, 7.2)*	5.6 *(8.8, 7.5)*	10.7 *(8.4, 12.9)*	15.1 *(12.2, 18.1)*	23.5 *(19.7, 27.2)*	30.6 *(26.3, 34.8)*	36.5 *(31.6, 41.4)*	45.3 *(39.7, 50.9)*	45.5 *(40.2, 50.7)*	50.2 *(46.9, 53.6)*
	OR[α] *(95% CI)*	0.057 *(0.034, 0.095)*	1.25 *(0.670, 2.32)*	1.31 *(0.708, 2.44)*	2.58 *(1.46, 4.56)*	3.91 *(2.22, 6.90)*	6.77 *(3.87, 11.9)*	9.70 *(5.56, 16.9)*	12.6 *(7.20, 22.1)*	18.3 *(10.4, 32.2)*	17.9 *(10.2, 31.3)*	21.6 *(12.7, 36.8)*
	P-value		0.486	0.386	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
1999[α]	Prevalence *(95% CI)* (%)	3.6 *(2.5, 4.7)*	7.1 *(5.3, 8.8)*	8.1 *(6.5, 9.8)*	12.4 *(10.6, 14.1)*	16.9 *(15.0, 18.9)*	23.0 *(20.6, 25.3)*	27.6 *(24.9, 30.3)*	36.5 *(33.2, 39.7)*	43.3 *(39.8, 46.7)*	47.1 *(43.6, 50.6)*	57.8 *(55.3, 60.2)*
	OR[α] *(95% CI)*	0.045 *(0.033, 0.061)*	2.05 *(1.36, 3.09)*	2.37 *(1.62, 3.47)*	3.73 *(2.64, 5.27)*	5.45 *(3.88, 7.64)*	7.97 *(5.69, 11.1)*	10.2 *(7.26, 14.2)*	15.4 *(11.0, 21.6)*	20.4 *(14.5, 28.6)*	23.3 *(16.6, 32.7)*	35.8 *(25.9, 49.5)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2000[α]	Prevalence *(95% CI)* (%)	3.5 *(3.0, 4.0)*	5.6 *(4.9, 6.2)*	7.7 *(6.9, 8.5)*	11.8 *(10.8, 12.8)*	17.0 *(15.7, 18.2)*	22.4 *(21.1, 23.7)*	29.4 *(27.8, 30.9)*	37.9 *(36.1, 39.7)*	41.9 *(39.8, 43.9)*	46.5 *(44.5, 48.6)*	54.0 *(52.6, 55.4)*
	OR[α] *(95% CI)*	0.045 *(0.038, 0.052)*	1.64 *(1.35, 2.00)*	2.31 *(1.91, 2.78)*	3.68 *(3.08, 4.40)*	5.66 *(4.76, 6.73)*	8.03 *(6.78, 9.50)*	11.6 *(9.79, 13.7)*	16.9 *(14.2, 20.0)*	20.2 *(17.0, 24.0)*	23.8 *(20.0, 28.2)*	31.7 *(27.0, 37.2)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2001	Prevalence *(95% CI)* (%)	3.7 *(3.3, 4.1)*	5.5 *(4.9, 6.0)*	7.7 *(7.1, 8.4)*	10.4 *(9.8, 11.1)*	15.5 *(14.7, 16.4)*	22.2 *(21.2, 23.2)*	28.7 *(27.6, 29.7)*	36.2 *(34.9, 37.5)*	43.1 *(41.5, 44.6)*	47.6 *(46.0, 49.2)*	54.8 *(53.8, 55.8)*
	OR[α] *(95% CI)*	0.048 *(0.042, 0.054)*	1.51 *(1.29, 1.77)*	2.18 *(1.88, 2.53)*	3.01 *(2.62, 3.47)*	4.76 *(4.15, 5.45)*	7.41 *(6.48, 8.48)*	10.5 *(9.17, 11.9)*	14.8 *(13.0, 16.9)*	19.7 *(17.2, 22.6)*	23.5 *(20.4, 26.9)*	30.6 *(27.0, 34.8)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2002[α]	Prevalence *(95% CI)* (%)	5.2 *(4.5, 5.9)*	7.9 *(7.0, 8.8)*	10.5 *(9.6, 11.4)*	14.3 *(13.2, 15.3)*	20.3 *(19.1, 21.6)*	27.3 *(25.9, 28.7)*	37.0 *(35.3, 38.6)*	43.3 *(41.4, 45.1)*	46.4 *(44.4, 48.4)*	51.8 *(49.7, 53.9)*	56.7 *(55.3, 58.1)*
	OR[α] *(95% CI)*	0.065 *(0.056, 0.075)*	1.54 *(1.28, 1.87)*	2.12 *(1.78, 2.53)*	3.00 *(2.54, 3.55)*	4.64 *(3.94, 5.47)*	6.81 *(5.79, 8.00)*	10.7 *(9.08, 12.5)*	13.8 *(11.7, 16.2)*	15.8 *(13.4, 18.6)*	19.3 *(16.3, 22.8)*	23.2 *(19.8, 27.1)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2003	Prevalence *(95% CI)* (%)	5.7 *(5.2, 6.3)*	7.7 *(7.0, 8.3)*	10.6 *(9.9, 11.3)*	14.8 *(14.0, 15.6)*	20.0 *(19.1, 20.8)*	26.0 *(25.1, 27.0)*	35.0 *(34.0, 36.1)*	43.0 *(41.8, 44.2)*	48.0 *(46.7, 49.3)*	51.2 *(50.5, 53.3)*	58.4 *(57.4, 59.3)*
	OR[α] (95% CI)	0.073 *(0.066, 0.080)*	1.36 *(1.18, 1.55)*	1.94 *(1.72, 2.19)*	2.84 *(2.53, 3.18)*	4.07 *(3.64, 4.55)*	5.76 *(5.17, 6.42)*	8.84 *(7.93, 9.85)*	12.4 *(11.1, 13.8)*	15.1 *(13.5, 16.8)*	17.5 *(15.7, 19.6)*	22.4 *(20.2, 24.9)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2004[α]	Prevalence *(95% CI)* (%)	4.8 *(3.8, 5.8)*	8.5 *(7.0, 10.0)*	12.3 *(10.7, 14.0)*	16.7 *(15.0, 18.5)*	22.8 *(21.0, 24.7)*	29.2 *(27.1, 31.4)*	36.2 *(33.9, 38.5)*	46.2 *(43.6, 48.7)*	51.9 *(49.2, 54.6)*	55.1 *(52.3, 57.9)*	60.4 *(58.6, 62.2)*
	OR[α] *(95% CI)*	0.060 *(0.049, 0.075)*	1.84 *(1.37, 2.46)*	2.77 *(2.12, 3.61)*	3.97 *(3.08, 5.11)*	5.84 *(6.40, 10.4)*	8.17 *(6.40, 10.4)*	11.2 *(8.81, 14.3)*	16.9 *(13.3, 21.6)*	21.4 *(16.8, 27.4)*	24.1 *(18.8, 30.8)*	29.4 *(23.3, 37.1)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2005	Prevalence *(95% CI)* (%)	5.2 *(4.7, 5.7)*	7.5 *(6.9, 8.2)*	9.4 *(8.8, 9.9)*	13.7 *(13.0, 14.4)*	19.5 *(18.8, 20.3)*	26.1 *(25.3, 27.0)*	34.3 *(33.4, 35.2)*	43.0 *(42.0, 44.1)*	47.4 *(46.3, 48.5)*	52.2 *(51.0, 53.4)*	57.7 *(56.9, 58.5)*
	OR[α] *(95% CI)*	0.066 *(0.059, 0.073)*	1.49 *(1.29, 1.71)*	1.89 *(1.67, 2.14)*	2.90 *(2.57, 3.28)*	4.42 *(3.93, 4.98)*	6.48 *(5.77, 7.27)*	9.58 *(8.54, 10.7)*	13.9 *(12.4, 15.5)*	16.5 *(14.7, 18.5)*	19.9 *(17.6, 22.3)*	24.4 *(21.8, 27.2)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2007	Prevalence *(95% CI)* (%)	5.1 *(4.5, 5.8)*	7.4 *(6.8, 8.0)*	9.3 *(8.7, 10.0)*	13.6 *(12.9, 14.3)*	19.1 *(18.4, 19.8)*	24.7 *(23.9, 25.5)*	34.6 *(33.7, 35.4)*	42.7 *(41.8, 43.7)*	48.3 *(47.4, 49.3)*	52.4 *(51.3, 53.5)*	57.7 *(57.1, 58.4)*
	OR[α] *(95% CI)*	0.065 *(0.057, 0.075)*	1.45 *(1.23, 1.70)*	1.87 *(1.61, 2.18)*	2.86 *(2.47, 3.31)*	4.32 *(3.75, 4.98)*	5.99 *(5.21, 6.88)*	9.69 *(8.44, 11.1)*	13.7 *(11.9, 15.7)*	17.3 *(15.0, 19.8)*	20.1 *(17.4, 23.1)*	24.4 *(21.3, 28.0)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2009	Prevalence *(95% CI)* (%)	3.9 *(3.3, 4.5)*	6.9 *(6.2, 7.7)*	9.1 *(8.5, 9.8)*	12.4 *(11.7, 13.0)*	17.2 *(16.5, 17.9)*	24.0 *(23.3, 24.8)*	32.4 *(31.6, 33.1)*	40.1 *(39.3, 40.9)*	45.9 *(45.1, 46.8)*	50.5 *(49.6, 51.4)*	56.0 *(55.4, 56.6)*
	OR[α] *(95% CI)*	0.049 *(0.042, 0.057)*	1.83 *(1.51, 2.20)*	2.44 *(2.07, 2.89)*	3.44 *(2.93, 4.04)*	5.10 *(4.36, 5.97)*	7.76 *(6.65, 9.05)*	11.8 *(10.1, 13.7)*	16.4 *(14.1, 19.1)*	21.0 *(18.0, 24.4)*	24.9 *(21.4, 29.0)*	30.5 *(26.2, 35.5)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2010[α]	Prevalence *(95% CI)* (%)	4.1 *(2.5, 5.6)*	8.8 *(6.1, 11.4)*	11.1 *(9.1, 13.1)*	16.2 *(14.1, 18.4)*	20.6 *(18.5, 22.7)*	28.3 *(26.1, 30.5)*	36.6 *(34.4, 38.9)*	44.2 *(42.1, 46.4)*	51.0 *(48.9, 53.2)*	60.7 *(58.5, 62.9)*	60.3 *(58.8, 61.7)*
	OR[α] *(95% CI)*	0.049 *(0.033, 0.073)*	2.21 *(1.32, 3.72)*	2.88 *(1.85, 4.49)*	4.49 *(2.93, 6.88)*	6.01 *(3.96, 9.11)*	9.08 *(6.02, 9.11)*	13.4 *(8.93, 20.2)*	18.3 *(12.2, 27.5)*	24.3 *(16.2, 36.5)*	35.7 *(23.7, 53.7)*	34.4 *(23.0, 51.4)*
	P-value		0.003*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2011	Prevalence *(95% CI)* (%)	3.4 *(3.0, 3.8)*	6.3 *(5.7, 6.9)*	8.3 *(7.7, 8.8)*	11.5 *(10.8, 12.2)*	15.8 *(15.1, 16.5)*	22.7 *(21.9, 23.5)*	30.1 *(29.3, 30.8)*	37.8 *(36.9, 38.6)*	43.4 *(42.6, 44.3)*	48.5 *(47.6, 49.4)*	54.3 *(53.7, 54.9)*
	OR[α] *(95% CI)*	0.042 *(0.037, 0.048)*	1.92 *(1.64, 2.24)*	2.54 *(2.20, 2.93)*	3.69 *(3.21, 4.24)*	5.31 *(4.65, 6.06)*	8.36 *(7.34, 9.52)*	12.2 *(10.7, 13.8)*	17.3 *(10.7, 13.8)*	21.8 *(19.2, 24.8)*	26.8 *(23.6, 30.4)*	33.0 *(29.1, 37.3)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2012	Prevalence *(95% CI)* (%)	3.6 *(3.2, 4.0)*	6.3 *(5.7, 7.0)*	8.7 *(8.2, 9.3)*	11.6 *(10.9, 12.3)*	16.8 *(16.0, 17.5)*	23.0 *(22.2, 23.8)*	30.0 *(29.2, 30.8)*	38.1 *(37.2, 38.9)*	45.7 *(44.8, 46.6)*	48.8 *(47.9, 49.8)*	55.6 *(55.0, 56.2)*
	OR[α] *(95% CI)*	0.044 *(0.039, 0.049)*	1.84 *(1.57, 2.14)*	2.56 *(2.24, 2.93)*	3.54 *(3.10, 4.03)*	5.43 *(4.79, 6.15)*	8.09 *(7.17, 9.14)*	11.6 *(10.3, 13.0)*	16.7 *(14.8, 18.7)*	22.8 *(20.2, 25.6)*	25.8 *(22.9, 29.0)*	33.2 *(29.6, 37.2)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2013	Prevalence *(95% CI)* (%)	3.3 *(3.0, 3.7)*	6.4 *(5.9, 7.0)*	7.9 *(7.4, 8.4)*	11.4 *(10.7, 12.0)*	16.0 *(15.2, 16.7)*	22.0 *(21.2, 22.8)*	29.7 *(28.9, 30.5)*	37.1 *(36.3, 38.0)*	42.7 *(41.8, 43.6)*	48.6 *(47.7, 49.6)*	54.7 *(54.0, 55.3)*
	OR[α] *(95% CI)*	0.042 *(0.037, 0.046)*	2.01 *(1.74, 2.31)*	2.46 *(2.17, 2.79)*	3.70 *(3.27, 4.19)*	5.52 *(4.89, 6.22)*	8.18 *(7.29, 9.19)*	12.3 *(10.9, 13.7)*	17.2 *(15.4, 19.2)*	21.7 *(19.4, 24.3)*	27.5 *(24.6, 30.8)*	34.4 *(30.8, 38.3)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2014	Prevalence *(95% CI)* (%)	3.0 *(2.7, 3.4)*	5.9 *(5.4, 6.4)*	9.2 *(8.5, 9.8)*	12.1 *(11.4, 12.9)*	16.7 *(15.9, 17.4)*	22.3 *(21.4, 23.1)*	30.1 *(29.3, 30.9)*	37.0 *(36.1, 37.8)*	43.6 *(42.7, 44.5)*	48.9 *(48.0, 49.8)*	55.5 *(54.9, 56.1)*
	OR[α] *(95% CI)*	0.038 *(0.033, 0.043)*	2.02 *(1.74, 2.35)*	3.20 *(2.78, 3.69)*	4.41 *(3.84, 5.06)*	6.36 *(5.57, 7.27)*	9.18 *(8.06, 10.5)*	13.7 *(12.1, 15.6)*	18.8 *(16.6, 21.3)*	24.8 *(21.9, 28.1)*	30.7 *(27.1, 34.8)*	39.2 *(34.6, 44.3)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2015	Prevalence *(95% CI)* (%)	3.2 *(2.8, 3.5)*	5.8 *(5.2, 6.3)*	7.6 *(7.0, 8.2)*	11.1 *(10.5, 11.7)*	15.2 *(14.4, 15.9)*	22.3 *(21.5, 23.2)*	28.7 *(27.9, 29.5)*	35.5 *(34.7, 36.4)*	42.0 *(41.1, 42.8)*	47.5 *(46.6, 48.4)*	53.6 *(53.0, 54.2)*
	OR[α] *(95% CI)*	0.039 *(0.035, 0.044)*	1.88 *(1.63, 2.17)*	2.53 *(2.21, 2.89)*	3.83 *(3.39, 4.34)*	5.48 *(4.86, 6.18)*	8.87 *(7.89, 10.0)*	12.3 *(11.0, 13.8)*	16.9 *(15.1, 19.0)*	22.3 *(20.0, 25.0)*	27.9 *(24.9, 31.2)*	35.0 *(31.3, 39.0)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2016	Prevalence *(95% CI)* (%)	3.2 *(2.9, 3.5)*	5.6 *(5.1, 6.1)*	7.7 *(7.2, 8.2)*	11.8 *(11.1, 12.4)*	16.1 *(15.3, 16.9)*	21.5 *(20.7, 22.4)*	29.5 *(28.6, 30.3)*	36.9 *(36.0, 37.8)*	43.3 *(42.4, 44.2)*	47.2 *(46.3, 48.1)*	55.0 *(54.3, 55.7)*
	OR[α] *(95% CI)*	0.039 *(0.036, 0.044)*	1.82 *(1.59, 2.09)*	2.55 *(2.25, 2.89)*	4.07 *(3.61, 4.59)*	5.85 *(5.19, 6.59)*	8.41 *(7.49, 9.43)*	12.8 *(11.4, 14.3)*	17.9 *(11.4, 14.3)*	23.4 *(21.0, 26.1)*	27.5 *(24.6, 30.7)*	36.8 *(33.1, 41.0)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2017	Prevalence *(95% CI)* (%)	3.1 *(2.8, 3.4)*	5.4 *(5.0, 5.9)*	8.2 *(7.6, 8.9)*	10.7 *(10.0, 11.4)*	15.5 *(14.6, 16.4)*	21.2 *(20.3, 22.2)*	28.4 *(27.5, 29.4)*	34.8 *(33.8, 35.7)*	41.7 *(40.7, 42.6)*	46.5 *(45.4, 47.5)*	52.1 *(51.4, 52.9)*
	OR[α] *(95% CI)*	0.039 *(0.035, 0.044)*	1.80 *(1.55, 2.07)*	2.80 *(2.43, 3.22)*	3.74 *(3.28, 4.27)*	5.72 *(5.02, 6.51)*	8.46 *(7.47, 9.58)*	12.4 *(11.0, 14.0)*	16.8 *(14.9, 18.9)*	22.4 *(19.9, 25.2)*	27.3 *(24.3, 30.8)*	33.6 *(29.9, 37.7)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2018	Prevalence *(95% CI)* (%)	3.4 *(3.1, 3.8)*	5.6 *(5.1, 6.1)*	8.6 *(8.0, 9.2)*	12.1 *(11.4, 12.8)*	16.1 *(15.3, 16.9)*	22.3 *(21.3, 23.2)*	29.5 *(28.5, 30.5)*	37.1 *(36.1, 38.1)*	42.9 *(41.9, 43.9)*	47.3 *(46.3, 48.3)*	54.3 *(53.6, 55.1)*
	OR[α] *(95% CI)*	0.043 *(0.038, 0.048)*	1.63 *(1.41, 1.88)*	2.64 *(2.31, 3.00)*	3.85 *(3.39, 4.36)*	5.41 *(4.78, 6.11)*	8.07 *(7.16, 9.10)*	11.8 *(10.5, 13.3)*	16.7 *(14.9, 18.7)*	21.3 *(19.0, 23.9)*	25.5 *(22.7, 28.5)*	33.1 *(29.6, 37.0)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

** Rheumatic disorder diagnoses: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

* P < 0.05: for a significant difference between 18 to 24 year olds (comparator group) and remaining older age groups, by logistic regression analysis

[α] Module questionnaire years

Table II: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing joint symptoms in various age groups, across years 2002 until 2018 (except for 2004), according to the National Health Interview Survey (NHIS)**

Year	Measurement	Age group (years)										
		Age 18 to 24	*Age 25 to 29*	*Age 30 to 34*	*Age 35 to 39*	*Age 40 to 44*	*Age 45 to 49*	*Age 50 to 54*	*Age 55 to 59*	*Age 60 to 64*	*Age 65 to 69*	*Age 70 & above*
2002	Prevalence *(95% CI)* (%)	14.3 *(12.8, 15.7)*	15.0 *(13.4, 16.6)*	18.8 *(17.2, 20.4)*	21.6 *(19.9, 23.2)*	27.7 *(25.9, 29.5)*	31.4 *(29.5, 33.3)*	37.6 *(35.4, 39.8)*	41.1 *(38.7, 43.4)*	43.9 *(41.2, 46.5)*	43.7 *(40.9, 46.6)*	48.5 *(46.8, 50.2)*
	OR$^{\alpha}$ *(95% CI)*	0.178 *(0.157, 0.200)*	1.06 *(0.891, 1.27)*	1.39 *(1.19, 1.63)*	1.65 *(1.42, 1.92)*	2.30 *(1.99, 2.67)*	2.75 *(2.37, 3.19)*	3.62 *(3.12, 4.21)*	4.18 *(3.59, 4.87)*	4.70 *(4.01, 5.52)*	4.68 *(3.97, 5.52)*	5.60 *(4.89, 6.42)*
	P-value		0.502	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2003	Prevalence *(95% CI)* (%)	14.7 *(13.3, 16.2)*	17.7 *(16.0, 19.4)*	18.5 *(17.0, 20.1)*	24.6 *(22.9, 36.3)*	28.6 *(26.8, 30.4)*	34.1 *(32.1, 36.2)*	38.8 *(36.7, 41.0)*	45.7 *(43.4, 48.0)*	46.1 *(43.5, 48.7)*	47.3 *(44.4, 50.1)*	52.1 *(50.4, 53.9)*
	OR$^{\alpha}$ (95% CI)	0.193 *(0.171, 0.217)*	1.25 *(1.06, 1.47)*	1.32 *(1.13, 1.54)*	1.89 *(1.62, 2.19)*	2.32 *(2.00, 2.69)*	3.00 *(2.59, 3.48)*	3.68 *(3.17, 4.27)*	4.88 *(4.20, 5.67)*	4.94 *(4.22, 5.79)*	5.18 *(4.40, 6.10)*	6.20 *(5.41, 7.10)*
	P-value		0.009*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2005	Prevalence *(95% CI)* (%)	14.0 *(12.4, 15.5)*	15.8 *(14.1, 17.5)*	18.0 *(16.4, 19.6)*	20.7 *(19.1, 22.3)*	28.0 *(26.2, 29.8)*	33.7 *(31.8, 35.7)*	38.1 *(36.1, 40.2)*	43.7 *(41.5, 45.9)*	48.2 *(45.7, 50.7)*	47.5 *(44.8, 50.3)*	52.2 *(50.5, 53.9)*
	OR$^{\alpha}$ *(95% CI)*	0.177 *(0.155, 0.201)*	1.15 *(0.959, 1.38)*	1.35 *(1.14, 1.60)*	1.61 *(1.37, 1.89)*	2.38 *(2.04, 2.79)*	3.13 *(2.68, 3.66)*	3.79 *(3.24, 4.42)*	4.77 *(4.08, 5.59)*	5.71 *(4.85, 6.72)*	5.54 *(4.67, 6.56)*	6.63 *(5.73, 7.66)*
	P-value		0.131	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2006	Prevalence *(95% CI)* (%)	11.7 *(10.2, 13.1)*	16.7 *(14.7, 18.6)*	18.1 *(16.1, 20.1)*	20.4 *(18.4, 22.3)*	25.1 *(23.0, 27.1)*	32.1 *(29.8, 34.4)*	37.8 *(35.3, 40.3)*	40.6 *(38.0, 43.2)*	46.6 *(43.6, 49.7)*	45.3 *(42.2, 48.5)*	49.4 *(47.4, 51.5)*
	OR$^{\alpha}$ *(95% CI)*	0.142 *(0.123, 0.164)*	1.51 *(1.24, 1.85)*	1.67 *(1.38, 2.03)*	1.94 *(1.61, 2.33)*	2.52 *(2.10, 3.01)*	3.57 *(3.00, 4.26)*	4.59 *(3.84, 5.47)*	5.15 *(4.31, 6.14)*	6.62 *(5.50, 7.98)*	6.25 *(5.17, 7.56)*	7.30 *(6.20, 8.59)*
	P-value		<0.001*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

2007	Prevalence *(95% CI)* (%)	9.9 *(8.5, 11.4)*	13.4 *(11.4, 15.4)*	16.6 *(14.7, 18.4)*	19.4 *(17.4, 21.4)*	24.5 *(22.3, 26.6)*	31.3 *(28.9, 33.6)*	35.3 *(32.8, 37.8)*	39.4 *(36.6, 42.2)*	42.0 *(39.2, 44.9)*	40.1 *(37.0, 43.1)*	45.6 *(43.6, 47.6)*
	OR[α] *(95% CI)*	0.121 *(0.103, 0.143)*	1.41 *(1.11, 1.78)*	1.81 *(1.46, 2.23)*	2.19 *(1.78, 2.69)*	2.94 *(2.41, 3.60)*	4.13 *(3.40, 5.03)*	4.97 *(4.08, 6.05)*	5.91 *(4.84, 7.21)*	6.61 *(5.51, 8.07)*	6.06 *(4.93, 7.44)*	7.52 *(6.27, 9.02)*
	P-value		0.005*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2008	Prevalence *(95% CI)* (%)	15.6 *(13.6, 17.6)*	17.1 *(15.1, 19.1)*	19.1 *(17.0, 21.1)*	22.4 *(20.2, 24.5)*	28.9 *(26.4, 31.4)*	31.9 *(29.5, 34.2)*	40.6 *(38.0, 43.2)*	40.3 *(37.6, 43.0)*	46.9 *(44.0, 49.8)*	47.9 *(44.7, 51.0)*	47.2 *(45.2, 49.3)*
	OR[α] *(95% CI)*	0.201 *(0.172, 0.234)*	1.12 *(0.909, 1.38)*	1.28 *(1.04, 1.56)*	1.56 *(1.28, 1.90)*	2.21 *(1.82, 2.68)*	2.54 *(2.11, 3.07)*	3.71 *(3.08, 4.48)*	3.66 *(3.03, 4.42)*	4.78 *(3.95, 5.78)*	4.99 *(4.10, 6.08)*	4.78 *(4.03, 5.69)*
	P-value		0.299	0.018*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2009	Prevalence *(95% CI)* (%)	14.8 *(13.0, 16.6)*	17.6 *(15.6, 19.7)*	21.4 *(19.3, 23.4)*	23.7 *(21.5, 26.0)*	28.5 *(26.1, 30.8)*	33.7 *(31.3, 36.1)*	41.5 *(39.0, 44.1)*	45.3 *(42.7, 47.9)*	49.5 *(46.8, 52.1)*	48.4 *(45.4, 51.4)*	51.5 *(49.5, 53.5)*
	OR[α] *(95% CI)*	0.185 *(0.160, 0.213)*	1.23 *(1.01, 1.51)*	1.57 *(1.29, 1.89)*	1.79 *(1.48, 2.17)*	2.29 *(1.91, 2.75)*	2.92 *(2.44, 3.50)*	4.09 *(3.42, 4.88)*	4.75 *(3.98, 5.68)*	5.66 *(4.73, 6.77)*	5.38 *(4.46, 6.49)*	6.08 *(5.16, 7.16)*
	P-value		0.042*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2010	Prevalence *(95% CI)* (%)	15.2 *(13.4, 16.9)*	18.1 *(16.2, 19.9)*	20.6 *(18.7, 22.5)*	23.1 *(21.1, 25.1)*	28.9 *(26.7, 31.1)*	35.8 *(33.5, 38.1)*	42.9 *(40.5, 45.3)*	48.7 *(46.2, 51.2)*	45.8 *(43.3, 48.3)*	50.0 *(47.1, 52.8)*	49.5 *(47.6, 51.4)*
	OR[α] *(95% CI)*	0.191 *(0.167, 0.219)*	1.23 *(1.02, 1.48)*	1.45 *(1.21, 1.73)*	1.67 *(1.40, 2.00)*	2.27 *(1.91, 2.70)*	3.12 *(2.63, 3.69)*	4.20 *(3.55, 4.95)*	5.30 *(4.48, 6.28)*	4.72 *(3.99, 5.59)*	5.57 *(4.66, 6.65)*	5.42 *(4.64, 6.32)*
	P-value		0.028*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2011	Prevalence *(95% CI)* (%)	13.7 *(12.3, 15.1)*	16.8 *(15.2, 18.4)*	21.1 *(19.3, 22.8)*	23.8 *(21.9, 25.7)*	29.5 *(27.5, 31.5)*	36.2 *(34.1, 38.4)*	41.7 *(39.5, 43.9)*	44.9 *(42.7, 47.2)*	49.6 *(47.3, 51.9)*	49.2 *(46.6, 51.7)*	53.5 *(51.8, 55.2)*
	OR[α] *(95% CI)*	0.169 *(0.149, 0.191)*	1.27 *(1.08, 1.50)*	1.68 *(1.43, 1.98)*	1.96 *(1.67, 2.30)*	2.63 *(2.25, 3.07)*	3.57 *(3.07, 4.16)*	4.49 *(3.86, 5.23)*	5.13 *(4.41, 5.97)*	6.18 *(5.31, 7.19)*	6.08 *(5.19, 7.11)*	7.18 *(6.25, 8.24)*
	P-value		0.005*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

2012	Prevalence *(95% CI)* (%)	13.2 *(11.8, 14.7)*	15.5 *(13.8, 17.3)*	18.9 *(17.2, 20.6)*	21.9 *(20.0, 23.8)*	22.5 *(20.6, 24.4)*	31.9 *(29.7, 34.1)*	37.4 *(35.2, 39.6)*	43.0 *(40.7, 45.2)*	46.9 *(44.6, 49.3)*	46.2 *(43.6, 48.8)*	45.9 *(44.1, 47.6)*
	OR$^{\alpha}$ *(95% CI)*	0.165 *(0.145, 0.187)*	1.21 *(1.00, 1.45)*	1.52 *(1.29, 1.80)*	1.84 *(1.55, 2.17)*	1.90 *(1.61, 3.60)*	3.07 *(2.61, 3.60)*	3.92 *(3.35, 4.59)*	4.95 *(4.23, 5.79)*	5.79 *(4.95, 6.77)*	5.61 *(4.76, 6.61)*	5.51 *(4.77, 6.37)*
	P-value		0.047*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2013	Prevalence *(95% CI)* (%)	13.0 *(11.4, 14.6)*	16.3 *(14.5, 18.0)*	19.2 *(17.4, 21.1)*	21.5 *(19.6, 23.4)*	26.6 *(24.6, 28.6)*	30.6 *(28.4, 32.8)*	39.4 *(37.1, 41.7)*	45.7 *(43.4, 48.0)*	48.0 *(45.6, 50.5)*	48.5 *(46.0, 51.1)*	51.7 *(49.9, 53.4)*
	OR$^{\alpha}$ *(95% CI)*	0.166 *(0.144, 0.191)*	1.30 *(1.07, 1.57)*	1.59 *(1.32, 1.91)*	1.82 *(1.52, 2.19)*	2.43 *(2.04, 2.90)*	2.95 *(2.47, 3.51)*	4.35 *(3.67, 5.16)*	5.62 *(4.75, 6.66)*	6.19 *(5.22, 7.35)*	6.29 *(5.29, 7.49)*	7.07 *(6.04, 8.28)*
	P-value		0.008*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2014	Prevalence *(95% CI)* (%)	14.3 *(12.6, 15.9)*	18.5 *(16.7, 20.3)*	20.0 *(17.9, 22.1)*	23.6 *(21.5, 25.6)*	27.5 *(25.4, 29.6)*	34.1 *(31.7, 36.4)*	39.4 *(36.9, 42.0)*	41.7 *(39.4, 44.0)*	47.6 *(45.1, 50.0)*	48.6 *(46.1, 51.1)*	50.8 *(49.0, 52.5)*
	OR$^{\alpha}$ *(95% CI)*	0.178 *(0.155, 0.204)*	1.36 *(1.13, 1.63)*	1.50 *(1.25, 1.81)*	1.85 *(1.55, 2.21)*	2.28 *(1.92, 2.70)*	3.10 *(2.62, 3.68)*	3.91 *(3.29, 4.65)*	4.29 *(3.64, 5.06)*	5.44 *(4.61, 6.43)*	5.67 *(4.79, 6.71)*	6.15 *(5.28, 7.15)*
	P-value		<0.001*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2015	Prevalence *(95% CI)* (%)	13.9 *(12.1, 15.7)*	18.8 *(16.9, 20.8)*	21.8 *(19.9, 23.8)*	23.5 *(21.4, 25.5)*	27.7 *(25.5, 30.0)*	33.5 *(31.1, 35.9)*	40.1 *(37.7, 42.5)*	46.0 *(43.5, 48.5)*	47.0 *(44.5, 49.6)*	51.9 *(49.4, 54.5)*	52.6 *(50.8, 54.4)*
	OR$^{\alpha}$ *(95% CI)*	0.171 *(0.147, 0.199)*	1.44 *(1.19, 1.75)*	1.73 *(1.43, 2.09)*	1.90 *(1.57, 2.30)*	2.38 *(1.97, 2.87)*	3.13 *(2.60, 3.76)*	4.15 *(3.47, 4.97)*	5.28 *(4.41, 6.32)*	5.50 *(4.59, 6.60)*	6.69 *(5.58, 8.02)*	6.84 *(5.80, 8.07)*
	P-value		<0.001*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2016	Prevalence *(95% CI)* (%)	13.8 *(12.2, 15.4)*	17.1 *(15.2, 19.0)*	20.6 *(18.5, 22.7)*	23.1 *(21.0, 25.3)*	27.2 *(24.8, 29.6)*	33.8 *(31.4, 36.2)*	41.8 *(39.4, 44.2)*	45.5 *(43.1, 47.9)*	51.7 *(49.3, 54.1)*	49.0 *(46.6, 51.3)*	51.6 *(49.9, 53.3*
	OR$^{\alpha}$ *(95% CI)*	0.175 *(0.153, 0.201)*	1.29 *(1.06, 1.56)*	1.62 *(1.34, 1.95)*	1.88 *(1.56, 2.25)*	2.33 *(1.95, 2.80)*	3.18 *(2.68, 3.78)*	4.50 *(3.81, 5.32)*	5.21 *(4.42, 6.15)*	6.67 *(5.65, 7.87)*	5.97 *(5.07, 7.03)*	6.60 *(5.68, 7.67)*
	P-value		0.009*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

2017	Prevalence *(95% CI)* (%)	14.2 *(12.5, 16.0)*	18.6 *(16.6, 20.6)*	19.2 *(17.3, 21.2)*	22.4 *(20.3, 24.5)*	29.9 *(27.4, 32.4)*	34.5 *(31.9, 37.0)*	42.0 *(39.4, 44.7)*	45.5 *(42.9, 48.0)*	48.6 *(46.2, 51.1)*	48.7 *(46.2, 51.1)*	54.1 *(52.5, 55.8)*
	OR[α] *(95% CI)*	0.186 *(0.161, 0.216)*	1.38 *(1.13, 1.67)*	1.43 *(1.19, 1.74)*	1.74 *(1.44, 2.10)*	2.57 *(2.13, 3.10)*	3.17 *(2.64, 3.81)*	4.38 *(3.66, 5.24)*	5.03 *(4.21, 6.00)*	5.72 *(4.81, 6.80)*	5.70 *(4.79, 6.78)*	7.05 *(6.02, 8.27)*
	P-value		0.001*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*
2018	Prevalence *(95% CI)* (%)	13.9 *(12.0, 15.9)*	17.3 *(15.2, 19.4)*	20.9 *(18.8, 23.0)*	23.4 *(21.2, 25.6)*	27.0 *(25.6, 30.4)*	33.3 *(30.7, 35.8)*	40.3 *(37.7, 42.9)*	44.9 *(42.4, 47.4)*	48.4 *(46.0, 50.9)*	51.1 *(48.8, 53.5)*	55.3 *(53.7, 57.0)*
	OR[α] *(95% CI)*	0.164 *(0.139, 0.194)*	1.29 *(1.04, 1.61)*	1.63 *(1.33, 2.00)*	1.88 *(1.53, 2.31)*	2.40 *(1.96, 2.93)*	3.08 *(2.52, 3.76)*	4.16 *(3.42, 5.06)*	5.03 *(4.15, 6.09)*	5.80 *(4.79, 7.01)*	6.46 *(5.35, 7.80)*	7.63 *(6.40, 9.10)*
	P-value		0.021*	<0.001*	<0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*

* P < 0.05: for a significant difference between 18 to 24 year olds (comparator group) and remaining older age groups, by logistic regression analysis
**Pain, aching, or stiffness in the 30 days prior to taking the NHIS Sample Adult Questionnaire

Table III: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing arthritis diagnoses in various age groups, across survey cycles 1999-2000 until 2017-2018, according to the National Health and Nutrition Examination Survey (NHANES) (Continuous)

Year	Measurement	Age group (years)										
		Age 20 to 24	*Age 25 to 29*	*Age 30 to 34*	*Age 35 to 39*	*Age 40 to 44*	*Age 45 to 49*	*Age 50 to 54*	*Age 55 to 59*	*Age 60 to 64*	*Age 65 to 69*	*Age 70 & above*
1999-2000	Prevalence *(95% CI)* (%)	2.5 *(0.4, 4.5)*	1.6 *(0.1, 3.2)*	5.1 *(2.3, 7.9)*	8.5 *(5.1, 12.0)*	14.3 *(9.8, 18.7)*	21.1 *(15.3, 27.0)*	30.9 *(24.9, 37.0)*	30.8 *(23.8, 37.7)*	43.7 *(37.3, 50.0)*	47.1 *(40.3, 53.9)*	53.5 *(49.2, 57.7)*
	OR$^{\alpha}$ *(95% CI)*	0.029 *(0.013, 0.068)*	0.700 *(0.183, 2.45)*	2.13 *(0.761, 5.98)*	3.73 *(1.43, 9.74)*	6.68 *(2.65, 16.8)*	10.5 *(4.20, 26.4)*	17.8 *(7.27, 43.6)*	18.4 *(7.72, 45.8)*	31.3 *(12.9, 76.1)*	36.5 *(14.9, 89.1)*	45.2 *(19.0, 108)*
	P-value		0.544	0.150	0.007*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2001-02	Prevalence *(95% CI)* (%)	3.5 *(1.5, 55)*	4.9 *(2.5, 7.3)*	7.1 *(4.1, 10.1)*	10.9 *(7.5, 14.3)*	11.5 *(7.9, 15.0)*	20.1 *(15.6, 24.6)*	23.9 *(19.3, 28.6)*	37.1 *(30.8, 43.5)*	45.7 *(39.5, 51.9)*	46.1 *(39.3, 53.0)*	50.4 *(46.6, 54.2)*
	OR$^{\alpha}$ (95% CI)	0.041 *(0.023, 0.075)*	1.42 *(0.646, 3.13)*	2.09 *(0.993, 4.42)*	3.40 *(1.71, 6.75)*	3.66 *(1.85, 7.24)*	7.09 *(3.70, 13.6)*	8.87 *(4.67, 16.8)*	16.6 *(8.69, 31.7)*	23.6 *(12.4, 44.6)*	23.7 *(12.3, 45.3)*	28.1 *(15.3, 51.5)*
	P-value		0.382	0.052	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2003-04	Prevalence *(95% CI)* (%)	2.9 *(1.0, 4.8)*	3.6 *(1.6, 5.7)*	10.4 *(6.8, 13.9)*	10.5 *(6.9, 14.0)*	20.4 *(15.7, 25.1)*	20.1 *(15.1, 25.2)*	34.1 *(28.5, 39.8)*	37.7 *(30.6, 44.8)*	42.1 *(35.9, 48.4)*	50.6 *(44.0, 57.2)*	54.6 *(50.9, 58.2)*
	OR$^{\alpha}$ *(95% CI)*	0.036 *(0.018, 0.068)*	1.29 *(0.530, 3.16)*	3.92 *(1.82, 8.45)*	3.93 *(1.82, 8.49)*	8.70 *(4.21, 18.0)*	8.56 *(4.10, 17.9)*	18.0 *(8.82, 36.6)*	20.4 *(9.86, 42.4)*	24.4 *(11.6, 49.7)*	35.4 *(17.3, 72.4)*	40.2 *(20.3, 79.4)*
	P-value		0.571	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2005-06	Prevalence *(95% CI)* (%)	4.0 *(2.0, 6.0)*	4.2 *(1.8, 6.5)*	7.9 *(4.8, 11.1)*	10.2 *(6.6, 13.8)*	19.0 *(14.3, 23.7)*	20.0 *(15.4, 24.6)*	26.9 *(21.7, 32.1)*	41.2 *(34.3, 48.1)*	46.6 *(40.0, 53.2)*	55.0 *(47.9, 62.1)*	53.1 *(48.1, 58.1)*
	OR$^{\alpha}$ *(95% CI)*	0.051 *(0.030, 0.086)*	1.03 *(0.475, 2.25)*	2.05 *(1.05, 4.00)*	2.75 *(1.44, 5.24)*	5.55 *(3.05, 10.1)*	6.07 *(3.36, 11.0)*	8.86 *(4.95, 15.8)*	16.9 *(9.38, 30.6)*	21.2 *(11.9, 37.8)*	29.5 *(16.4, 53.1)*	27.1 *(15.6, 47.1)*
	P-value		0.935	0.036*	0.002*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2007-08	Prevalence (95% CI) (%)	2.7 (0.9, 4.4)	5.1 (2.5, 7.7)	6.8 (4.2, 9.4)	14.3 (10.7, 17.9)	19.0 (14.3, 23.6)	24.1 (19.5, 28.8)	30.2 (25.1, 35.4)	35.1 (28.9, 41.4)	49.2 (43.6, 54.8)	56.4 (49.9, 62.9)	55.2 (51.8, 58.5)
	OR[α] (95% CI)	0.033 (0.016, 0.066)	1.99 (0.828, 4.76)	2.68 (1.20, 5.99)	6.12 (2.89, 13.0)	8.55 (4.02, 18.2)	11.8 (5.66, 24.6)	16.3 (7.86, 33.8)	19.6 (9.33, 41.1)	36.2 (17.5, 74.6)	48.0 (23.0, 100)	44.7 (22.2, 90.2)
	P-value		0.124	0.016*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2009-10	Prevalence (95% CI) (%)	2.9 (1.2, 4.6)	4.5 (2.3, 6.6)	7.2 (4.5, 9.8)	10.0 (7.0, 12.9)	12.3 (9.0, 15.5)	23.1 (18.8, 27.5)	30.3 (25.1, 35.4)	33.2 (27.4, 39.0)	42.2 (36.6, 47.7)	49.6 (43.3, 56.0)	56.3 (53.0, 59.6)
	OR[α] (95% CI)	0.036 (0.020, 0.066)	1.55 (0.712, 3.39)	2.57 (1.26, 5.24)	3.70 (1.87, 7.33)	4.63 (2.36, 9.07)	10.1 (5.32, 19.3)	14.5 (7.63, 27.7)	16.8 (8.76, 32.3)	24.2 (12.8, 45.9)	33.7 (17.6, 64.5)	42.6 (23.1, 78.5)
	P-value		0.268	0.010	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2011-12	Prevalence (95% CI) (%)	2.7 (0.5, 4.9)	3.8 (1.6, 5.9)	5.9 (3.5, 8.3)	8.3 (5.3, 11.3)	12.2 (8.2, 16.2)	21.5 (16.1, 26.9)	26.3 (20.4, 32.2)	37.2 (30.1, 44.3)	33.9 (27.3, 40.6)	45.2 (36.7, 53.7)	55.6 (51.4, 59.8)
	OR[α] (95% CI)	0.034 (0.015, 0.078)	1.41 (0.508, 3.94)	2.26 (0.883, 5.78)	3.28 (1.31, 8.23)	5.10 (2.05, 12.7)	9.90 (4.07, 24.1)	13.0 (5.35, 31.4)	22.0 (9.07, 53.4)	18.7 (7.75, 45.2)	30.6 (12.4, 75.4)	45.1 (19.3, 105)
	P-value		0.507	0.089	0.011	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2013-14	Prevalence (95% CI) (%)	3.4 (1.3, 5.5)	3.7 (1.5, 5.8)	9.7 (6.6, 12.8)	8.9 (6.0, 11.7)	16.3 (12.3, 20.4)	21.4 (16.8, 26.0)	33.7 (28.0, 39.4)	35.4 (29.4, 41.3)	51.5 (45.4, 57.6)	54.0 (47.0, 60.9)	55.6 (51.7, 59.6
	OR[α] (95% CI)	0.047 (0.025, 0.088)	1.07 (0.441, 2.58)	3.08 (1.49, 6.39)	2.70 (1.30, 5.60)	5.50 (2.72, 11.1)	7.73 (3.86, 15.5)	14.5 (7.31, 29.0)	16.1 (8.06, 32.0)	30.8 (15.5, 61.2)	34.2 (17.1, 68.7)	35.6 (18.4, 68.7)
	P-value		0.886	0.003*	0.008*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2015-16	Prevalence (95% CI) (%)	4.4 (2.0, 6.8)	4.6 (2.3, 6.8)	3.0 (1.2, 4.7)	12.7 (8.6, 16.7)	15.8 (11.1, 20.4)	21.0 (16.1, 25.9)	29.4 (23.3, 35.5)	40.9 (34.3, 47.5)	50.2 (42.8, 57.6)	54.6 (46.8, 62.4)	55.8 (51.6, 60.0
	OR[α] (95% CI)	0.058 (0.033, 0.104)	1.04 (0.482, 2.26)	0.662 (0.286, 1.53)	3.15 (1.60, 6.23)	4.05 (2.07, 7.93)	5.89 (3.08, 11.3)	9.20 (4.81, 17.6)	15.5 (8.17, 29.4)	22.8 (12.0, 43.5)	26.5 (13.8, 51.1)	27.6 (15.2, 50.4)
	P-value		0.915	0.335	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2017-18	Prevalence *(95% CI)* (%)	2.2 *(0.7, 3.6)*	5.5 *(2.5, 8.4)*	7.5 *(4.7, 10.3)*	12.1 *(8.2, 15.9)*	16.8 *(11.2, 22.5)*	19.4 *(13.8, 25.0)*	37.9 *(29.8, 45.9)*	36.5 *(29.6, 43.5)*	44.1 *(37.0, 51.2)*	53.1 *(44.6, 61.6)*	60.6 *(56.4, 64.7)*
	OR[α] *(95% CI)*	0.026 *(0.013, 0.050)*	2.61 *(1.08, 6.33)*	3.71 *(1.70, 8.11)*	6.16 *(2.88, 13.2)*	9.32 *(4.27, 20.4)*	11.0 *(5.14, 23.5)*	27.8 *(13.1, 59.1)*	26.3 *(12.6, 55.0)*	36.0 *(17.3, 74.7)*	52.0 *(24.5, 110)*	69.6 *(34.9, 139)*
	P-value		0.033*	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

* P < 0.05: for a significant difference between 18 to 24 year olds (comparator group) and remaining older age groups, by logistic regression analysis

Table IV: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing low back pain in various age groups, across survey years 1997 until 2018 (except 2004), according to the National Health Interview Survey (NHIS)

Year	Measurement	Age group (years)										
		Age 18 to 24	*Age 25 to 29*	*Age 30 to 34*	*Age 35 to 39*	*Age 40 to 44*	*Age 45 to 49*	*Age 50 to 54*	*Age 55 to 59*	*Age 60 to 64*	*Age 65 to 69*	*Age 70 & above*
1997	Prevalence *(95% CI)* (%)	21.9 *(20.3, 23.5)*	25.0 *(23.3, 26.6)*	26.2 *(24.6, 27.7)*	28.7 *(27.2, 30.3)*	29.0 *(27.4, 30.7)*	29.8 *(28.1, 31.6)*	33.1 *(31.0, 35.1)*	31.6 *(29.4, 33.9)*	30.8 *(28.5, 33.2)*	30.0 *(27.6, 32.4)*	29.3 *(27.9, 30.7)*
	OR[α] *(95% CI)*	0.301 *(0.274, 0.331)*	1.18 *(1.04, 1.35)*	1.26 *(1.12, 1.43)*	1.43 *(1.27, 1.62)*	1.46 *(1.29, 1.65)*	1.52 *(1.34, 1.72)*	1.76 *(1.54, 2.00)*	1.64 *(1.43, 1.89)*	1.59 *(1.37, 1.83)*	1.52 *(1.31, 1.76)*	1.45 *(1.30, 1.63)*
	P-value		0.009*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
1998	Prevalence *(95% CI)* (%)	20.9 *(19.3, 22.6)*	25.4 *(23.7, 27.2)*	26.5 *(24.8, 28.2)*	27.5 *(25.9, 29.2)*	26.5 *(24.9, 28.2)*	29.5 *(27.7, 31.4)*	32.4 *(30.3, 34.4)*	31.9 *(29.6, 34.3)*	31.2 *(28.8, 33.7)*	31.2 *(28.7, 33.6)*	31.8 *(30.2, 33.3)*
	OR[α] *(95% CI)*	0.287 *(0.259, 0.318)*	1.28 *(1.12, 1.47)*	1.36 *(1.19, 1.55)*	1.43 *(1.26, 1.63)*	1.36 *(1.19, 1.56)*	1.58 *(1.38, 1.81)*	1.80 *(1.57, 2.07)*	1.76 *(1.52, 2.05)*	1.71 *(1.47, 1.99)*	1.70 *(1.46, 1.98)*	1.73 *(1.46, 1.98)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
1999	Prevalence *(95% CI)* (%)	20.4 *(18.7, 22.0)*	23.8 *(21.9, 25.6)*	24.3 *(22.6, 26.1)*	25.6 *(24.0, 27.3)*	26.7 *(25.0, 28.4)*	29.8 *(27.8, 31.8)*	31.0 *(28.9, 33.1)*	30.1 *(27.9, 32.4)*	27.9 *(25.6, 30.3)*	28.7 *(26.2, 31.3)*	28.8 *(27.3, 30.3)*
	OR[α] *(95% CI)*	0.280 *(0.252, 0.311)*	1.22 *(1.05, 1.41)*	1.25 *(1.09, 1.44)*	1.35 *(1.18, 1.54)*	1.42 *(1.24, 1.63)*	1.66 *(1.44, 1.91)*	1.75 *(1.52, 2.02)*	1.68 *(1.45, 1.94)*	1.51 *(1.30, 1.77)*	1.56 *(1.33, 1.84)*	1.56 *(1.37, 1.77)*
	P-value		0.007*	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2000	Prevalence *(95% CI)* (%)	21.0 *(19.4, 22.7)*	23.2 *(21.4, 24.9)*	24.0 *(22.3, 25.7)*	27.2 *(25.5, 28.9)*	28.2 *(26.5, 30.0)*	29.7 *(27.8, 31.6)*	29.1 *(27.1, 31.0)*	31.7 *(29.4, 33.9)*	32.3 *(29.9, 34.8)*	28.7 *(26.2, 31.3)*	30.5 *(29.0, 32.0)*
	OR[α] *(95% CI)*	0.288 *(0.260, 0.319)*	1.13 *(0.983, 1.30)*	1.19 *(1.03, 1.36)*	1.40 *(1.23, 1.60)*	1.48 *(1.30, 1.69)*	1.59 *(1.39, 1.82)*	1.54 *(1.34, 1.77)*	1.74 *(1.51, 2.01)*	1.79 *(1.54, 2.08)*	1.50 *(1.28, 1.76)*	1.63 *(1.28, 1.76)*
	P-value		0.086	0.014*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2001	Prevalence *(95% CI)* (%)	25.8 *(24.0, 27.5)*	25.9 *(24.1, 27.7)*	27.6 *(25.9, 29.3)*	31.6 *(29.8, 33.3)*	31.3 *(29.6, 33.0)*	33.9 *(32.0, 35.8)*	35.4 *(33.4, 37.4)*	35.6 *(33.3, 37.8)*	37.2 *(34.7, 39.8)*	30.7 *(28.2, 33.2)*	32.5 *(30.9, 34.1)*
	OR$^{\alpha}$ *(95% CI)*	0.373 *(0.340, 0.410)*	1.01 *(0.884, 1.14)*	1.10 *(0.971, 1.24)*	1.33 *(1.18, 1.50)*	1.31 *(1.16, 1.48)*	1.48 *(1.30, 1.67)*	1.58 *(1.39, 1.79)*	1.59 *(1.39, 1.82)*	1.70 *(1.48, 1.96)*	1.27 *(1.09, 1.47)*	1.37 *(1.22, 1.54)*
	P-value		0.928	0.137	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.002*	<0.001*
2002	Prevalence *(95% CI)* (%)	20.8 *(19.2, 22.4)*	22.1 *(20.2, 23.9)*	23.9 *(22.2, 25.6)*	25.6 *(23.9, 27.3)*	26.6 *24.9, 28.4)*	28.7 *(26.8, 30.6)*	29.8 *(27.7, 31.9)*	31.9 *(29.7, 34.1)*	29.3 *(26.9, 31.8)*	26.6 *(24.1, 29.1)*	29.6 *(28.1, 31.2)*
	OR$^{\alpha}$ *(95% CI)*	0.290 *(0.262, 0.321)*	1.08 *(0.930, 1.25)*	1.19 *(1.04, 1.37)*	1.31 *(1.14, 1.49)*	1.38 *(1.21, 1.58)*	1.53 *(1.34, 1.75)*	1.61 *(1.40, 1.85)*	1.77 *(1.54, 2.04)*	1.58 *(1.35, 1.84)*	1.38 *(1.17, 1.62)*	1.57 *(1.39, 1.79)*
	P-value		0.322	0.011*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2003	Prevalence *(95% CI)* (%)	19.6 *(18.0, 21.2)*	24.1 *(22.1, 24.0)*	23.1 *(21.4, 24.8)*	27.9 *(26.1, 29.7)*	27.7 *(25.9, 29.5)*	29.3 *(27.4, 31.2)*	31.3 *(29.3, 33.4)*	35.7 *(33.4, 37.9)*	30.5, *(28.1, 32.9)*	31.2 *(27.6, 32.7)*	29.8 *(28.2, 31.4)*
	OR$^{\alpha}$ (95% CI)	0.270 *(0.243, 0.300)*	1.30 *(1.12, 1.50)*	1.23 *(1.07, 1.41)*	1.58 *(1.38, 1.81)*	1.57 *(1.37, 1.79)*	1.69 *(1.48, 1.94)*	1.87 *(1.62, 2.14)*	2.27 *(1.97, 2.61)*	1.79 *(1.54, 2.09)*	1.76 *(1.51, 2.07)*	1.71 *(1.50, 1.94)*
	P-value		<0.001*	0.003*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2005	Prevalence *(95% CI)* (%)	20.4 *(18.7, 22.1)*	23.6 *(21.7, 25.5)*	24.3 *(22.6, 26.1)*	27.8 *(26.0, 29.7)*	30.2 *(28.4, 32.1)*	29.2 *(27.3, 31.0)*	31.4 *(29.5, 33.4)*	31.4 *(29.4, 33.5)*	36.0 *(33.6, 38.5)*	31.6 *(299.1, 34.2)*	33.6 *(32.0, 35.2)*
	OR$^{\alpha}$ *(95% CI)*	0.283 *(0.254, 0.315)*	1.20 *(1.04, 1.39)*	1.26 *(1.09, 1.45)*	1.51 *(1.31, 1.73)*	1.68 *(1.47, 1.93)*	1.60 *(1.40, 1.84)*	1.79 *(1.55, 2.05)*	1.78 *(1.55, 2.06)*	2.19 *(1.55, 2.06)*	1.79 *(1.53, 2.09)*	1.94 *(1.71, 2.20)*
	P-value		0.015*	0.002*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2006	Prevalence *(95% CI)* (%)	18.6 *(16.8, 20.5)*	24.6 *(22.3, 26.9)*	24.7 *(22.5, 26.9)*	24.6 *(22.4, 26.8)*	28.6 *(26.5, 30.8)*	28.6 *(26.4, 30.7)*	31.5 *(29.2, 33.9)*	31.7 *(29.2, 34.2)*	34.0 *(31.1, 36.9)*	30.5 *(27.6, 33.5)*	32.2 *(30.2, 34.1)*
	OR$^{\alpha}$ *(95% CI)*	0.248 *(0.218, 0.281)*	1.43 *(1.20, 1.70)*	1.43 *(1.21, 1.70)*	1.43 *(1.21, 1.69)*	1.75 *(1.49, 2.06)*	1.75 *(1.49, 2.05)*	2.01 *(1.71, 2.37)*	2.02 *(1.71, 2.38)*	2.25 *(1.89, 2.69)*	1.92 *(1.60, 2.31)*	2.04 *(1.76, 2.38)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2007	Prevalence *(95% CI)* (%)	17.7 *(15.8, 19.6)*	21.7 *(19.5, 23.8)*	23.7 *(21.6, 25.9)*	23.9 *(21.8, 26.0)*	25.5 *(23.3, 27.8)*	28.5 *(26.3, 30.8)*	27.3 *(25.0, 29.6)*	29.7 *(27.2, 32.3)*	29.9 *(27.2, 32.6)*	30.1 *(27.2, 32.9)*	29.3 *(27.5, 31.2)*
	OR$^{\alpha}$ *(95% CI)*	0.237 *(0.207, 0.270)*	1.29 *(1.07, 1.55)*	1.45 *(1.21, 1.73)*	1.46 *(1.23, 1.74)*	1.59 *(1.34, 1.90)*	1.85 *(1.56, 2.20)*	1.75 *(1.47, 2.08)*	1.96 *(1.64, 2.35)*	1.98 *(1.65, 2.38)*	1.99 *(1.64, 2.39)*	1.90 *(1.62, 2.22)*
	P-value		0.007*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2008	Prevalence *(95% CI)* (%)	20.7 *(18.6, 22.8)*	23.1 *(20.9, 25.4)*	24.9 *(22.6, 2.1)*	26.7 *(24.4, 29.1)*	28.8 *(26.3, 31.3)*	27.1 *(24.9, 29.4)*	31.5 *(29.11, 34.0)*	28.4 *(26.0, 30.9)*	31.3 *(28.6, 34.0)*	33.2 *(33.2, 36.2)*	31.1 *(29.1, 33.0)*
	OR$^{\alpha}$ *(95% CI)*	0.289 *(0.253, 0.331)*	1.15 *(0.959, 1.38)*	1.27 *(1.06, 1.51)*	1.40 *(1.17, 1.66)*	1.55 *(1.29, 1.85)*	1.42 *(1.19, 1.69)*	1.76 *(1.48, 2.10)*	1.52 *(1.27, 1.81)*	1.74 *(1.45, 2.08)*	1.90 *(1.58, 2.29)*	1.69 *(1.44, 1.98)*
	P-value		0.130	0.008*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2009	Prevalence *(95% CI)* (%)	18.1 *(16.2, 19.9)*	23.9 *(21.7, 26.1)*	25.3 *(23.1, 27.4)*	27.4 *(25.1, 29.7)*	20.3 *(27.9, 32.7)*	32.5 *(30.1, 34.9)*	31.4 *(29.0, 33.7)*	33.6 *(31.1, 36.1)*	33.2 *(30.7, 35.7)*	30.8 *(28.0, 33.6)*	32.3 *(30.4, 34.2)*
	OR$^{\alpha}$ *(95% CI)*	0.244 *(0.214, 0.277)*	1.42 *(1.20, 1.69)*	1.53 *(1.29, 1.81)*	1.71 *(1.44, 2.02)*	1.97 *(1.66, 2.33)*	2.18 *(1.85, 2.57)*	2.07 *(1.75, 2.44)*	2.27 *(1.92, 2.68)*	2.27 *(1.91, 2.68)*	2.00 *(1.67, 2.40)*	2.13 *(1.83, 2.48)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2010	Prevalence *(95% CI)* (%)	19.4 *(17.6, 21.2)*	24.9 *(22.9, 27.0)*	25.4 *(23.4, 27.5)*	28.5 *(26.4, 30.7)*	30.2 *(28.0, 32.4)*	30.4 *(28.2, 32.5)*	32.4 *(30.1, 34.6)*	35.2 *(32.8, 37.6)*	32.4 *(30.0, 34.7)*	33.0 *(30.3, 35.7)*	31.3 *(29.5, 33.0)*
	OR$^{\alpha}$ *(95% CI)*	0.264 *(0.234, 0.299)*	1.38 *(1.17, 1.62)*	1.42 *(1.21, 1.66)*	1.66 *(1.42, 1.94)*	1.80 *(1.54, 2.10)*	1.81 *(1.55, 2.12)*	1.99 *(1.70, 2.32)*	2.25 *(1.69, 2.32)*	1.98 *(1.69, 2.32)*	2.04 *(1.72, 2.41)*	1.86 *(1.61, 2.14)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2011	Prevalence *(95% CI)* (%)	18.0 *(16.4, 19.6)*	22.3 *(20.5, 24.1)*	26.5 *(24.5, 28.4)*	26.9 *(25.0, 28.9)*	31.7 *(29.7, 33.8)*	32.2 *(30.1, 34.2)*	32.3 *(30.2, 34.4)*	35.3 *(33.1, 37.5)*	33.6 *(31.5, 35.8)*	33.2 *(30.8, 35.5)*	32.5 *(31.0, 34.1)*
	OR$^{\alpha}$ *(95% CI)*	0.236 *(0.210, 0.264)*	1.31 *(1.12, 1.52)*	1.64 *(1.41, 1.90)*	1.67 *(1.44, 1.94)*	2.12 *(1.87, 2.45)*	2.16 *(1.87, 2.49)*	2.17 *(1.88, 2.51)*	2.48 *(2.14, 2.87)*	2.30 *(1.99, 2.66)*	2.25 *(1.93, 2.63)*	2.17 *(1.90, 2.47)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2012	Prevalence *(95% CI)* (%)	19.1 *(17.4, 20.9)*	24.5 *(22.4, 26.5)*	23.0 *(21.1, 24.8)*	27.7 *(25.6, 29.7)*	28.3 *(26.2, 30.4)*	33.0 *(30.8, 35.1)*	30.3 *(28.2, 32.5)*	32.1 *(39.0, 34.2)*	34.2 *(32.0, 36.4)*	30.2 *(28.4, 33.2)*	30.2 *(28.6, 31.8)*
	OR$^{\alpha}$ *(95% CI)*	0.261 *(0.233, 0.293)*	1.37 *(1.17, 1.61)*	1.26 *(1.08, 1.47)*	1.62 *(1.39, 1.88)*	1.67 *(1.43, 1.94)*	2.08 *(1.79, 2.41)*	1.84 *(1.58, 2.14)*	2.00 *(1.72, 2.33)*	2.19 *(1.88, 2.54)*	1.87 *(1.60, 2.20)*	1.81 *(1.58, 2.07)*
	P-value		<0.001*	0.003*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2013	Prevalence *(95% CI)* (%)	18.0 *(16.1, 19.8)*	23.0 *(21.0, 25.0)*	25.4 *(23.5, 27.3)*	26.7 *(24.6, 28.9)*	28.7 *(26.6, 30.8)*	31.8 *(29.6, 34.0)*	33.2 *(31.0, 35.4)*	36.4 *(34.2, 38.7)*	33.4 *(31.1, 35.7)*	34.1 *(31.7, 36.4)*	33.5 *(31.8, 35.2)*
	OR$^{\alpha}$ *(95% CI)*	0.238 *(0.209, 0.270)*	1.36 *(1.15, 1.61)*	1.55 *(1.32, 1.82)*	1.66 *(1.40, 1.96)*	1.84 *(1.57, 2.17)*	2.13 *(1.81, 2.50)*	2.26 *(1.93, 2.65)*	2.61 *(2.23, 3.05)*	2.29 *(1.95, 2.69)*	2.35 *(2.00, 2.76)*	2.28 *(1.97, 2.63)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2014	Prevalence *(95% CI)* (%)	20.3 *(17.8, 22.8)*	21.9 *(20.0, 23.8)*	24.6 *(22.5, 26.7)*	27.9 *(25.7, 30.1)*	28.3 *(26.2, 30.4)*	32.2 *(29.9, 34.6)*	29.8 *(27.6, 32.0)*	33.9 *(31.8, 36.1)*	32.9 *(30.6, 35.2)*	33.4 *(31.1, 35.7)*	33.3 *(31.7, 35.0)*
	OR$^{\alpha}$ *(95% CI)*	0.279 *(0.238, 0.329)*	1.10 *(0.910, 1.33)*	1.28 *(1.06, 1.55)*	1.51 *(1.26, 1.83)*	1.55 *(1.28, 1.86)*	1.86 *(1.55, 2.25)*	1.66 *(1.38, 2.00)*	2.01 *(1.68, 2.41)*	1.92 *(1.60, 2.31)*	1.96 *(1.63, 2.36)*	1.94 *(1.63, 2.30)*
	P-value		0.327	0.011*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2015	Prevalence *(95% CI)* (%)	16.2 *(14.4, 18.0)*	25.1 *(22.9, 27.2)*	26.6 *(24.5, 28.7)*	27.2 *(25.0, 29.4)*	28.0 *(25.8, 30.2)*	33.6 *(31.2, 36.0)*	35.6 *(33.3, 38.0)*	35.4 *(33.1, 37.8)*	36.9 *(34.5, 39.4)*	33.4 *(31.0, 35.8)*	34.8 *(33.1, 36.5)*
	OR$^{\alpha}$ *(95% CI)*	0.206 *(0.179, 0.368)*	1.73 *(1.45, 2.07)*	1.87 *(1.57, 2.22)*	1.93 *(1.62, 2.29)*	2.01 *(1.69, 2.39)*	2.61 *(2.20, 3.11)*	2.85 *(2.41, 3.38)*	2.83 *(2.39, 3.36)*	3.02 *(2.54, 3.58)*	2.58 *(2.17, 3.07)*	2.74 *(2.35, 3.20)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2016	Prevalence *(95% CI)* (%)	18.3 *(16.3, 20.2)*	23.7 *(21.4, 25.9)*	24.8 *(22.7, 27.0)*	27.6 *(25.3, 29.9)*	30.8 *(28.3, 33.4)*	30.7 *(28.4, 33.0)*	33.5 *(31.1, 35.8)*	33.0 *(30.8, 35.2)*	35.8 *(33.5, 38.0)*	32.6 *(30.4, 34.8)*	32.5 *(31.0, 34.0)*
	OR$^{\alpha}$ *(95% CI)*	0.240 *(0.210, 0.274)*	1.39 *(1.15, 1.66)*	1.48 *(1.24, 1.76)*	1.70 *(1.43, 2.02)*	1.99 *(1.67, 2.38)*	1.98 *(1.67, 2.34)*	2.25 *(1.90, 2.65)*	2.20 *(1.86, 2.59)*	2.48 *(2.11, 2.92)*	2.16 *(1.83, 2.54)*	2.14 *(1.84, 2.47)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

2017	Prevalence *(95% CI)* (%)	16.9 *(15.0, 18.7)*	24.3 *(22.0, 26.6)*	25.4 *(23.3, 27.6)*	26.6 *(24.3, 28.9)*	28.9 *(26.4, 31.5)*	31.3 *(28.8, 33.8)*	32.3 *(29.9, 34.8)*	33.1 *(30.7, 35.5)*	33.6 *(31.3, 36.0)*	32.6 *(33.3, 34.9)*	33.2 *(31.7, 34.8)*
	OR$^{\alpha}$ *(95% CI)*	0.245 *(0.195, 0.258)*	1.59 *(1.32, 1.91)*	1.68 *(1.41, 2.01)*	1.79 *(1.49, 2.13)*	2.01 *(1.67, 2.41)*	2.25 *(1.88, 2.68)*	23.5 *(1.97, 2.80)*	2.43 *(2.05, 2.89)*	2.50 *(2.10, 2.96)*	2.37 *(2.00, 2.81)*	2.43 *(2.09, 2.83)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
2018	Prevalence *(95% CI)* (%)	16.5 *(14.5, 18.5)*	24.8 *(22.3, 27.3)*	26.3 *(24.1, 28.6)*	28.8 *(26.4, 31.1)*	29.1 *(26.7, 31.5)*	31.0 *(28.5, 33.5)*	31.2 *(28.9, 33.7)*	33.3 *(31.0, 35.7)*	36.4 *(34.1, 38.8)*	34.9 *(32.6, 37.2)*	37.8 *(36.2, 39.4)*
	OR$^{\alpha}$ *(95% CI)*	0.213 *(0.183, 0.248)*	1.67 *(1.37, 2.04)*	1.81 *(1.50, 2.18)*	2.05 *(1.70, 2.47)*	2.07 *(1.72, 2.50)*	2.27 *(1.88, 2.74)*	2.31 *(1.92, 2.78)*	2.53 *(2.11, 3.03)*	2.90 *(2.43, 3.46)*	2.71 *(2.27, 3.23)*	3.06 *(2.60, 3.59)*
	P-value		<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

* P < 0.05: for a significant difference between 18 to 24 year olds (comparator group) and remaining older age groups, by logistic regression analysis

APPENDIX I

Annual sex-specific trends of each musculoskeletal pain type

Table I: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing rheumatic disorder diagnoses in the sexes, across years 1996 until 2018 (except for 2006 and 2008), according to the Behavioural Risk Factor Surveillance System (BRFSS)**

Year	Measurement	Sex	
		Male	*Female*
1996[α]	Prevalence *(95% CI)* (%)	22.1 *(20.6, 23.7)*	32.6 *(31.2, 34.0)*
	OR[α] *(95% CI)*	0.035 *(0.024, 0.050)*	1.58 *(1.40, 1.79)*
	P-value	< 0.001*	
1997[α]	Prevalence *(95% CI)* (%)	17.3 *(15.9, 18.9)*	27.3 *(25.8, 28.8)*
	OR[α] *(95% CI)*	0.026 *(0.017, 0.041)*	1.70 *(1.48, 1.95)*
	P-value	< 0.001*	
1998[α]	Prevalence *(95% CI)* (%)	17.7 *(16.1, 19.3)*	26.5 *(25.0, 28.0)*
	OR[α] *(95% CI)*	0.035 *(0.021, 0.059)*	1.61 *(1.40, 1.86)*
	P-value	< 0.001*	
1999[α]	Prevalence *(95% CI)* (%)	19.0 *(17.9, 20.2)*	27.0 *(26.0, 28.0)*
	OR[α] *(95% CI)*	0.030 *(0.022, 0.041)*	1.48 *(0.135, 1.63)*
	P-value	< 0.001*	
2000[α]	Prevalence *(95% CI)* (%)	18.4 *(17.9, 19.0)*	27.5 *(26.9, 28.0)*
	OR[α] *(95% CI)*	0.028 *(0.024, 0.033)*	1.59 *(1.51, 1.67)*
	P-value	< 0.001*	
2001	Prevalence *(95% CI)* (%)	18.2 *(17.7, 18.6)*	27.5 *(27.1, 27.9)*
	OR[α] *(95% CI)*	0.030 *(0.026, 0.034)*	1.62 *(1.56, 1.68)*
	P-value	< 0.001*	
2002[α]	Prevalence *(95% CI)* (%)	22.7 *(22.1, 23.3)*	30.6 *(30.0, 31.2)*
	OR[α] (95% CI)	0.046 *(0.039, 0.053)*	1.43 *(1.36, 1.50)*
	P-value	< 0.001*	
2003	Prevalence *(95% CI)* (%)	22.8 *(22.4, 23.3)*	31.1 *(30.6, 31.5)*
	OR[α] *(95% CI)*	0.050 *(0.046, 0.056)*	1.44 *(1.39, 1.49)*
	P-value	< 0.001*	

2004[α]	Prevalence *(95% CI)* (%)	24.7 *(23.7, 25.7)*		33.4 *(32.5, 34.3)*
	OR[α] *(95% CI)*	0.041 *(0.033, 0.052)*		1.46 *(1.36, 1.57)*
	P-value		< 0.001*	
2005	Prevalence *(95% CI)* (%)	22.3 *(21.9, 22.7)*		30.7 *(30.4, 31.1)*
	OR[α] *(95% CI)*	0.044 *(0.040, 0.049)*		1.49 *(1.44, 1.53)*
	P-value		< 0.001*	
2007	Prevalence *(95% CI)* (%)	22.8 *(22.4, 23.2)*		31.0 *(30.7, 31.3)*
	OR[α] *(95% CI)*	0.045 *(0.039, 0.051)*		1.46 *(1.42, 1.51)*
	P-value		< 0.001*	
2009	Prevalence *(95% CI)* (%)	21.8 *(21.4, 22.2)*		29.8 *(29.5, 30.2)*
	OR[α] *(95% CI)*	0.033 *(0.029, 0.039)*		1.47 *(1.43, 1.51)*
	P-value		< 0.001*	
2010[α]	Prevalence *(95% CI)* (%)	26.6 *(25.5, 27.8)*		33.7 *(32.8, 34.6)*
	OR[α] *(95% CI)*	0.037 *(0.025, 0.056)*		1.33 *(1.23, 1.43)*
	P-value		< 0.001*	
2011	Prevalence *(95% CI)* (%)	20.7 *(20.4, 21.1)*		28.6 *(28.3, 28.9)*
	OR[α] *(95% CI)*	0.029 *(0.025, 0.033)*		1.46 *(1.42, 1.50)*
	P-value		< 0.001*	
2012	Prevalence *(95% CI)* (%)	21.7 *(21.4, 22.0)*		29.3 *(29.0, 29.7)*
	OR[α] *(95% CI)*	0.030 *(0.027, 0.034)*		1.45 *(1.41, 1.49)*
	P-value		< 0.001*	
2013	Prevalence *(95% CI)* (%)	20.9 *(20.6, 21.3)*		28.8 *(28.5, 29.2)*
	OR[α] *(95% CI)*	0.028 *(0.025, 0.031)*		1.49 *(1.45, 1.53)*
	P-value		< 0.001*	
2014	Prevalence *(95% CI)* (%)	21.5 *(21.1, 21.8)*		29.5 *(29.2, 29.9)*
	OR[α] *(95% CI)*	0.025 *(0.022, 0.029)*		1.49 *(1.45, 1.53)*
	P-value		< 0.001*	
2015	Prevalence *(95% CI)* (%)	20.6 *(20.3, 21.0)*		28.5 *(28.2, 28.8)*
	OR[α] *(95% CI)*	0.026 *(0.024, 0.029)*		1.50 *(1.46, 1.54)*
	P-value		< 0.001*	

2016	Prevalence *(95% CI)* (%)	21.2 *(20.9, 21.5)*		29.3 *(28.9, 29.6)*
	OR[α] *(95% CI)*	0.026 *(0.024, 0.029)*		1.50 *(1.46, 1.54)*
	P-value		< 0.001*	
2017	Prevalence *(95% CI)* (%)	20.3 *(20.0, 20.6)*		28.6 *(28.2, 28.9)*
	OR[α] *(95% CI)*	0.025 *(0.023, 0.028)*		1.54 *(1.49, 1.59)*
	P-value		< 0.001*	
2018	Prevalence *(95% CI)* (%)	21.7 *(21.4, 22.1)*		29.7 *(29.3, 30.0)*
	OR[α] *(95% CI)*	0.029 (0.026, 0.032)		1.49 (1.45, 1.54)
	P-value		< 0.001*	

** Rheumatic disorder diagnoses: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[α] Module questionnaire years

* $P < 0.05$: for a significant difference between males (comparator group) and females, by logistic regression analysis

Table II: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing joint symptoms in the sexes, across years 2002 until 2018 (except for 2004), according to the National Health Interview Survey (NHIS)**

Year	Measurement	Sex	
		Male	*Female*
2002	Prevalence *(95% CI)* (%)	27.7 *(26.9, 28.6)*	31.2 *(30.4, 32.0)*
	OR[α] *(95% CI)*	0.155 *(0.137, 0.176)*	1.14 *(1.08, 1.21)*
	P-value	< 0.001*	
2003	Prevalence *(95% CI)* (%)	28.8 *(28.0, 29.7)*	34.5 *(33.6, 35.3)*
	OR[α] (95% CI)	0.153 *(0.135, 0.174)*	1.26 *(1.18, 1.33)*
	P-value	< 0.001*	
2005	Prevalence *(95% CI)* (%)	28.8 *(27.9, 29.7)*	33.3 *(32.5, 34.1)*
	OR[α] *(95% CI)*	0.149 *(0.130, 0.170)*	1.19 *(1.12, 1.26)*
	P-value	< 0.001*	
2006	Prevalence *(95% CI)* (%)	27.8 *(26.8, 28.8)*	31.5 *(30.6, 32.5)*
	OR[α] *(95% CI)*	0.123 *(0.106, 0.142)*	1.15 *(1.07, 1.23)*
	P-value	< 0.001*	
2007	Prevalence *(95% CI)* (%)	25.2 *(24.2, 26.2)*	29.9 *(29.0, 30.9)*
	OR[α] *(95% CI)*	0.099 *(0.084, 0.117)*	1.22 *(1.14, 1.32)*
	P-value	< 0.001*	
2008	Prevalence *(95% CI)* (%)	29.0 *(28.0, 30.1)*	33.4 *(32.4, 34.4)*
	OR[α] *(95% CI)*	0.168 *(0.144, 0.197)*	1.19 *(1.11, 1.28)*
	P-value	< 0.001*	
2009	Prevalence *(95% CI)* (%)	31.2 *(30.2, 32.3)*	34.7 *(33.8, 35.7)*
	OR[α] *(95% CI)*	0.163 *(0.140, 0.189)*	1.14 *(1.06, 1.22)*
	P-value	< 0.001*	
2010	Prevalence *(95% CI)* (%)	31.4 *(30.4, 32.4)*	35.1 *(34.2, 36.0)*
	OR[α] *(95% CI)*	0.167 *(0.145, 0.192)*	1.15 *(1.08, 1.22)*
	P-value	< 0.001*	
2011	Prevalence *(95% CI)* (%)	31.9 *(31.0, 32.8)*	35.3 *(34.4, 36.1)*
	OR[α] *(95% CI)*	0.150 *(0.132, 0.170)*	1.13 *(1.06, 1.19)*
	P-value	< 0.001*	

2012	Prevalence *(95% CI)* (%)	28.4 *(27.5, 29.3)*	32.3 *(31.5, 33.2)*
	OR[α] *(95% CI)*	0.140 *(0.123, 0.160)*	1.17 *(1.10, 1.25)*
	P-value	< 0.001*	
2013	Prevalence *(95% CI)* (%)	29.5 *(28.6, 30.4)*	34.6 *(33.8, 35.5)*
	OR[α] *(95% CI)*	0.134 *(0.116, 0.154)*	1.24 *(1.17, 1.32)*
	P-value	< 0.001*	
2014	Prevalence *(95% CI)* (%)	30.9 *(29.9, 31.9)*	34.5 *(33.6, 35.4)*
	OR[α] *(95% CI)*	0.155 *(0.135, 0.179)*	1.14 *(1.07, 1.22)*
	P-value	< 0.001*	
2015	Prevalence *(95% CI)* (%)	32.1 *(31.1, 33.1)*	35.5 *(34.5, 36.4)*
	OR[α] *(95% CI)*	0.151 *(0.130, 0.177)*	1.13 *(1.06, 1.20)*
	P-value	< 0.001*	
2016	Prevalence *(95% CI)* (%)	31.4 *(30.5, 32.4)*	36.0 *(35.1, 36.9)*
	OR[α] *(95% CI)*	0.146 *(0.127, 0.167)*	1.20 *(1.13, 1.28)*
	P-value	< 0.001*	
2017	Prevalence *(95% CI)* (%)	31.2 *(30.2, 32.2)*	37.1 *(30.2, 32.2)*
	OR[α] *(95% CI)*	0.146 *(0.126, 0.169)*	1.28 *(1.19, 1.36)*
	P-value	< 0.001*	
2018	Prevalence *(95% CI)* (%)	33.4 *(32.4, 34.5)*	35.1 *(34.2, 36.1)*
	OR[α] *(95% CI)*	0.159 *(0.135, 0.189)*	1.03 *(0.966, 1.10)*
	P-value	0.359	

** Pain, aching, or stiffness in the 30 days prior to taking the NHIS Sample Adult Questionnaire

* P < 0.05: for a significant difference between males (comparator group) and females, by logistic regression analysis

Table III: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing arthritis diagnoses in the sexes, across survey cycles 1999-2000 until 2017-2018, according to the National Health and Nutrition Examination Survey (NHANES) (Continuous)

Year	Measurement	Sex	
		Male	*Female*
1999-2000	Prevalence *(95% CI)* (%)	16.4 *(14.4, 18.3)*	23.8 *(21.6, 26.0)*
	OR[α] *(95% CI)*	0.019 *(0.008, 0.045)*	1.63 *(1.32, 2.01)*
	P-value	< 0.001*	
2001-02	Prevalence *(95% CI)* (%)	17.0 *(15.2, 18.8)*	23.4 *(21.5, 25.3)*
	OR[α] (95% CI)	0.029 *(0.016, 0.052)*	1.52 *(1.27, 1.82)*
	P-value	< 0.001*	
2003-04	Prevalence *(95% CI)* (%)	20.3 *(18.3, 22.3)*	28.0 *(25.9, 30.1)*
	OR[α] *(95% CI)*	0.022 *(0.011, 0.044)*	1.53 *(1.27, 1.83)*
	P-value	< 0.001*	
2005-06	Prevalence *(95% CI)* (%)	20.2 *(18.3, 22.2)*	28.6 *(26.4, 30.8)*
	OR[α] *(95% CI)*	0.033 *(0.019, 0.055)*	1.58 *(1.30, 1.90)*
	P-value	< 0.001*	
2007-08	Prevalence *(95% CI)* (%)	21.6 *(19.7, 23.5)*	29.5 *(27.4, 31.5)*
	OR[α] *(95% CI)*	0.022 *(0.011, 0.043)*	1.52 *(1.28, 1.80)*
	P-value	< 0.001*	
2009-10	Prevalence *(95% CI)* (%)	20.3 *(18.5, 22.1)*	27.6 *(25.7, 29.5)*
	OR[α] *(95% CI)*	0.024 *(0.013, 0.044)*	1.50 *(1.28, 1.77)*
	P-value	< 0.001*	
2011-12	Prevalence *(95% CI)* (%)	18.8 *(16.6, 20.9)*	26.9 *(24.6, 29.2)*
	OR[α] *(95% CI)*	0.021 *(0.009, 0.049)*	1.62 *(1.32, 2.00)*
	P-value	< 0.001*	
2013-14	Prevalence *(95% CI)* (%)	20.9 *(18.9, 22.9)*	32.0 *(29.9, 34.1)*
	OR[α] *(95% CI)*	0.025 *(0.013, 0.047)*	1.89 *(1.59, 2.26)*
	P-value	< 0.001*	
2015-16	Prevalence *(95% CI)* (%)	22.0 *(19.7, 24.3)*	31.5 *(29.1, 33.9)*
	OR[α] *(95% CI)*	0.034 *(0.019, 0.060)*	1.73 *(1.42, 2.11)*
	P-value	< 0.001*	

2017-18	Prevalence *(95% CI)* (%)	24.4 *(21.7, 27.0)*	31.0 *(28.5, 33.6)*
	OR[α] *(95% CI)*	0.018 *(0.009, 0.036)*	1.41 *(1.14, 1.73)*
	P-value	0.001*	

* P < 0.05: for a significant difference between males (comparator group) and females, by logistic regression analysis

Table IV: Prevalence (95% confidence interval), as well as Odds Ratios (95% confidence interval) and P-value, comparing low back pain in the sexes, across survey years 1997 until 2018 (except 2004), according to the National Health Interview Survey (NHIS)

Year	Measurement	Sex	
		Male	*Female*
1997	Prevalence *(95% CI)* (%)	26.5 *(25.7, 27.3)*	29.6 *(28.8, 30.3)*
	OR[α] *(95% CI)*	0.260 *(0.236, 0.287)*	1.16 *(1.10, 1.22)*
	P-value	< 0.001*	
1998	Prevalence *(95% CI)* (%)	26.1 *(25.3, 26.9)*	29.7 *(28.9, 30.4)*
	OR[α] (95% CI)	0.243 *(0.219, 0.270)*	1.18 *(1.12, 1.25)*
	P-value	< 0.001*	
1999	Prevalence *(95% CI)* (%)	24.6 *(23.8, 25.4)*	28.3 *(27.5, 29.1)*
	OR[α] *(95% CI)*	0.233 *(0.209, 0.259)*	1.20 *(1.13, 1.27)*
	P-value	< 0.001*	
2000	Prevalence *(95% CI)* (%)	25.5 *(24.7, 26.3)*	28.9 *(28.1, 29.6)*
	OR[α] *(95% CI)*	0.244 *(0.220, 0.271)*	1.18 *(1.11, 1.25)*
	P-value	< 0.001*	
2001	Prevalence *(95% CI)* (%)	29.4 *(28.5, 30.2)*	32.7 *(31.9, 33.5)*
	OR[α] *(95% CI)*	0.321 *(0.292, 0.353)*	1.16 *(1.10, 1.23)*
	P-value	< 0.001*	
2002	Prevalence *(95% CI)* (%)	24.3 *(23.5, 25.1)*	28.4 *(27.6, 29.2)*
	OR[α] *(95% CI)*	0.237 *(0.214, 0.263)*	1.22 *(1.15, 1.30)*
	P-value	< 0.001*	
2003	Prevalence *(95% CI)* (%)	25.2 *(24.4, 26.1)*	29.6 *(28.8, 30.3)*
	OR[α] *(95% CI)*	0.219 *(0.197, 0.243)*	1.23 *(1.16, 1.31)*
	P-value	< 0.001*	
2005	Prevalence *(95% CI)* (%)	26.3 *(25.4, 27.1)*	30.6 *(29.8, 31.4)*
	OR[α] *(95% CI)*	0.231 *(0.208, 0.258)*	1.22 *(1.15, 1.29)*
	P-value	< 0.001*	
2006	Prevalence *(95% CI)* (%)	25.8 *(24.8, 26.8)*	29.3 *(28.3, 30.2)*
	OR[α] *(95% CI)*	0.210 *(0.185, 0.239)*	1.18 *(1.10, 1.26)*
	P-value	< 0.001*	

2007	Prevalence *(95% CI)* (%)	23.6 *(22.6, 24.5)*		27.5 *(26.6, 28.4)*
	OR[α] *(95% CI)*	0.194 *(0.169, 0.222)*		1.22 *(1.13, 1.31)*
	P-value		< 0.001*	
2008	Prevalence *(95% CI)* (%)	25.2 *(24.1, 26.2)*		29.5 *(28.6, 30.5)*
	OR[α] *(95% CI)*	0.234 *(0.205, 0.268)*		1.24 *(1.15, 1.33)*
	P-value		< 0.001*	
2009	Prevalence *(95% CI)* (%)	26.3 *(25.3, 27.3)*		30.6 *(29.7, 31.6)*
	OR[α] *(95% CI)*	0.199 *(0.175, 0.226)*		1.23 *(1.15, 1.31)*
	P-value		< 0.001*	
2010	Prevalence *(95% CI)* (%)	26.7 *(25.7, 27.6)*		30.8 *(29.9, 31.7)*
	OR[α] *(95% CI)*	0.218 *(0.193, 0.246)*		1.21 *(1.14, 1.29)*
	P-value		< 0.001*	
2011	Prevalence *(95% CI)* (%)	27.3 *(26.5, 28.2)*		30.5 *(29.7, 31.3)*
	OR[α] *(95% CI)*	0.204 *(0.182, 0.229)*		1.15 *(1.09, 1.22)*
	P-value		< 0.001*	
2012	Prevalence *(95% CI)* (%)	25.8 *(24.9, 26.7)*		30.1 *(29.3, 31.0)*
	OR[α] *(95% CI)*	0.212 *(0.188, 0.238)*		1.23 *(1.16, 1.31)*
	P-value		< 0.001*	
2013	Prevalence *(95% CI)* (%)	27.1 *(26.2, 28.0)*		30.8 *(30.0, 31.7)*
	OR[α] *(95% CI)*	0.201 *(0.177, 0.228)*		1.18 *(1.11, 1.26)*
	P-value		< 0.001*	
2014	Prevalence *(95% CI)* (%)	26.5 *(25.6, 27.4)*		30.6 *(29.7, 31.6)*
	OR[α] *(95% CI)*	0.231 *(0.199, 0.268)*		1.21 *(1.13, 1.29)*
	P-value		< 0.001*	
2015	Prevalence *(95% CI)* (%)	28.3 *(27.3, 29.3)*		31.3 *(30.4, 32.2)*
	OR[α] *(95% CI)*	0.181 *(0.158, 0.208)*		1.14 *(1.07, 1.21)*
	P-value		< 0.001*	
2016	Prevalence *(95% CI)* (%)	27.4 *(26.4, 28.3)*		30.5 *(29.6, 31.4)*
	OR[α] *(95% CI)*	0.208 *(0.182, 0.237)*		1.16 *(1.08, 1.23)*
	P-value		< 0.001*	

2017	Prevalence *(95% CI)* (%)	26.3 *(25.3, 27.2)*	30.8 *(29.9, 31.8)*
	OR[α] *(95% CI)*	0.181 *(0.158, 0.208)*	1.24 *(1.16, 1.32)*
	P-value	< 0.001*	
2018	Prevalence *(95% CI)* (%)	28.0 *(27.0, 29.0)*	31.6 *(30.6, 32.5)*
	OR[α] *(95% CI)*	0.182 *(0.157, 0.211)*	1.17 *(1.09, 1.25)*
	P-value	< 0.001*	

* P < 0.05: for a significant difference between males (comparator group) and females, by logistic regression analysis

APPENDIX J

Annual employment-specific trends of each musculoskeletal pain type

Table I: Comparison of lifetime rheumatic disorder diagnoses in various employment status groups, according to the Behavioural Risk Factor Surveillance System (BRFSS), from 1996 until 2018**

Year	Employment Status	Prevalence (95% CI) (%)	OR (95% CI)	P-value
1996[α]	Employed for wages	17.3 *(16.0, 18.6)*	0.053 *(0.035, 0.082)*	
	Homemaker	31.3 *(27.5, 35.1)*	1.08 *(0.867, 1.36)*	0.476
	Retired	54.3 *(52.0, 56.7)*	1.20 *(0.963, 1.49)*	0.105
	Self-employed	22.9 *(19.3, 26.5)*	1.09 *(0.850, 1.39)*	0.504
	Student	5.0 *(2.2, 7.9)*	0.803 *(0.423, 1.53)*	0.504
	Unable to work	57.3 *(50.2, 64.4)*	4.26 *(3.10, 5.86)*	< 0.001*
	Unemployed	21.8 *(17.0, 26.6)*	1.40 *(1.01, 1.94)*	0.044*
1997[α]	Employed for wages	14.2 *(13.0, 15.5)*	0.036 *(0.024, 0.055)*	
	Homemaker	27.1 *(23.2, 31.0)*	1.26 *(0.990, 1.61)*	0.060
	Retired	47.5 *(44.6, 50.3)*	1.27 *(0.992, 1.63)*	0.058
	Self-employed	18.1 *(14.5, 21.7)*	1.09 *(0.820, 1.44)*	0.557
	Student	6.3 *(2.8, 9.7)*	1.54 *(0.851, 2.77)*	0.154
	Unable to work	54.8 *(48.4, 61.3)*	4.52 *(3.28, 6.23)*	< 0.001*
	Unemployed	19.0 *(14.5, 23.5)*	1.37 *(0.980, 1.92)*	0.066
1998[α]	Employed for wages	14.5 *(13.2, 15.7)*	0.050 *(0.029, 0.086)*	
	Homemaker	23.5 *(19.4, 27.5)*	1.10 *(0.846, 1.43)*	0.478
	Retired	47.8 *(44.9, 50.7)*	1.41 *(1.08, 1.85)*	0.013*
	Self-employed	14.0 *(10.9, 17.1)*	0.789 *(0.563, 1.02)*	0.069
	Student	6.4 *(1.4, 11.4)*	1.29 *(0.522, 3.18)*	0.581
	Unable to work	59.4 *(52.1, 66.6)*	5.06 *(3.55, 7.22)*	< 0.001*
	Unemployed	21.2 *(14.6, 27.7)*	1.59 *(1.04, 2.43)*	0.032*
1999[α]	Employed for wages	14.3 *(13.4, 15.1)*	0.045 *(0.032, 0.063)*	
	Homemaker	27.5 *(25.3, 29.8)*	1.17 *(1.01, 1.35)*	0.041*
	Retired	51.6 *(49.5, 53.7)*	1.41 *(1.19, 1.67)*	< 0.001*
	Self-employed	15.9 *(13.6, 18.1)*	0.836 *(0.687, 1.02)*	0.075
	Student	3.0 *(1.1, 4.9)*	0.626 *(0.313, 1.25)*	0.187
	Unable to work	56.2 *(52.1, 60.2)*	4.66 *(3.83, 5.68)*	< 0.001*
	Unemployed	16.6 *(12.7, 20.4)*	1.53 *(1.11, 2.10)*	0.009*
2000[α]	Employed for wages	15.1 *(14.6, 15.6)*	0.044 *(0.038, 0.052)*	
	Homemaker	25.0 *(23.5, 26.6)*	1.17 *(1.06, 1.29)*	0.002*
	Retired	49.8 *(48.6, 50.9)*	1.35 *(1.23, 1.49)*	< 0.001*
	Self-employed	17.8 *(16.6, 19.1)*	0.861 *(0.779, 0.951)*	0.003*
	Student	4.1 *(3.2, 5.1)*	0.748 *(0.582, 0.961)*	0.023*
	Unable to work	56.0 *(53.3, 58.6)*	4.13 *(3.64, 4.68)*	< 0.001*
	Unemployed	17.7 *(15.8, 19.7)*	1.32 *(1.14, 1.52)*	< 0.001*
2001	Employed for wages	14.6 *(14.3, 15.0)*	0.047 *(0.041, 0.054)*	
	Homemaker	24.7 *(23.6, 25.8)*	1.06 *(0.987, 1.14)*	0.109
	Retired	49.9 *(49.0, 50.7)*	1.34 *(1.25, 1.44)*	< 0.001*
	Self-employed	17.9 *(17.0, 18.9)*	0.950 *(0.880, 1.03)*	0.189
	Student	4.1 *(3.4, 4.8)*	0.748 *(0.620, 0.902)*	0.002*
	Unable to work	55.7 *(53.7, 57.6)*	4.45 *(4.07, 4.87)*	< 0.001*
	Unemployed	19.5 *(18.0, 20.9)*	1.57 *(1.41, 1.74)*	< 0.001*

2002[α]	Employed for wages	19.1 *(18.5, 19.6)*	0.061 *(0.052, 0.071)*	
	Homemaker	27.0 *(25.5, 28.5)*	1.05 *(0.955, 1.15)*	0.324
	Retired	53.9 *(52.8, 55.1)*	1.42 *(1.30, 1.55)*	< 0.001*
	Self-employed	21.8 *(20.5, 23.1)*	0.903 *(0.823, 0.992)*	0.033*
	Student	6.8 *(5.5, 8.1)*	0.983 *(0.783, 1.24)*	0.885
	Unable to work	58.6 *(56.0, 61.3)*	3.97 *(3.54, 4.45)*	< 0.001*
	Unemployed	20.1 *(18.4, 21.9)*	1.17 *(1.03, 1.32)*	0.014*
2003	Employed for wages	18.7 *(18.4, 19.1)*	0.069 *(0.062, 0.077)*	
	Homemaker	28.2 *(27.1, 29.2)*	1.06 *(1.00, 1.13)*	0.052
	Retired	54.5 *(53.7, 55.3)*	1.37 *(1.29, 1.45)*	< 0.001*
	Self-employed	21.2 *(20.3, 22.2)*	0.891 *(0.835, 0.952)*	< 0.001*
	Student	6.3 *(5.5, 7.2)*	0.838 *(0.714, 0.983)*	0.030*
	Unable to work	59.7 *(58.0, 61.4)*	4.20 *(3.87, 4.55)*	< 0.001*
	Unemployed	23.3 *(21.9, 24.6)*	1.48 *(1.36, 1.61)*	< 0.001*
2004[α]	Employed for wages	20.7 *(19.9, 21.6)*	0.057 *(0.045, 0.072)*	
	Homemaker	30.9 *(28.5, 33.2)*	1.07 *(0.945, 1.22)*	0.275
	Retired	56.8 *(55.2, 58.4)*	1.35 *(1.20, 1.52)*	< 0.001*
	Self-employed	24.8 *(22.7, 26.9)*	0.989 *(0.866, 1.13)*	0.865
	Student	6.1 *(4.2, 8.1)*	0.843 *(0.591, 1.20)*	0.348
	Unable to work	64.3 *(61.1, 67.5)*	4.54 *(3.88, 5.30)*	< 0.001*
	Unemployed	23.0 *(20.1, 25.9)*	1.40 *(1.16, 1.68)*	< 0.001*
2005	Employed for wages	18.5 *(18.2, 18.8)*	0.062 *(0.055, 0.070)*	
	Homemaker	25.8 *(24.9, 26.7)*	0.995 *(0.939, 1.05)*	0.855
	Retired	54.3 *(53.6, 55.0)*	1.40 *(1.33, 1.48)*	< 0.001*
	Self-employed	21.0 *(20.2, 21.9)*	0.906 *(0.854, 0.961)*	< 0.001*
	Student	6.2 *(5.4, 7.1)*	0.873 *(0.745, 1.02)*	0.091
	Unable to work	58.5 *(57.0, 60.0)*	4.16 *(3.88, 4.46)*	< 0.001*
	Unemployed	21.6 *(20.4, 22.8)*	1.36 *(1.25, 1.47)*	< 0.001*
2007	Employed for wages	18.6 *(18.3, 19.0)*	0.061 *(0.053, 0.071)*	
	Homemaker	26.3 *(25.5, 27.2)*	1.06 *(1.01, 1.12)*	0.031*
	Retired	54.1 *(53.5, 54.7)*	1.39 *(1.32, 1.45)*	< 0.001*
	Self-employed	21.3 *(20.4, 22.2)*	0.943 *(0.891, 0.997)*	0.040*
	Student	6.1 *(5.2, 7.0)*	0.898 *(0.748, 1.08)*	0.247
	Unable to work	59.5 *(58.2, 60.8)*	4.35 *(4.10, 4.63)*	< 0.001*
	Unemployed	22.3 *(21.1, 23.5)*	1.43 *(1.32, 1.55)*	< 0.001*
2009	Employed for wages	17.9 *(17.6, 18.2)*	0.045 *(0.038, 0.053)*	
	Homemaker	24.9 *(24.0, 25.7)*	1.06 *(1.01, 1.13)*	0.031*
	Retired	52.5 *(52.0, 53.0)*	1.41 *(1.35, 1.47)*	< 0.001*
	Self-employed	20.8 *(20.0, 21.5)*	0.943 *(0.893, 0.996)*	0.037 *
	Student	4.9 *(4.2, 5.6)*	0.907 *(0.761, 1.08)*	0.273
	Unable to work	59.2 *(57.9, 60.5)*	4.76 *(4.48, 5.06)*	< 0.001*
	Unemployed	19.8 *(18.9, 20.6)*	1.35 *(1.27, 1.44)*	< 0.001*
2010[α]	Employed for wages	20.4 *(19.5, 21.4)*	0.043 *(0.028, 0.066)*	
	Homemaker	31.3 *(28.9, 33.8)*	1.19 *(1.03, 1.37)*	0.017*
	Retired	57.9 *(56.6, 59.3)*	1.45 *(1.30, 1.62)*	< 0.001*
	Self-employed	24.1 *(21.7, 26.6)*	0.915 *(0.788, 1.06)*	0.248

	Student	7.3 *(4.7, 10.0)*	1.13 *(0.709, 1.79)*	0.614
	Unable to work	64.0 *(61.4, 66.6)*	4.63 *(4.05, 5.30)*	< 0.001*
	Unemployed	22.1 *(19.2, 25.0)*	1.39 *(1.14, 1.70)*	< 0.001*
2011	Employed for wages	15.6 *(15.3, 15.9)*	0.036 *(0.032, 0.042)*	
	Homemaker	24.6 *(23.8, 25.4)*	1.13 *(1.08, 1.19)*	< 0.001*
	Retired	50.5 *(50.0, 51.0)*	1.53 *(1.47, 1.60)*	< 0.001*
	Self-employed	18.9 *(18.2, 19.6)*	0.984 *(0.931, 1.04)*	0.572
	Student	4.4 *(3.8, 5.0)*	0.968 *(0.828, 1.13)*	0.684
	Unable to work	59.1 *(58.0, 60.3)*	5.40 *(5.11, 5.70)*	< 0.001*
	Unemployed	19.3 *(18.5, 20.1)*	1.51 *(1.42, 1.60)*	< 0.001*
2012	Employed for wages	16.0 *(15.7, 16.3)*	0.038 *(0.033, 0.043)*	
	Homemaker	26.0 *(25.0, 26.9)*	1.19 *(1.12, 1.26)*	< 0.001*
	Retired	51.9 *(51.4, 52.5)*	1.59 *(1.52, 1.66)*	< 0.001*
	Self-employed	19.6 *(18.9, 20.4)*	0.980 *(0.926, 1.04)*	0.493
	Student	4.6 *(4.1, 5.2)*	1.01 *(0.870, 1.16)*	0.935
	Unable to work	60.5 *(59.3, 61.7)*	5.64 *(5.32, 5.98)*	< 0.001*
	Unemployed	20.7 *(19.8, 21.6)*	1.54 *(1.44, 1.64)*	< 0.001*
2013	Employed for wages	15.5 *(15.2, 15.8)*	0.035 *(0.031, 0.040)*	
	Homemaker	24.7 *(23.7, 25.6)*	1.14 *(1.07, 1.21)*	< 0.001*
	Retired	50.6 *(50.0, 51.2)*	1.51 *(1.45, 1.58)*	< 0.001*
	Self-employed	18.3 *(17.6, 19.1)*	0.942 *(0.890, 0.997)*	0.038*
	Student	4.5 *(3.9, 5.1)*	1.05 *(0.906, 1.23)*	0.500
	Unable to work	59.4 *(58.3, 60.5)*	5.43 *(5.14, 5.73)*	< 0.001*
	Unemployed	21.3 *(20.4, 22.2)*	1.66 *(1.56, 1.77)*	< 0.001*
2014	Employed for wages	15.8 *(15.5, 16.0)*	0.033 *(0.029, 0.037)*	
	Homemaker	24.8 *(23.8, 25.7)*	1.14 *(1.07, 1.21)*	< 0.001*
	Retired	51.7 *(51.2, 52.3)*	1.57 *(1.50, 1.64)*	< 0.001*
	Self-employed	18.9 *(18.2, 19.6)*	0.942 *(0.890, 0.997)*	0.038*
	Student	4.4 *(3.8, 5.0)*	1.04 *(0.885, 1.22)*	0.652
	Unable to work	59.7 *(58.6, 60.8)*	5.32 *(5.05, 5.60)*	< 0.001*
	Unemployed	21.5 *(20.5, 22.5)*	1.66 *(1.54, 1.78)*	< 0.001*
2015	Employed for wages	14.9 *(14.6, 15.2)*	0.035 *(0.031, 0.039)*	
	Homemaker	24.6 *(23.7, 25.6)*	1.24 *(1.17, 1.32)*	< 0.001*
	Retired	50.1 *(49.6, 50.7)*	1.64 *(1.57, 1.72)*	< 0.001*
	Self-employed	17.7 *(17.0, 18.4)*	0.948 *(0.895, 1.00)*	0.070
	Student	4.0 *(3.5, 4.5)*	0.978 *(0.842, 1.14)*	0.773
	Unable to work	58.4 *(57.3, 59.5)*	5.26 *(5.00, 5.55)*	< 0.001*
	Unemployed	19.8 *(18.8, 20.7)*	1.53 *(1.43, 1.63)*	< 0.001*
2016	Employed for wages	15.3 *(15.0, 15.6)*	0.036 *(0.032, 0.041)*	
	Homemaker	24.1 *(23.1, 25.1)*	1.15 *(1.08, 1.22)*	< 0.001*
	Retired	51.4 *(50.8, 51.9)*	1.66 *(1.58, 1.73)*	< 0.001*
	Self-employed	18.6 *(17.8, 19.3)*	0.944 *(0.892, 0.999)*	0.044*
	Student	3.7 *(3.2, 4.3)*	0.893 *(0.759, 1.05)*	0.169
	Unable to work	59.1 *(58.0, 60.1)*	5.18 *(4.91, 5.46)*	< 0.001*
	Unemployed	21.4 *(20.3, 22.4)*	1.61 *(1.50, 1.73)*	< 0.001*

2017	Employed for wages	14.7 (14.4, 15.1)	0.036 *(0.031, 0.041)*	
	Homemaker	23.7 (22.5, 24.9)	1.16 *(1.08, 1.25)*	< 0.001*
	Retired	48.5 (47.9, 49.1)	1.51 *(1.43, 1.59)*	< 0.001*
	Self-employed	18.2 (17.4, 19.0)	0.971 *(0.912, 1.03)*	0.348
	Student	3.5 (3.0, 4.0)	0.875 *(0.733, 1.04)*	0.137
	Unable to work	58.6 (57.5, 59.8)	5.23 *(4.93, 5.54)*	< 0.001*
	Unemployed	23.5 (22.3, 24.7)	1.79 *(1.66, 1.93)*	< 0.001*
2018	Employed for wages	15.8 *(15.5, 16.2)*	0.041 *(0.036, 0.046)*	
	Homemaker	25.0 *(23.8, 26.1)*	1.17 *(1.09, 1.26)*	< 0.001*
	Retired	50.8 *(50.2, 51.4)*	1.58 *(1.50, 1.67)*	< 0.001*
	Self-employed	19.2 *(18.4, 20.0)*	0.971 *(0.915, 1.03)*	0.323
	Student	3.7 *(3.2, 4.2)*	0.801 *(0.679, 0.945)*	0.009*
	Unable to work	58.9 *(57.7, 60.1)*	4.72 *(4.45, 5.01)*	< 0.001*
	Unemployed	21.9 *(20.7, 23.1)*	1.59 *(1.46, 1.73)*	< 0.001*

** Rheumatic disorder diagnoses: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[α] Module questionnaire years

* $P < 0.05$: for a significant difference between the comparator group (employed for wages) by logistic regression analysis

Table II: Comparison of joint symptom reports by employment status, according to the National Health Interview Survey (NHIS), from 2002 to 2018**

Year	Employment Status	Prevalence (95% CI) (%)	OR *(95% CI)*	P-value
2002	Working for pay at a job/business	24.8 *(24.1, 25.5)*	0.148 *(0.130, 0.168)*	< 0.001*
	Not working	33.4 *(32.0, 34.7)*	1.49 *(1.38, 1.60)*	
2003	Working for pay at a job/business	26.7 *(26.0, 27.4)*	0.165 *(0.145, 0.187)*	< 0.001*
	Not working	35.2 *(33.8, 36.5)*	1.43 *(1.33, 1.54)*	
2005	Working for pay at a job/business	25.3 *(31.2, 45.2)*	0.143 *(0.123, 0.165)*	< 0.001*
	Not working	42.6 *(41.5, 43.7)*	1.47 *(1.37, 1.59)*	
2006	Working for pay at a job/business	24.2 *(23.3, 39.5)*	0.115 *(0.097, 0.135)*	< 0.001*
	Not working	40.3 *(39.0, 41.5)*	1.45 *(1.33, 1.59)*	
2007	Working for pay at a job/business	22.5 *(18.2, 33.5)*	0.100 *(0.083, 0.120)*	< 0.001*
	Not working	37.2 *(36.0, 38.4)*	1.43 *(1.31, 1.57)*	
2008	Working for pay at a job/business	26.4 *(25.5, 27.3)*	0.173 *(0.146, 0.205)*	< 0.001*
	Not working	41.3 *(40.0, 42.6)*	1.41 *(1.29, 1.55)*	
2009	Working for pay at a job/business	27.8 *(26.8, 28.7)*	0.155 *(0.131, 0.185)*	< 0.001*
	Not working	43.4 *(42.1, 44.6)*	1.44 *(1.32, 1.56)*	
2010	Working for pay at a job/business	28.6 *(27.7, 29.5)*	0.166 *(0.142, 0.194)*	< 0.001*
	Not working	43.0 *(41.8, 44.2)*	1.39 *(1.28, 1.51)*	
2011	Working for pay at a job/business	27.3 *(26.5, 28.1)*	0.131 *(0.114, 0.151)*	< 0.001*
	Not working	45.0 *(43.9, 46.1)*	1.60 *(1.48, 1.72)*	
2012	Working for pay at a job/business	24.5 *(23.7, 25.3)*	0.130 *(0.112, 0.151)*	< 0.001*
	Not working	41.8 *(40.7, 42.9)*	1.70 *(1.57, 1.83)*	
2013	Working for pay at a job/business	25.6 *(24.8, 26.5)*	0.140 *(0.119, 0.165)*	< 0.001*
	Not working	43.8 *(42.7, 44.9)*	1.56 *(1.44, 1.68)*	
2014	Working for pay at a job/business	27.2 *(26.4, 28.1)*	0.160 *(0.137, 0.186)*	< 0.001*
	Not working	42.5 *(41.4, 43.7)*	1.37 *(1.27, 1.48)*	
2015	Working for pay at a job/business	27.7 *(26.9, 28.6)*	0.146 *(0.123, 0.173)*	< 0.001*
	Not working	44.4 *(43.3, 45.6)*	1.44 *(1.33, 1.56)*	
2016	Working for pay at a job/business	27.7 *(26.9, 28.6)*	0.148 *(0.126, 0.173)*	< 0.001*
	Not working	44.8 *(43.7, 46.0)*	1.48 *(1.37, 1.60)*	
2017	Working for pay at a job/business	28.0 *(27.1, 28.9)*	0.162 *(0.138, 0.191)*	< 0.001*
	Not working	45.6 *(44.4, 46.9)*	1.46 *(1.35, 1.58)*	
2018	Working for pay at a job/business	27.5 *(26.7, 28.4)*	0.138 *(0.115, 0.166)*	< 0.001*
	Not working	46.4 *(45.2, 47.7)*	1.49 *(1.37, 1.62)*	

* $P < 0.05$: for a significant difference between those working for pay at a job/business (comparator group) and those without work, by logistic regression analysis

** Pain, aching, or stiffness in the 30 days prior to taking the NHIS Sample Adult Questionnaire

Table III: Comparison of lifetime arthritis diagnoses, by employment status, according to the National Health and Nutrition Examination Survey (NHANES) (Continuous) survey, from the 1999-2000 survey cycle until the 2017-18 survey cycle

Year	Employment status	Prevalence (95% CI) (%)	OR *(95% CI)*	P-value
1999-2000	Working for pay at a job/business	12.2 *(10.6, 13.9)*	0.026 *(0.011, 0.062)*	< 0.001*
	Not working	36.7 *(33.8, 39.6)*	1.81 *(1.41, 2.33)*	
2001-02	Working for pay at a job/business	13.9 *(12.4, 15.5)*	0.038 *(0.020, 0.069)*	< 0.001*
	Not working	33.6 *(31.1, 36.1)*	1.69 *(1.35, 2.11)*	
2003-04	Working for pay at a job/business	15.6 *(13.9, 17.4)*	0.028 *(0.014, 0.058)*	< 0.001*
	Not working	41.4 *(38.7, 44.0)*	1.98 *(1.60, 2.46)*	
2005-06	Working for pay at a job/business	16.3 *(14.6, 18.0)*	0.041 *(0.023, 0.073)*	< 0.001*
	Not working	42.2 *(39.4, 44.9)*	1.74 *(1.39, 2.17)*	
2007-08	Working for pay at a job/business	17.2 *(15.5, 18.9)*	0.021 *(0.010, 0.046)*	< 0.001*
	Not working	42.2 *(39.7, 44.6)*	1.90 *(1.57, 2.31)*	
2009-10	Working for pay at a job/business	16.1 *(14.5, 17.7)*	0.029 *(0.015, 0.055)*	< 0.001*
	Not working	39.6 *(37.3, 41.9)*	1.87 *(1.55, 2.26)*	
2011-12	Working for pay at a job/business	15.8 *(13.7, 17.8)*	0.023 *(0.009, 0.063)*	< 0.001*
	Not working	37.2 *(34.4, 39.9)*	1.79 *(1.41, 2.28)*	
2013-14	Working for pay at a job/business	17.6 *(15.8, 19.4)*	0.037 *(0.019, 0.074)*	< 0.001*
	Not working	43.0 *(40.4, 45.6)*	1.83 *(1.50, 2.23)*	
2015-16	Working for pay at a job/business	17.5 *(15.6, 19.5)*	0.050 *(0.027, 0.091)*	< 0.001*
	Not working	46.3 *(43.3, 49.4)*	1.96 *(1.55, 2.48)*	
2017-18	Working for pay at a job/business	18.1 *(15.8, 20.3)*	0.021 *(0.010, 0.043)*	< 0.001*
	Not working	48.1 *(45.0, 51.2)*	2.07 *(1.62, 2.63)*	

* P < 0.05: for a significant difference between males (comparator group) and females, by logistic regression analysis

Table IV: Comparison of low back pain reports by employment status, according to the National Health Interview Survey (NHIS), from 2002 to 2018

Year	Employment Status	Prevalence (95% CI) (%)	OR *(95% CI)*	P-value
2002	Working for pay at a job/business	24.0 *(23.3, 24.7)*	0.238 *(0.213, 0.266)*	< 0.001*
	Not working	32.9 *(31.5, 34.2)*	1.55 *(1.44, 1.67)*	
2003	Working for pay at a job/business	25.0 *(24.2, 25.7)*	0.224 *(0.200, 0.251)*	< 0.001*
	Not working	33.6 *(32.3, 34.9)*	1.53 *(1.42, 1.65)*	
2005	Working for pay at a job/business	24.9 *(24.1, 25.6)*	0.225 *(0.199, 0.254)*	< 0.001*
	Not working	35.1 *(34.0, 36.1)*	1.60 *(1.49, 1.73)*	
2006	Working for pay at a job/business	24.0 *(23.1, 24.8)*	0.193 *(0.166, 0.223)*	< 0.001*
	Not working	34.0 *(32.8, 35.3)*	1.67 *(1.53, 1.82)*	
2007	Working for pay at a job/business	22.3 *(21.5, 23.2)*	0.185 *(0.159, 0.215)*	< 0.001*
	Not working	31.9 *(30.7, 33.1)*	1.66 *(1.52, 1.82)*	
2008	Working for pay at a job/business	24.4 *(23.5, 25.3)*	0.246 *(0.211, 0.287)*	< 0.001*
	Not working	32.9 *(31.6, 34.1)*	1.48 *(1.35, 1.63)*	
2009	Working for pay at a job/business	25.1 *(24.2, 26.0)*	0.195 *(0.167, 0.226)*	< 0.001*
	Not working	34.7 *(33.5, 35.9)*	1.64 *(1.51, 1.79)*	
2010	Working for pay at a job/business	25.7 *(24.8, 26.5)*	0.215 *(0.186, 0.249)*	< 0.001*
	Not working	34.9 *(33.7, 36.0)*	1.64 *(1.51, 1.78)*	
2011	Working for pay at a job/business	24.8 *(24.0, 25.5)*	0.181 *(0.157, 0.207)*	< 0.001*
	Not working	35.9 *(34.9, 36.9)*	1.81 *(1.68, 1.95)*	
2012	Working for pay at a job/business	24.4 *(23.6, 25.2)*	0.203 *(0.177, 0.233)*	< 0.001*
	Not working	34.6 *(33.5, 35.6)*	1.78 *(1.64, 1.92)*	
2013	Working for pay at a job/business	24.6 *(23.8, 25.4)*	0.184 *(0.158, 0.214)*	< 0.001*
	Not working	36.3 *(35.2, 37.4)*	1.78 *(1.65, 1.93)*	
2014	Working for pay at a job/business	24.4 *(23.5, 25.2)*	0.217 *(0.179, 0.263)*	< 0.001*
	Not working	35.6 *(34.5, 36.7)*	1.72 *(1.58, 1.87)*	
2015	Working for pay at a job/business	26.1 *(25.2, 26.9)*	0.167 *(0.143, 0.196)*	< 0.001*
	Not working	36.1 *(35.0, 37.3)*	1.62 *(1.49, 1.76)*	
2016	Working for pay at a job/business	25.0 *(24.1, 25.8)*	0.181 *(0.155, 0.212)*	< 0.001*
	Not working	36.2 *(35.1, 37.3)*	1.81 *(1.66, 1.96)*	
2017	Working for pay at a job/business	24.6 *(23.7, 25.4)*	0.71 *(0.145, 0.201)*	< 0.001*
	Not working	35.6 *(34.5, 36.8)*	1.74 *(1.60, 1.90)*	
2018	Working for pay at a job/business	25.8 *(24.9, 26.7)*	0.175 *(0.148, 0.208)*	< 0.001*
	Not working	37.5 *(36.4, 38.7)*	1.62 *(1.48, 1.75)*	

* P < 0.05: for a significant difference between those working for pay at a job/business (comparator group) and those without work, by logistic regression analysis

APPENDIX K

Geospatial trends: state-specific trends of rheumatic disorder diagnoses (BRFSS)

Appendix K consists of tables showing the spatial correlation (Global Moran's I) results and corresponding P-values, median rheumatic disorder diagnosis prevalence and interquartile range by state, as well as five states at the upper and lower regions. Appendix K also consists of annual state prevalences for all states in the overall population, various age groups, and the sexes.

Table I: Spatial trends in the prevalence of rheumatic disorders in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS)

Y[π]	**Global Moran's I (variance)**	**P-value**	**Median prevalence estimate (IQR[0])**	**Five states/regions with the highest prevalence**		**Five states/regions with the lowest prevalence**	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
2001	0.354 (0.010)	< 0.001 *	22.1 (20.6, 25.6)	West Virginia	30.5 [28.8, 32.3]	Hawaii	11.8 [10.6, 13.0]
				Alabama	30.3 [28.4, 32.2]	Alaska	16.8 [15.0, 18.7]
				Kentucky	30.0 [28.5, 31.4]	Puerto Rico	18.0 [16.6, 19.4]
				Michigan	28.7 [27.1, 30.3]	California	18.9 [17.4, 20.3]
				Arkansas	27.4 [25.6, 29.1]	Wyoming	19.7 [18.2, 21.2]
2003	0.281 (0.009)	< 0.001 *	27.0 (25.6, 28.7)	West Virginia	37.2 [35.4, 39.1]	Hawaii	17.9 [16.5, 19.2]
				Kentucky	34.6 [33.0, 36.2]	California	22.0 [20.6, 23.4]
				Alabama	34.0 [32.1, 35.1]	Utah	22.3 [20.7, 24.0]
				Michigan	32.3 [30.6, 34.0]	District of Columbia	23.1 [20.8, 25.3]
				Pennsylvania	31.6 [29.9, 33.3]	Texas	24.1 [22.9, 25.3]
2005	0.239 (0.009)	0.004 *	26.9 (25.5, 29.3)	West Virginia	34.9 [33.1, 36.6]	Hawaii	22.1 [20.8, 23.5]
				Alabama	32.9 [30.9, 34.9]	California	22.3 [21.0, 23.6]
				Missouri	32.1 [30.3, 34.0]	Texas	22.3 [21.1, 23.5]
				Mississippi	32.1 [30.5, 33.8]	District of Columbia	22.4 [20.7, 24.1]
				Pennsylvania	31.7 [30.5, 32.8]	Utah	22.7 [21.3, 24.0]
2007	0.333 (0.009)	< 0.001 *	27.5 (25.3, 30.1)	West Virginia	35.6 [33.9, 37.2]	California	20.8 [19.5, 22.1]
				Alabama	34.7 [33.1, 36.3]	Utah	21.8 [20.4, 23.2]
				Tennessee	34.0 [32.1, 35.9]	Puerto Rico	22.1 [20.7, 23.5]
				Maine	32.2 [30.9, 33.6]	Minnesota	22.9 [21.6, 24.3]

				Ohio	32.2 [31.0, 33.4]	District of Columbia	23.6 [22.0, 25.1]
2009	0.212 (0.010)	0.008 *	25.9 (23.9, 29.1)	Kentucky	35.6 [33.8, 37.3]	Puerto Rico	18.1 [16.9, 19.4]
				Alabama	34.0 [32.3, 35.6]	California	20.3 [19.5, 21.1]
				West Virginia	33.9 [32.3, 35.4]	District of Columbia	20.8 [19.4, 22.3]
				Pennsylvania	31.3 [30.0, 32.6]	Minnesota	20.9 [19.6, 22.2]
				Arkansas	31.3 [29.3, 33.3]	Hawaii	21.2 [19.9, 22.4]
2011	0.281 (0.009)	< 0.001 *	24.4 (23.1, 26.9)	West Virginia	35.9 [34.4, 37.5]	Hawaii	18.2 [17.1, 19.4]
				Kentucky	31.9 [30.5, 33.2]	Puerto Rico	19.7 [18.6, 20.7]
				Michigan	31.0 [29.8, 32.2]	Utah	19.8 [18.9, 20.6]
				Alabama	30.2 [28.8, 31.5]	Texas	20.2 [19.2, 21.2]
				Maine	29.7 [28.7, 30.6]	Minnesota	20.5 [19.6, 21.3]
2012	0.275 (0.009)	0.001 *	25.5 (23.9, 28.0)	West Virginia	36.4 [35.0, 37.9]	Utah	20.0 [19.2, 20.8]
				Kentucky	35.0 [33.7, 36.4]	Hawaii	20.3 [19.0, 21.7]
				Alabama	33.9 [32.6, 35.3]	Texas	21.3 [20.3, 22.4]
				Michigan	31.8 [30.7, 32.9]	Minnesota	21.5 [20.6, 22.4]
				Mississippi	30.8 [29.4, 32.1]	New Jersey	21.8 [21.0, 22.7]
2013	0.253 (0.009)	0.002 *	25.1 (23.6, 27.8)	West Virginia	36.2 [34.8, 37.6]	District of Columbia	19.5 [18.0, 21.0]
				Alabama	32.2 [30.7, 33.7]	Utah	19.5 [18.7, 20.3]
				Kentucky	31.9 [30.6, 33.2]	Minnesota	19.9 [18.7, 21.1]
				Michigan	31.3 [30.3, 32.4]	Hawaii	19.9 [18.7, 21.2]
				Maine	30.4 [29.2, 31.7]	California	20.4 [19.4, 21.3]
2014	0.310 (0.009)	< 0.001 *	26.0 (24.6, 28.0)	West Virginia	40.0 [38.6, 41.4]	District of Columbia	19.2 [17.4, 20.9]
				Alabama	34.0 [32.7, 35.3]	Texas	19.5 [18.5, 20.4]
				Kentucky	34.0 [32.6, 35.3]	Utah	20.1 [19.3, 20.8]
				Tennessee	32.6 [30.9, 34.3]	California	20.4 [19.3, 21.4]
				Michigan	31.9 [30.7, 33.1]	Hawaii	20.7 [18.5, 20.4]

2015	0.252 (0.009)	0.002 *	24.7 (23.2, 27.9)	West Virginia	38.0 [36.6, 39.4]	District of Columbia	18.5 [16.6, 20.4]
				Alabama	33.3 [31.9, 34.6]	Hawaii	18.9 [17.8, 20.0]
				Tennessee	32.0 [30.3, 33.7]	California	19.1 [18.3, 20.0]
				Kentucky	32.0 [30.4, 33.5]	Utah	19.6 [18.7, 20.4]
				Maine	31.0 [29.7, 32.3]	Texas	20.0 [19.0, 20.4]
2016	0.248 (0.009)	0.003 *	25.5 (23.8, 28.0)	West Virginia	38.9 [37.6, 40.2]	District of Columbia	16.9 [15.6, 18.1]
				Maine	33.8 [32.4, 35.2]	California	19.0 [18.0, 19.9]
				Alabama	33.6 [32.2, 34.9]	Utah	19.8 [18.9, 20.7]
				Kentucky	33.5 [32.2, 34.8]	Texas	21.7 [20.3, 23.0]
				Arkansas	33.4 [31.3, 35.6]	Hawaii	21.9 [20.7, 23.2]
2017	0.254 (0.009)	0.002 *	24.8 (22.6, 27.8)	West Virginia	39.2 [37.6, 40.7]	District of Columbia	14.3 [13.1, 15.4]
				Alabama	33.3 [31.9, 34.8]	Utah	19.3 [18.4, 20.2]
				Kentucky	32.4 [0.8, 33.9]	California	19.4 [18.3, 20.5]
				Maine	31.2 [29.8, 32.6]	Minnesota	19.8 [19.1, 20.4]
				Arkansas	30.9 [28.8, 33.0]	Nevada	20.3 [18.5, 22.1]
2018	0.269 (0.009)	0.001 *	26.1 (24.6, 29.1)	West Virginia	40.1 [38.5, 41.8]	District of Columbia	20.5 [19.6, 21.5]
				Kentucky	33.4 [31.8, 34.9]	California	20.5 [19.6, 21.5]
				Tennessee	32.5 [30.8, 34.1]	Utah	21.6 [20.7, 22.5]
				Alabama	34.7 [33.3, 36.2]	Hawaii	22.2 [21.0, 23.6]
				Arkansas	33.0 [31.3, 34.7]	Colorado	22.6 [21.7, 23.6]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

[θ] IQR – Interquartile range

[α]Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[π] Y: Year

Table II: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2001

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	0.069 (0.009)	0.175	3.8 (2.7, 4.8)	Montana	8.7 [4.2, 13.2]	Puerto Rico	1.1 [0.2, 2.0]
				Alabama	7.0 [3.7, 10.4]	District of Columbia	1.2 [0.0, 2.5]
				Rhode Island	6.9 [3.1, 10.8]	Nevada	1.6 [0.0, 3.4]
				Michigan	6.7 [3.7, 9.8]	Delaware	1.8 [0.1, 3.4]
				Kansas	5.8 [2.4, 9.1]	Alaska	1.9 [0.5, 3.3]
25 to 29	0.108 (0.009)	0.084	5.5 (4.3, 5.9)	West Virginia	17.7 [11.5, 23.9]	Puerto Rico	0.4 [0.0, 0.8]
				Kentucky	12.5 [7.4, 17.5]	District of Columbia	0.6 [0.0, 1.4]
				Arkansas	11.2 [5.3, 17.0]	Nebraska	1.2 [0.1, 2.4]
				Rhode Island	10.5 [6.4, 14.7]	South Carolina	2.7 [1.0, 4.4]
				New Hampshire	10.2 [5.2, 15.3]	Hawaii	2.9 [0.7, 5.0]
30 to 34	0.239 (0.009)	0.003 *	7.5 (5.7, 9.5)	Kentucky	15.8 [11.9, 19.6]	Hawaii	1.3 [0.1, 2.4]
				West Virginia	15.5 [10.6, 2..4]	Puerto Rico	2.6 [0.4, 4.8]
				Tennessee	12.5 [8.0, 16.9]	North Dakota	4.2 [1.3, 7.1]
				Pennsylvania	11.8 [7.3, 16.3]	Alaska	4.4 [1.7, 7.1]
				Maine	11.4 [6.3, 16.5]	Maryland	4.9 [2.5, 7.2]
35 to 39	0.096 (0.010)	0.117	10.5 (8.9, 13.1)	West Virginia	17.6 [12.7, 22.4]	Hawaii	6.0 [2.8, 9.3]
				Indiana	17.1 [130, 21.2]	District of Columbia	7.2 [3.4, 10.9]
				Kentucky	16.8 [13.4, 20.2]	California	7.6 [4.9, 10.2]
				Michigan	16.7 [12.6, 20.8]	New Jersey	8.0 [5.6, 10.3]
				Missouri	15.5 [10.5, 20.4]	Washington	8.0 [5.4, 10.7]

40 to 44	0.226 (0.009)	0.002 *	15.5 (12.9, 18.3)	Alabama	25.4 [19.9, 31.0]	Hawaii	5.3 [2.9, 7.6]
				Kentucky	23.8 [19.6, 28.1]	Puerto Rico	7.6 [4.7, 10.6]
				West Virginia	21.3 [16.3, 26.2]	Iowa	9.6 [6.3, 12.9]
				Michigan	21.0 [16.9, 25.1]	Illinois	10.3 [6.2, 14.4]
				Missouri	20.5 [15.2, 25.8]	Connecticut	10.8 [8.4, 13.1]
45 to 49	0.283 (0.009)	< 0.001 *	21.2 (18.9, 23.8)	West Virginia	34.3 [28.4, 40.3]	Hawaii	11.4 [7.8, 15.1]
				Kentucky	32.6 [28.0, 37.2]	Nebraska	15.1 [11.3, 19.6]
				Alabama	31.3 [25.5, 37.0]	Connecticut	15.7 [12.7, 18.7]
				Michigan	30.8 [25.9, 35.8]	Minnesota	16.2 [12.1, 20.4]
				Tennessee	28.5 [22.2, 34.8]	Puerto Rico	16.5 [11.5, 21.5]
50 to 54	0.300 (0.010)	< 0.001 *	27.1 (24.2, 31.3)	Tennessee	37.4 [29.6, 45.3]	Hawaii	12.9 [8.8, 17.1]
				Mississippi	37.3 [31.0, 43.5]	Wyoming	19.9 [15.3, 24.4]
				Indiana	37.1 [31.7, 42.5]	District of Columbia	20.7 [13.5, 27.9]
				Michigan	37.0 [31.7, 42.3]	Colorado	22.0 [15.5, 28.5]
				Kentucky	36.1 [31.1, 41.2]	Puerto Rico	22.8 [17.9, 27.6]
55 to 59	0.321 (0.010)	< 0.001 *	36.8 (32.5, 40.2)	Alabama	51.7 [42.6, 60.7]	Hawaii	14.6 [9.3, 20.0]
				Michigan	46.3 [40.1, 52.6]	California	27.1 [21.4, 32.7]
				Missouri	46.1 [38.1, 54.2]	Colorado	28.5 [19.4, 37.6]
				Kentucky	45.4 [39.7, 51.1]	Nebraska	29.0 [22.7]
				Ohio	44.4 [36.8, 52.1]	Texas	29.5 [24.6, 34.4]
60 to 64	0.038 (0.009)	0.271	42.9 (38.9, 46.3)	West Virginia	52.8 [45.6, 60.1]	Hawaii	27.9 [20.6, 35.3]
				Missouri	51.3 42.7, 59.8]	Nevada	28.7 [19.7, 37.7]
				Kentucky	50.7 [44.6, 56.9]	Wyoming	31.0 [23.7, 38.4]
				Alabama	50.6 [42.5, 58.7]	North Dakota	31.8 [23.4, 40.3]
				Utah	50.2 [40.4, 59.9]	District of Columbia	33.0 [22.7, 43.4]

65 to 69	0.189 (0.009)	0.016 *	46.9 (42.6, 51.1)	Alabama	60.1 [52.0, 68.2]	Hawaii	23.3 [16.2, 30.4]
				Kentucky	59.8 [53.6, 66.0]	Oregon	39.0 [29.6, 48.3]
				Michigan	59.8 [52.2, 67.3]	Iowa	39.2 [32.2, 46.3]
				Georgia	56.1 [48.5, 63.7]	Minnesota	39.5 [32.3, 46.6]
				Indiana	54.4 [47.1, 61.8]	Connecticut	40.6 [34.9, 46.4]
70 & over	0.437 (0.009)	< 0.001 *	54.0 (50.1, 57.1)	Alabama	66.9 [61.8, 72.1]	Hawaii	31.3 [26.5, 36.0]
				Michigan	61.1 [56.3, 65.9]	Alaska	39.3 [28.9, 49.6]
				Mississippi	61.0 [55.7, 66.2]	Wyoming	43.3 [37.8, 48.8]
				Oklahoma	60.4 [55.8, 65.0]	Massachusetts	47.0 [43.6, 50.5]
				District of Columbia	60.3 [52.8, 67.8]	Minnesota	47.4 [43.1, 51.7]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

[θ] IQR – Interquartile range

[α]Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[π] A: Age group (years)

Table III: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2003

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.014 (0.009)	0.472	6.0 (5.0, 7.3)	Kentucky	12.0 [7.6, 16.5]	Florida	2.4 [0.7, 4.1]
				Minnesota	11.2 [6.4, 16.1]	Hawaii	2.4 [0.6, 4.2]
				Nevada	8.8 [4.0, 13.7]	Puerto Rico	2.9 [0.6, 5.1]
				Arizona	8.3 [2.4, 14.2]	California	3.4 [1.5, 5.3]
				South Carolina	8.1 [5.2, 11.1]	Nebraska	3.9 [1.7, 6.0]
25 to 29	0.170 (0.010)	0.025 *	8.3 (6.5, 10.0)	Kentucky	12.6 [8.6, 16.6]	Puerto Rico	2.8 [0.0, 6.1]
				West Virginia	12.5 [6.8, 18.2]	District of Columbia	3.3 [0.9, 5.6]
				Alabama	12.5 [7.6, 17.4]	Hawaii	3.6 [1.3, 5.8]
				Tennessee	12.5 [6.2, 18.8]	Nevada	3.9 [1.1, 6.7]
				New Hampshire	11.9 [7.7, 16.1]	Florida	4.2 [1.4, 6.9]
30 to 34	0.213 (0.009)	0.008 *	10.7 (8.8, 13.0)	West Virginia	21.1 [15.8, 26.5]	District of Columbia	3.5 [0.8, 6.2]
				Tennessee	17.9 [12.0, 23.9]	Florida	4.6 [2.3, 7.0]
				Pennsylvania	17.2 12.1, 22.3]	California	6.1 [3.7, 8.5]
				Michigan	16.4 [11.4, 21.5]	Maine	6.4 [2.5, 10.3]
				Arkansas	16.4 [12.3, 20.4]	Puerto Rico	6.5 [3.4, 9.36]
35 to 39	0.138 (0.009)	0.051	14.7 (13.3, 16.9)	Nevada	23.3 [16.5, 30.1]	Hawaii	6.7 [3.8, 9.5]
				Tennessee	22.9 [16.9, 28.9]	Maryland	9.6 [6.6, 12.6]
				Kentucky	22.8 [18.1, 27.5]	District of Columbia	10.0 [4.7, 15.3]
				West Virginia	22.3 [16.8, 27.8]	Puerto Rico	10.8 [7.3, 14.2]
				Maine	20.4 [14.6, 26.2]	Connecticut	11.2 [8.4, 13.9]

40 to 44	0.343 (0.009)	< 0.001 *	19.4 (16.9, 21.8)	West Virginia	34.4 [28.3, 40.6]	Puerto Rico	13.6 [9.7, 17.5]
				Kentucky	30.8 [25.7, 35.9]	Hawaii	14.0 [9.9, 18.1]
				Tennessee	29.2 [22.8, 35.7]	Nevada	14.3 [9.3, 19.3]
				Alabama	28.9 [23.1, 34.6]	Illinois	14.9 [10.3, 19.5]
				Indiana	24.9 [21.0, 28.8]	Montana	15.0 [11.0, 19.0]
45 to 49	0.260 (0.009)	0.002 *	26.9 (24.7, 29.7)	Alabama	39.6 [33.4, 45.7]	Hawaii	15.6 [11.5, 19.8]
				Kentucky	37.8 [32.9, 42.8]	California	16.8 [12.9, 20.8]
				Mississippi	37.3 [32.1, 42.5]	Massachusetts	20.3 [16.7, 23.9]
				West Virginia	35.4 [29.8, 41.1]	Utah	20.6 [15.6, 25.7]
				Michigan	33.9 [28.4, 39.5]	Texas	21.4 [17.7, 25.0]
50 to 54	0.390 (0.010)	< 0.001 *	33.7 (31.1, 37.4)	Mississippi	46.2 [40.9, 51.4]	Hawaii	22.0 [17.2, 26.8]
				West Virginia	45.8 [40.1, 51.6]	Connecticut	26.8 [22.4, 31.2]
				Michigan	44.7 [38.8, 50.6]	Puerto Rico	27.2 [21.5, 32.8]
				Kentucky	43.8 [38.6, 49.0]	Montana	28.1 [22.9, 33.3]
				North Carolina	41.4 [36.3, 46.5]	Wisconsin	28.1 [22.9, 33.4]
55 to 59	0.193 (0.009)	0.013 *	42.5 (39.8, 46.8)	Alabama	60.2 [54.1, 66.3]	Hawaii	28.3 [22.2, 34.4]
				Michigan	57.2 [51.2, 63.3]	Montana	33.5 [27.2, 39.8]
				Kentucky	56.4 [51.1, 61.8]	Arizona	34.9 [27.9, 42.0]
				West Virginia	51.9 [51.1, 61.8]	Florida	34.9 [28.6, 41.3]
				Mississippi	51.7 [45.9, 57.45]	Colorado	35.3 [29.9, 40.7]
60 to 64	0.155 (0.010)	0.036 *	47.5 (44.5, 47.8)	West Virginia	58.7 [52.6, 64.8]	Hawaii	28.3 [21.7, 34.9]
				Alabama	58.1 [51.6, 64.5]	Arizona	37.1 [29.3, 44.9]
				Ohio	56.6 [49.7, 63.5]	Kansas	38.7 [29.3, 44.9]
				Rhode Island	56.5 [49.5, 63.6]	Montana	38.9 [31.8, 45.9]
				Michigan	55.9 [49.5, 62.3]	New Hampshire	39.0 [33.2, 44.8]

65 to 69	0.130 (0.009)	0.058	51.9 (49.2, 55.0)	Michigan	66.1 [58.8, 73.4]	Hawaii	34.9 [27.8, 42.1]
				West Virginia	62.1 [55.4, 68.8]	Kansas	35.2 [29.7, 40.6]
				District of Columbia	61.9 [50.7, 73.2]	Illinois	38.5 [294, 47.6]
				Alabama	58.9 [52.0, 65.9]	North Dakota	41.0 [33.9, 48.2]
				Delaware	58.5 [50.6, 60.4]	Minnesota	45.2 [38.4, 51.9]
70 & over	-0.119 (0.009)	0.843	57.6 (55.5, 60.0)	Pennsylvania	66.3 [62.1, 70.5]	Hawaii	40.6 [35.8, 45.3]
				Kentucky	64.7 [60.8, 68.7]	New Mexico	52.0 [48.1, 55.8]
				Mississippi	64.1 [60.1, 68.2]	Kansas	52.2 [48.1, 56.3]
				Alabama	63.0 [58.3, 67.7]	Virginia	52.5 [47.5, 57.5]
				Michigan	62.5 [58.3, 66.6]	Alaska	53.4 [42.5, 64.4]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

[θ] IQR – Interquartile range

[α]Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[π] A: Age Group

Table IV: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2005

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.030 (0.009)	0.537	5.3 (4.0, 6.2)	Alabama	11.1 [5.4, 16.9]	District of Columbia	1.4 [0.0, 2.7]
				South Carolina	9.9 [6.7, 13.1]	Alaska	2.3 0.0, 5.5]
				Minnesota	8.5 [3.5, 13.6]	California	2.34 [0.7, 4.0]
				Maine	8.3 [3.7, 13.0]	Puerto Rico	2.4 [0.6, 4.3]
				Missouri	8.3 [4.4, 12.3]	New Mexico	2.8 [0.9, 4.6]
25 to 29	0.079 (0.010)	0.153	8.1 (6.5, 8.2)	Ohio	13.7 [8.2, 19.3]	Puerto Rico	2.8 [0.3, 5.3]
				Delaware	12.9 [7.1, 18.7]	Connecticut	4.1 [1.4, 6.9]
				Oklahoma	12.4 [9.1, 15.7]	California	4.6 [2.6, 6.7]
				Missouri	12.0 [6.1, 17.9]	New Jersey	5.3 [3.3, 7.2]
				Indiana	12.0 [8.3, 15.6]	Texas	5.4 [2.8, 8.1]
30 to 34	0.166 (0.010)	0.028 *	11.0 (8.4, 12.0)	Ohio	16.2 [11.5, 20.9]	California	4.8 [3.1, 6.6]
				Wyoming	16.2 [11.8, 20.5]	North Dakota	5.0 [2.5, 7.5]
				Mississippi	15.0 [10.1, 19.8]	District of Columbia	5.3 [2.9, 7.8]
				West Virginia	14.5 [9.8, 19.2]	Arizona	5.7 [2.5, 9.1]
				Maine	14.3 [9.8, 18.8]	Puerto Rico	5.8 [2.5, 9.1]
35 to 39	0.121 (0.010)	0.073	14.4 (12.0, 17.0)	West Virginia	23.7 [18.1, 29.3]	District of Columbia	8.2 [4.8, 11.7]
				Mississippi	23.3 [18.3, 28.4]	Texas	9.8 [7.0, 12.7]
				Arkansas	21.4 [17.0, 25.9]	California	9.8 [7.2, 12.5]
				South Carolina	20.1 [16.7, 23.5]	Nevada	9.9 [5.3, 14.4]
				Alabama	19.9 [14.3, 25.5]	Puerto Rico	10.3 [6.1, 14.6]

40 to 44	0.370 (0.010)	< 0.001 *	19.8 (17.1, 22.4)	Alabama	28.4 [22.1, 34.8]	Hawaii	12.6 [9.3, 15.9]
				Georgia	27.6 [22.1, 332]	Arizona	13.1 [7.9, 18.3]
				Mississippi	27.4 [22.3, 32.4]	California	15.5 [12.1, 18.9]
				West Virginia	27.3 [21.8, 32.8]	Puerto Rico	16.1 [11.4, 20.7]
				Missouri	27.2 [21.5, 32.9]	Connecticut	16.3 [12.6, 20.0]
45 to 49	0.275 (0.009)	0.001 *	26.2 (23.6, 28.0)	West Virginia	39.3 [33.6, 45.0]	Connecticut	20.3 [16.3, 24.2]
				Tennessee	35.9 [29.7, 42.0]	Nevada	21.7 [15.3, 28.1]
				Arkansas	35.5 [30.7, 40.3]	Hawaii	21.7 [17.4, 26.0]
				Mississippi	34.2 [29.3, 39.1]	District of Columbia	21.8 [16.0, 27.6]
				Alabama	34.1 [28.3, 40.0]	California	21.9 [17.8, 25.9]
50 to 54	0.186 (0.010)	0.018 *	33.5 (31.5, 37.7)	Pennsylvania	42.6 [38.7, 46.6]	Hawaii	26.6 [22.2, 31.0]
				Oklahoma	42.1 [37.9, 46.3]	Alaska	27.9 [21.3, 34.6]
				Alabama	41.9 [35.7, 48.1]	New Jersey	28.4 [25.3, 31.5]
				Missouri	41.7 [35.1, 48.2]	Texas	28.9 [24.5, 33.4]
				Kentucky	40.7 [35.5, 46.0]	Utah	29.0 [24.0, 33.9]
55 to 59	0.371 (0.009)	< 0.001 *	41.8 (40.0, 45.2)	Mississippi	56.3 [51.1, 61.5]	Hawaii	33.2 [28.0, 38.4]
				Alabama	55.1 [48.2, 61.9]	North Dakota	35.8 [30.6, 41.0]
				Ohio	49.5 [44.0, 55.0]	Connecticut	36.8 [31.5, 42.1]
				West Virginia	49.2 [43.5, 54.9]	Montana	37.8 [32.9, 42.7]
				Michigan	48.5 [45.4, 51.7]	Puerto Rico	37.9 [31.9, 43.9]
60 to 64	0.010 (0.009)	0.373	48.4 (46.5, 50.9)	West Virginia	58.0 [51.6, 64.3]	Hawaii	36.6 [31.1, 42.0]
				Mississippi	57.7 [52.3, 63.2]	Texas	39.3 [34.3, 44.2]
				Indiana	57.3 52.1, 62.5]	Minnesota	40.4 [33.8, 46.9]
				Wisconsin	55.9 [49.8, 62.0]	California	40.7 [34.7, 46.8]
				Michigan	53.9 [50.5, 57.3]	New Jersey	41.8 [38.0, 45.6]

65 to 69	0.146 (0.010)	0.044 *	51.3 (48.8, 54.8)	Delaware	59.8 [53.0, 66.6]	Hawaii	38.2 [32.1, 44.3]
				Michigan	59.7 [56.1, 63.2]	North Dakota	42.2 [35.8, 48.5]
				Missouri	58.5 [52.2, 64.7]	Montana	42.9 [36.7, 49.0]
				West Virginia	57.9 [51.7, 64.1]	Colorado	43.8 [38.4, 49.3]
				Mississippi	57.8 [51.5, 64.1]	New York	45.0 [39.6, 50.5]
70 & over	-0.157 (0.010)	0.919	57.3 (55.0, 59.4)	Virginia	64.5 [60.4, 68.6]	Hawaii	47.7 [43.7, 51.7]
				Michigan	64.1 [61.8, 66.3]	Alaska	48.2 [38.1, 58.4]
				Rhode Island	62.4 [58.2, 66.5]	Kentucky	51.7 [47.7, 55.7]
				Alabama	61.9 [57.3, 66.5]	Connecticut	52.5 [48.7, 45.3]
				Maine	61.3 [56.9, 65.7]	Utah	53.3 [48.7, 57.8]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group

Table V: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2007

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[0])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	0.219 (0.009)	0.007 *	5.4 (3.6, 6.9)	West Virginia	12.4 [6.3, 18.6]	New Jersey	0.5 [0.0, 1.5]
				Tennessee	11.5 [3.6, 19.3]	Alaska	1.5 [0.0, 2.9]
				Maine	10.4 [4.6, 16.3]	Oregon	1.6 [0.0, 3.3]
				Missouri	9.7 [4.7, 14.7]	Arizona	2.7 [0.0, 5.5]
				Indiana	9.0 [4.5, 13.5]	Nevada	2.8 [0.6, 4.9]
25 to 29	0.037 (0.010)	0.275	7.9 (6.2, 9.6)	Tennessee	13.4 [7.6, 19.3]	Puerto Rico	1.6 [0.0, 3.3]
				Nevada	12.7 [6.1, 19.3]	California	2.2 [0.7, 3.8]
				Alabama	12.7 [7.4, 17.9]	Arizona	3.8 [0.9, 6.7]
				Delaware	12.4 [5.7, 19.1]	District of Columbia	4.0 [1.1, 6.9]
				Pennsylvania	12.2 [7.8, 16.7]	Iowa	4.4 [1.8, 7.1]
30 to 34	0.062 (0.009)	0.193	10.2 (8.4, 12.1)	West Virginia	21.5 [15.7, 27.2]	Arizona	4.4 [1.7, 7.1]
				Delaware	18.4 [11.9, 24.8]	Connecticut	5.4 [2.9, 7.9]
				Montana	14.9 [9.7, 20.2]	California	6.5 [3.7, 9.3]
				Alaska	14.8 [7.0, 22.7]	Virginia	6.8 [3.7, 9.9]
				Missouri	14.6 [9.3, 20.0]	District of Columbia	6.8 [3.3, 10.4]
35 to 39	0.200 (0.009)	0.011 *	13.8 (11.8, 15.7)	West Virginia	25.3 [19.8, 30.7]	Minnesota	7.7 [5.0, 10.5]
				Tennessee	21.7 [15.7, 27.8]	Utah	9.1 [6.3, 11.8]
				Alabama	20.4 [14.9, 25.9]	District of Columbia	10.0 [6.4, 13.5]
				Kentucky	18.9 [13.4, 24.4]	Florida	10.4 [7.8, 13.0]
				Mississippi	18.8 [15.1, 22.4]	Illinois	10.6 [7.2, 14.0]

40 to 44	0.333 (0.009)	< 0.001 *	19.6 (17.7, 23.2)	Alabama	29.5 [24.8, 34.3]	California	12.8 [9.5, 16.1]
				Tennessee	28.3 [22.1, 34.5]	Puerto Rico	13.7 [3.3, 23.5]
				Mississippi	26.7 [22.4, 31.1]	Texas	14.8 [12.3, 17.3]
				Arkansas	24.9 [20.2, 29.7]	Hawaii	15.5 [11.8, 19.3]
				South Carolina	24.6 [20.6, 28.6]	District of Columbia	16.1 [11.3, 20.8]
45 to 49	0.263 (0.009)	0.002 *	24.9 (22.6, 28.4)	Alabama	35.6 [30.5, 40.6]	California	16.1 [12.5, 19.7]
				West Virginia	33.8 [28.9, 38.8]	District of Columbia	16.8 [12.1, 21.5]
				Tennessee	33.4 [27.2, 39.7]	Florida	19.0 [16.3, 21.6]
				Ohio	32.4 [28.9, 35.9]	Hawaii	19.5 [15.6, 23.5]
				Alaska	31.8 [23.9, 39.6]	Minnesota	20.1 [16.3, 23.8]
50 to 54	0.195 (0.010)	0.014 *	34.2 (30.1, 37.5)	Alabama	44.9 [40.2, 49.6]	Alaska	25.4 [18.8, 32.0]
				Kentucky	44.3 [38.8, 49.7]	Puerto Rico	26.5 [21.4, 31.6]
				Tennessee	42.9 [37.3, 48.5]	Idaho	27.4 [23.1, 31.7]
				Indiana	42.1 [37.1, 47.0]	Connecticut	27.8 [23.9, 31.8]
				Arkansas	41.9 [37.3, 46.4]	Louisiana	28.1 [24.2, 32.0]
55 to 59	0.158 (0.010)	0.034 *	43.5 (39.0, 47.5)	Alabama	54.3 [49.7, 58.9]	Florida	34.9 [31.4, 38.3]
				Indiana	51.0 [46.1, 55.9]	Minnesota	35.5 [30.8, 40.2]
				West Virginia	51.0 [46.3, 55.7]	Hawaii	35.5 [30.8, 40.3]
				Arizona	49.9 [42.0, 57.8]	California	35.8 [30.6, 40.9]
				Alaska	49.4 [40.1, 58.6]	Nevada	36.4 [30.4, 42.7]
60 to 64	0.190 (0.010)	0.015 *	48.2 (44.9, 52.1)	Michigan	59.1 [55.1, 63.1]	Puerto Rico	39.3 [33.9, 44.7]
				Alabama	58.5 [53.9, 63.1]	Florida	39.8 [36.6, 43.0]
				Tennessee	56.0 [50.3, 61.6]	California	40.9 [35.5, 46.2]
				Ohio	55.7 [51.9, 59.5]	North Dakota	41.0 [35.6, 46.2]
				Pennsylvania	55.1 [50.7, 59.6]	Arizona	54.9 [47.1, 62.7]

65 to 69	0.236 (0.004)	0.004 *	53.2 (49.4, 55.9)	Ohio	61.3 [57.4, 65.2]	Hawaii	40.3 [34.4, 46.3]
				Michigan	60.4 [55.5, 65.2]	Florida	43.6 [40.3, 47.0]
				Wisconsin	59.5 [53.9, 65.2]	California	44.9 [38.2, 51.7]
				Tennessee	59.2 [53.5, 62.9]	Wyoming	45.9 [41.1, 50.6]
				Alabama	58.2 [53.5, 62.9]	Connecticut	46.6 [41.5, 51.7]
70 & over	0.059 (0.009)	0.202	58.2 (56.4, 59.7)	Missouri	66.4 [62.6, 70.1]	Florida	49.0 [46.9, 51.1]
				Delaware	65.1 [60.9, 69.4]	Hawaii	49.9 [46.1, 53.8]
				Alabama	65.0 [61.7, 68.2]	California	52.7 [48.6, 56.8]
				Michigan	64.7 [62.0, 67.4]	Puerto Rico	53.5 [49.7, 57.4]
				Illinois	63.5 [60.3, 66.7]	Minnesota	54.3 [50.9, 57.7]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table VI: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2009

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.069 (0.009)	0.692	4.1 (2.6, 5.6)	Kentucky	10.9 [4.1, 17.8]	Arizona	0.1 [0.0, 0.3]
				Oregon	9.8 [3.7, 15.9]	Georgia	0.7 [0.0, 1.8]
				Alaska	8.5 [0.0, 19.5]	New Jersey	0.9 [0.0, 1.9]
				Pennsylvania	7.5 [3.5, 11.5]	Iowa	1.5 [0.0, 3.3]
				Arkansas	6.9 [1.7, 12.2]	New York	1.6 [0.0, 3.2]
25 to 29	0.051 (0.009)	0.225	6.9 (5.3, 8.5)	Arkansas	16.8 [8.7, 25.0]	Puerto Rico	1.1 [0.0, 3.1]
				Missouri	13.4 [6.8, 19.9]	Wisconsin	1.6 [0.0, 3.7]
				West Virginia	13.1 [7.8, 18.3]	District of Columbia	2.9 [0.5, 5.3]
				Illinois	12.1 [6.8, 17.4]	Colorado	3.5 [1.9, 5.2]
				North Dakota	11.8 [5.5, 18.0]	New Hampshire	3.6 [0.4, 6.8]
30 to 34	0.201 (0.010)	0.012 *	9.4 (7.5, 12.2)	West Virginia	16.2 [11.3, 21.1]	District of Columbia	2.9 [0.9, 4.9]
				Kentucky	15.6 [11.0, 20.2]	Puerto Rico	4.7 [1.6, 7.8]
				Indiana	14.7 [10.8, 18.6]	California	4.9 [3.3, 6.4]
				Mississippi	14.5 [10.7, 18.2]	Arizona	5.2 [2.4, 8.0]
				Missouri	13.8 [8.6, 19.0]	Connecticut	4.9 [3.3, 6.4]
35 to 39	-0.013 (0.009)	0.467	13.3 (10.7, 15.8)	Kentucky	22.9 [16.8, 29.0]	Puerto Rico	5.0 [20.3, 7.7]
				Alabama	22.2 [16.9, 27.6]	Minnesota	7.1 [4.3, 10.0]
				South Carolina	20.7 [15.5, 25.9]	Iowa	7.6 [4.8, 10.4]
				Wyoming	19.1 [14.5, 23.6]	Texas	7.8 [5.3, 10.3]
				Oklahoma	18.9 [14.6, 23.3]	California	7.9 [6.2, 9.7]

40 to 44	0.240 (0.009)	0.004 *	17.3 (14.6, 20.7)	Kentucky	31.8 [25.4, 38.2]	Puerto Rico	8.6 [5.1, 12.1]
				West Virginia	29.4 [23.9, 35.0]	Arizona	9.7 [5.5, 14.0]
				Alabama	27.5 [22.0, 33.1]	District of Columbia	12.5 [8.1, 16.8]
				Mississippi	27.2 [22.8, 31.6]	Nevada	12.9 [7.6, 18.2]
				Arkansas	26.8 [19.8, 33.9]	Texas	13.1 [10.1, 16.2]
45 to 49	0.097 (0.010)	0.113	23.8 (20.5, 27.2)	Kentucky	35.6 [30.6, 40.7]	Puerto Rico	15.8 [11.5, 20.2]
				Alabama	34.1 [28.7, 39.5]	Hawaii	16.9 [13.1, 20.6]
				South Carolina	33.4 [28.6, 38.1]	Alaska	17.5 [12.0, 23.1]
				Michigan	32.3 [28.6, 36.1]	Minnesota	17.8 [14.4, 21.2]
				West Virginia	32.1 [26.8, 37.4]	District of Columbia	18.1 [13.5, 22.8]
50 to 54	0.216 (0.009)	0.007 *	32.7 (28.8, 35.7)	Kentucky	46.5 [41.8, 51.2]	Puerto Rico	23.3 [18.6, 28.1]
				West Virginia	42.5 [37.7, 47.4]	Minnesota	23.7 [20.0, 27.5]
				Missouri	42.1 [36.3, 47.9]	Connecticut	24.8 [20.4, 29.2]
				Alabama	41.6 [36.5, 46.8]	New Jersey	24.9 [22.0, 27.7]
				Arkansas	41.1 [35.3, 46.9]	South Dakota	26.5 [22.7, 30.4]
55 to 59	0.066 (0.010)	0.186	40.1 [36.8, 43.4]	Kentucky	50.7 [45.8, 55.5]	Hawaii	30.0 [25.7, 34.2]
				Alabama	48.1 [43.2, 53.1]	Puerto Rico	31.4 [26.6, 36.3]
				Mississippi	48.0 [44.6, 51.5]	Minnesota	32.9 [29.1, 36.6]
				Oklahoma	47.6 [43.6, 51.5]	New Jersey	35.6 [32.0, 39.1]
				Rhode Island	47.5 [43.2, 51.9]	Kansas	35.6 [33.4, 37.9]
60 to 64	0.059 (0.009)	0.206	45.9 (42.8, 48.6)	Missouri	57.5 [51.5, 63.5]	Minnesota	37.1 [32.7, 41.4]
				Kentucky	55.8 [51.2, 60.4]	Tennessee	38.8 [34.0, 43.6]
				Rhode Island	55.2 [50.5, 59.9]	Puerto Rico	38.9 [33.9, 43.9]
				West Virginia	54.2 [49.5, 58.9]	California	40.4 [37.2, 43.5]
				Alabama	52.8 [47.7, 57.9]	Alaska	40.4 [31.5, 49.4]

65 to 69	0.071 (0.009)	0.172	50.2 (47.6, 53.5)	Alabama	60.6 [55.3, 65.9]	Minnesota	40.5 [35.9, 45.2]
				Mississippi	59.6 [56.3, 62.9]	Puerto Rico	41.8 [36.8, 46.7]
				Michigan	59.4 [55.7, 63.2]	Alaska	42.1 [30.9, 53.4]
				Rhode Island	58.3 [53.4, 63.3]	Hawaii	42.5 [37.3, 47.6]
				Oklahoma	57.2 [53.0, 61.3]	California	44.3 [40.8, 47.9]
70 & over	0.054 (0.009)	0.214	56.4 (53.6, 58.0)	Ohio	61.7 [59.3, 64.2]	Tennessee	43.1 [39.7, 46.5]
				Rhode Island	61.2 [58.1, 64.3]	Hawaii	44.1 [40.7, 47.5]
				Illinois	61.1 [57.9, 64.2]	Minnesota	46.5 [43.5, 49.4]
				Mississippi	60.9 [58.6, 63.1]	Puerto Rico	47.8 [44.4, 51.3]
				Michigan	60.8 [58.4, 63.2]	South Dakota	50.9 [48.0, 53.8]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table VII: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2011

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	0.052 (0.009)	0.223	3.5 (2.7, 4.4)	West Virginia	9.1 [4.8, 13.4]	Puerto Rico	0.3 [0.0, 0.8]
				North Dakota	6.7 [3.3, 10.1]	Hawaii	0.3 [0.0, 0.8]
				Illinois	6.5 [2.3, 10.7]	Tennessee	0.5 [0.0, 1.5]
				Oregon	5.9 [2.6, 9.1]	Nevada	1.1 [0.0, 2.1]
				Alabama	5.6 [2.9, 8.3]	Colorado	1.7 [0.5, 2.8]
25 to 29	0.137 (0.010)	0.053	6.3 (4.8, 8.3)	Maine	10.8 [7.2, 14.5]	South Dakota	1.9 [0.7, 3.1]
				West Virginia	10.7 [5.7, 15.7]	Puerto Rico	2.5 [0.8, 4.2]
				Tennessee	10.2 [3.0, 17.5]	Arizona	3.0 [0.6, 5.3]
				Missouri	10.0 [5.8, 14.2]	Alaska	3.4 [0.2, 6.7]
				Alabama	9.9 [5.9, 14.0]	Hawaii	3.7 [1.2, 6.1]
30 to 34	0.151	0.040 *	8.3 (6.8, 11.3)	Ohio	15.0 [10.5, 19.5]	Puerto Rico	5.2 [2.9, 7.5]
				New Hampshire	14.7 [10.5, 19.5]	Connecticut	5.7 [2.8, 8.7]
				Michigan	13.9 [10.0, 17.8]	Hawaii	5.9 [3.3, 8.4]
				Oklahoma	13.6 [9.8, 17.3]	Minnesota	5.9 [3.7, 8.1]
				West Virginia	13.5 [9.4, 17.7]	Florida	6.0 [3.8, 8.3]
35 to 39	0.226 (0.009)	0.005 *	12.7 (9.7, 14.2)	Kentucky	22.5 [17.7, 27.4]	District of Columbia	6.6 [3.1, 10.1]
				West Virginia	22.1 [17.0, 27.2]	Puerto Rico	7.3 [4.3, 10.3]
				Maine	18.6 [15.0, 22.3]	Oregon	7.3 [4.1, 10.6]
				Oklahoma	17.0 [12.4, 21.7]	Texas	7.9 [5.3, 10.6]
				Alabama	17.0 [12.3, 21.7]	California	8.2 [6.1, 10.4]

40 to 44	0.156 (0.009)	0.031 *	15.8 (13.2, 18.8)	West Virginia	32.1 [26.5, 37.8]	California	10.7 [8.7, 12.7]
				Michigan	24.9 [20.5, 29.3]	District of Columbia	11.4 [7.4, 15.4]
				Arkansas	23.3 [16.0, 30.5]	Connecticut	11.5 [8.1, 15.0]
				Kentucky	23.2 [18.8, 27.5]	New Jersey	11.9 [9.7, 14.1]
				Louisiana	22.4 [17.7, 27.0]	Texas	11.9 [8.9, 14.9]
45 to 49	0.327 (0.009)	< 0.001 *	22.6 (20.0, 26.0)	West Virginia	36.5 [31.1, 41.8]	Minnesota	16.0 [13.5, 18.6]
				Kentucky	32.4 [27.8, 37.1]	Idaho	16.6 [12.2, 21.0]
				Arkansas	32.0 [25.4, 38.5]	District of Columbia	16.8 [11.3, 22.3]
				Oklahoma	31.4 [27.0, 35.8]	Hawaii	17.4 [12.9, 21.8]
				Mississippi	29.9 [25.5, 34.3]	California	17.9 [15.1, 20.6]
50 to 54	0.223 (0.010)	0.006 *	29.0 (27.4, 33.3)	West Virginia	41.0 [36.3, 45.6]	Hawaii	21.3 [17.4, 25.2]
				Arkansas	38.9 [33.0, 44.9]	Minnesota	22.1 [19.4, 24.8]
				Alabama	38.9 [34.2, 43.6]	Nevada	23.8 [17.9, 29.6]
				Ohio	37.2 [33.2, 41.1]	Puerto Rico	24.2 [20.1, 28.2]
				Kentucky	37.1 [33.0, 41.1]	Connecticut	24.5 [20.5, 28.6]
55 to 59	0.242 (0.010)	0.004 *	37.0 (34.7, 40.8)	West Virginia	48.8 [44.3, 53.3]	Hawaii	24.8 [20.8, 28.9]
				Mississippi	47.1 [43.1, 51.2]	South Dakota	29.2 [24.3, 34.2]
				Kentucky	45.8 [41.6, 49.9]	Minnesota	31.4 [28.4, 34.4]
				Michigan	45.7 [41.6, 49.7]	Arizona	31.7 [25.2, 38.1]
				Alabama	45.0 [40.5, 49.5]	Texas	32.1 [28.2, 36.0]
60 to 64	0.152 (0.009)	0.037 *	42.1 (40.3, 46.2)	West Virginia	56.6 [52.0, 61.1]	Hawaii	29.0 [25.1, 32.9]
				Kentucky	55.2 [51.2, 59.3]	Minnesota	37.2 [34.0, 40.4]
				Indiana	52.1 [48.0, 56.2]	Connecticut	37.8 [33.0, 42.6]
				Alabama	51.8 [48.0, 56.2]	Iowa	38.5 [34.4, 42.6]
				Mississippi	50.0 [46.0, 54.0]	Maryland	38.5 [34.6, 42.4]

65 to 69	0.261 (0.009)	0.002 *	47.8 (45.7, 50.6)	West Virginia	59.6 [54.9, 64.3]	Hawaii	35.4 [30.3, 40.5]
				Kentucky	56.3 [51.8, 60.9]	Minnesota	42.6 [38.8, 46.4]
				Mississippi	54.8 [50.6, 59.0]	New Jersey	42.9 [39.0, 46.9]
				Oregon	54.0 [49.1, 58.8]	Idaho	44.2 [39.0, 49.5]
				Michigan	52.8 [48.6, 57.1]	Montana	44.3 [39.8, 48.8]
70 & over	0.323 (0.009)	< 0.001 *	53.8 (51.8, 56.2)	Michigan	63.4 [60.6, 66.2]	Hawaii	41.9 [38.4, 45.4]
				Kentucky	62.0 [59.0, 65.0]	Wyoming	47.1 [43.3, 51.0]
				West Virginia	60.2 [56.8, 63.6]	Minnesota	48.6 [46.1, 51.1]
				Ohio	59.4 [56.6, 42.2]	Texas	48.7 [45.8, 51.6]
				Mississippi	59.1 [56.4, 61.8]	Alaska	49.0 [42.1, 55.9]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

[θ] IQR – Interquartile range

[α]Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[π] A: Age group (years)

Table VIII: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2012

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[0])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.004 (0.009)	0.431	3.8 (2.7, 4.4)	Alabama	7.2 [4.2, 10.2]	Hawaii	1.4 [0.3, 2.6]
				Delaware	6.3 [3.1, 9.5]	North Dakota	1.5 [0.0, 3.6]
				Kentucky	6.1 [4.0, 8.2]	Texas	1.6 [0.5, 2.7]
				Montana	5.7 [3.0, 8.4]	Vermont	2.0 [0.1, 3.9]
				Oklahoma	5.0 [2.6, 7.5]	New Mexico	2.1 [0.7, 3.4]
25 to 29	0.105	0.096	6.2 (5.2, 7.8)	Kentucky	12.8 [8.1, 17.5]	District of Columbia	1.6 [0.0, 4.1]
				Arkansas	11.3 [6.4, 16.3]	New Jersey	2.5 [1.3, 3.8]
				Wyoming	11.3 [5.7, 16.9]	Georgia	2.6 [0.4, 4.8]
				Tennessee	11.2 [6.9, 15.6]	Puerto Rico	3.0 [0.9, 5.0]
				West Virginia	10.6 [6.0, 15.2]	Nebraska	3.3 [1.8, 4.7]
30 to 34	0.140 (0.010)	0.050	8.8 (7.3, 10.6)	Idaho	17.7 [10.6, 24.8]	New York	4.5 [2.5, 6.6]
				Alabama	15.7 [11.4, 19.9]	District of Columbia	4.9 [1.0, 8.7]
				Oregon	15.4 [10.4, 20.4]	Wyoming	4.9 [2.0, 7.9]
				Kentucky	14.9 [11.2, 18.6]	Connecticut	5.4 [2.7, 8.2]
				Ohio	14.8 [11.1, 18.5]	Minnesota	5.6 [3.7, 7.5]
35 to 39	0.156 (0.009)	0.031*	11.8 (9.2, 14.7)	Kentucky	24.8 [20.0, 29.6]	Delaware	7.3 [3.8, 10.7]
				Alabama	19.9 [15.3, 24.5]	Puerto Rico	7.7 [5.3, 10.0]
				South Carolina	19.1 [14.9, 23.2]	Alaska	7.8 [4.7, 10.9]
				Arkansas	17.9 [12.1, 23.8]	District of Columbia	8.4 [3.8, 13.1]
				West Virginia	17.9 [13.3, 22.4]	Rhode Island	8.4 [5.1, 11.8]

40 to 44	0.156 (0.009)	0.031 *	17.0 (14.5, 19.8)	West Virginia	32.0 [26.5, 37.4]	District of Columbia	9.9 [4.2, 15.6]
				Kentucky	31.7 [26.9, 36.6]	Minnesota	11.7 [9.1, 14.2]
				Alabama	29.6 [24.4, 34.9]	New Jersey	11.8 [9.6, 13.9]
				Missouri	23.4 [17.8, 28.9]	Connecticut	12.2 [8.8, 15.6]
				Tennessee	23.1 [18.7, 27.5]	Puerto Rico	12.7 [9.4, 16.0]
45 to 49	0.240 (0.010)	0.004 *	23.9 (19.5, 26.9)	West Virginia	35.8 [30.3, 41.3]	Hawaii	15.0 [10.9, 19.2]
				Alabama	34.8 [30.0, 39.6]	New Jersey	16.6 [13.9, 19.3]
				Kentucky	33.9 [29.1, 38.7]	Texas	17.0 [13.2, 20.8]
				Michigan	32.8 [28.6, 36.9]	District of Columbia	17.2 [10.2, 24.1]
				Missouri	31.9 [26.5, 37.4]	Illinois	17.4 [12.9, 21.9]
50 to 54	0.367 (0.009)	< 0.001 *	30.1 (26.6, 32.9)	Alabama	44.4 [39.9, 49.0]	Hawaii	23.1 [18.5, 27.8]
				Kentucky	42.9 [38.7, 47.1]	Connecticut	24.6 [20.9, 28.2]
				West Virginia	42.5 [37.6, 47.4]	North Dakota	24.9 [20.5, 29.4]
				Arkansas	39.3 [33.9, 44.8]	Iowa	25.1 [21.4, 28.7]
				Mississippi	39.0 [34.4, 43.6]	New Jersey	25.1 [22.3, 28.0]
55 to 59	0.311 (0.009)	< 0.001 *	37.8 (34.7, 40.9)	West Virginia	53.4 [49.1, 57.8]	Hawaii	28.7 [23.7, 33.7]
				Kentucky	49.7 [45.6, 53.8]	District of Columbia	29.1 [22.4, 35.8]
				Alabama	48.7 [44.6, 52.8]	New Jersey	29.6 [26.6, 32.6]
				Michigan	46.8 [43.1, 50.4]	Minnesota	29.8 [26.7, 32.9]
				Mississippi	46.4 [39.8, 50.56]	Alaska	30.6 [25.1, 36.2]
60 to 64	0.374 (0.010)	< 0.001 *	44.3 (40.8, 48.7)	West Virginia	55.9 [51.7, 60.0]	Hawaii	35.2 [30.4, 40.1]
				Alabama	55.1 [51.1, 59.0]	District of Columbia	36.1 [29.6, 42.6]
				Louisiana	53.4 [49.1, 57.7]	South Dakota	36.3 [30.7, 42.0]
				Mississippi	53.4 [49.2, 57.6]	Minnesota	36.6 [33.2, 40.0]
				Kentucky	53.3 [49.2, 57.5]	Wyoming	37.4 [32.5, 42.4]

65 to 69	0.240 (0.010)	0.004 *	48.9 (46.5, 51.5)	Michigan	58.2 [54.5, 61.8]	Hawaii	36.8 [31.1, 42.4]
				Kentucky	56.8 [52.5, 61.2]	South Dakota	42.0 [35.2, 48.7]]
				Alabama	55.7 [51.6, 59.8]	Kansas	42.1 [38.6, 45.5]
				West Virginia	55.2 [50.5, 59.9]	Florida	42.4 [37.5, 47.3]
				Ohio	54.7 [51.0, 58.4]	Arizona	43.3 [38.2, 48.4]
70 & over	0.239 (0.009)	0.004 *	55.6 (53.9, 57.7)	Kentucky	62.5 [59.5, 65.5]	Hawaii	41.7 [37.6, 45.7]
				Mississippi	62.3 [59.6, 65.1]	Minnesota	48.3 [45.6, 51.0]
				West Virginia	61.7 [58.5, 64.9]	Nevada	49.2 [44.2, 54.1]
				Michigan	61.6 [57.5, 63.8]	New Jersey	50.4 [47.8, 53.0]
				Puerto Rico	60.7 [57.5, 63.8]	New Mexico	50.7 [47.8, 53.5]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table IX: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2013

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	0.069 (0.010)	0.179	3.3 (2.4, 4.2)	Kentucky	5.6 [3.4, 7.8]	Puerto Rico	1.3 [0.3, 2.2]
				Michigan	5.4 [3.7, 7.0]	Arizona	1.6 [0.0, 3.1]
				Oregon	5.3 [2.5, 8.1]	Alabama	1.7 [0.3, 3.0]
				Oklahoma	5.2 [2.9, 7.5]	Minnesota	1.7 [0.8, 2.6]
				Ohio	5.1 [2.9, 7.3]	Nevada	1.7 [0.4, 3.1]
25 to 29	0.236 (0.010)	0.004 *	6.7 (5.4, 8.1)	Mississippi	9.7 [5.4, 14.1]	Puerto Rico	2.3 [0.3, 4.3]
				Ohio	9.7 [6.2, 13.2]	Connecticut	3.0 [0.9, 5.0]
				Michigan	9.6 [6.1, 13.0]	California	3.9 [2.1, 5.6]
				Kentucky	9.4 [5.2, 13.6]	Massachusetts	4.1 [2.2, 5.9]
				Oregon	9.2 [4.7, 13.7]	Minnesota	4.3 [2.5, 6.0]
30 to 34	0.128 (0.010)	0.063	8.6 (6.6, 11.0)	West Virginia	17.5 [12.9, 22.2]	California	3.6 [2.3, 5.0]
				Alabama	15.1 [9.9, 20.3]	Illinois	4.1 [1.3, 6.9]
				Oklahoma	14.7 [11.0, 18.4]	Georgia	4.2 [2.3, 6.1]
				Mississippi	14.7 [10.1, 19.3]	Puerto Rico	4.9 [2.2, 7.6]
				Oregon	13.7 [9.2, 18.3]	Vermont	5.3 [2.8, 7.8]
35 to 39	0.167 (0.009)	0.027 *	12.3 (10.3, 14.3)	Kentucky	21.3 [16.5, 26.0]	California	6.8 [4.8, 8.9]
				West Virginia	21.1 [16.5, 25.7]	Connecticut	7.3 [4.0, 10.5]
				Maine	18.6 [13.6, 23.6]	Maryland	7.7 [5.2, 10.1]
				Oregon	17.6 [21.0, 23.2]	Arizona	8.1 [3.4, 12.7]
				Alabama	17.4 [12.2, 22.5]	Illinois	8.2 [4.9, 11.5]

40 to 44	0.218 (0.010)	0.007 *	16.4 (13.4, 19.8)	West Virginia	28.2 [23.1, 33.3]	Puerto Rico	9.4 [6.2, 12.5]
				Kentucky	25.5 [21.2, 29.7]	Illinois	9.8 [6.1, 13.5]
				Arkansas	25.4 [18.8, 32.0]	California	10.6 [8.0, 13.1]
				Alabama	24.9 [19.6, 30.2]	District of Columbia	11.8 [7.2, 16.4]
				South Carolina	24.7 [20.2, 29.2]	Hawaii	11.9 [8.4, 15.3]
45 to 49	0.352	< 0.001 *	22.7 (19.2, 25.2)	West Virginia	35.6 [30.1, 40.5]	District of Columbia	15.7 [10.5, 20.8]
				Alabama	32.2 [26.7, 37.6]	California	15.8 [12.6, 18.9]
				Arkansas	30.2 [23.8, 36.6]	Nevada	15.8 [9.3, 22.3]
				Delaware	29.5 [23.4, 35.6]	Hawaii	16.1 [11.5, 20.7]
				Kentucky	29.3 [25.0, 33.7]	Connecticut	16.6 [12.8, 20.4]
50 to 54	0.195 (0.009)	0.012 *	30.8 (27.3, 32.9)	West Virginia	44.1 [39.5, 48.7]	Wisconsin	23.1 [18.4, 27.7]
				Alabama	42.1 [37.1, 47.2]	Minnesota	24.7 [20.7, 28.9]
				Mississippi	40.9 [35.8, 45.9]	Hawaii	24.7 [19.9, 29.6]
				Missouri	36.7 [31.4, 42.0]	New Jersey	24.8 [21.3, 28.4]
				Kentucky	36.3 [31.4, 39.5]	Colorado	25.0 [22.1, 27.9]
55 to 59	0.249 (0.009)	0.003 *	37.0 (34.4, 40.6)	Michigan	49.2 [45.7, 52.6]	Hawaii	24.9 [15.8, 33.9]
				West Virginia	49.0 [44.7, 53.3]	Nevada	28.6 [22.0, 35.1]
				Alabama	48.3 [43.6, 53.1]	New Jersey	29.5 [26.0, 33.1]
				South Carolina	45.5 [41.4, 49.6]	Oregon	29.8 [25.9, 33.8]
				Kentucky	45.2 [41.1, 49.3]	Minnesota	30.1 [25.9, 34.2]
60 to 64	0.244 (0.009)	0.003 *	42.4 (39.9, 44.7)	West Virginia	55.4 [51.2, 59.6]	Nevada	31.8 [25.7, 37.9]
				Kentucky	54.7 [50.5, 58.8]	Hawaii	32.0 [27.2, 36.7]
				Alabama	53.7 [49.3, 58.2]	Minnesota	32.7 [27.6, 37.8]
				Michigan	53.4 [50.0, 56.8]	Alaska	36.4 [30.8, 42.0]
				Arkansas	50.4 [45.2, 55.5]	Utah	36.8 [33.2, 40.3]

65 to 69	0.153 (0.010)	0.037 *	47.2 (45.8, 52.2)	West Virginia	58.6 [53.9, 63.3]	Hawaii	34.8 [29.7, 39.9]
				Michigan	57.1 [53.4, 60.7]	Minnesota	37.5 [31.9, 43.1]
				Ohio	55.0 [50.9, 59.2]	Nevada	40.0 [32.3, 47.7]
				Kentucky	55.0 [50.7, 59.2]	New Jersey	43.1 [38.7, 47.4]
				South Carolina	54.8 [50.9, 58.7]	District of Columbia	44.1 [38.1, 50.0]
70 & over	0.157 (0.009)	0.031 *	54.4 (52.6, 56.0)	West Virginia	62.3 [59.1, 65.5]	Minnesota	42.5 [38.2, 46.8]
				Alabama	61.7 [58.6, 64.9]	Hawaii	44.7 [40.8, 48.5]
				Michigan	61.0 [58.7, 63.4]	New Mexico	48.9 [45.8, 52.1]
				Mississippi	59.8 [56.7, 63.4]	Tennessee	49.2 [45.4, 53.1]
				Pennsylvania	59.1 [56.6, 61.6]	Nevada	49.9 [44.5, 55.3]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table X: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2014

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.092 (0.009)	0.769	3.1 (2.5, 4.4)	West Virginia	8.2 [4.7, 11.6]	Delaware	1.4 [0.0, 2.9]
				District of Columbia	6.5 [0.5, 12.4]	California	1.5 [0.7, 2.3]
				Tennessee	6.2 [1.6, 10.8]	Arizona	1.5 [0.4, 2.6]
				Pennsylvania	6.1 [2.5, 9.8]	Texas	1.8 [0.5, 3.0]
				Oklahoma	5.5 [3.2, 7.8]	New Jersey	2.0 [0.5, 3.0]
25 to 29	0.220 (0.010)	0.007 *	6.4 (4.8, 8.7)	West Virginia	12.9 [8.6, 17.2]	Puerto Rico	2.1 [0.3, 3.8]
				Indiana	12.1 [8.3, 15.9]	Hawaii	3.2 [1.5, 4.8]
				Kentucky	11.5 [7.1, 16.0]	Arizona	3.2 [1.1, 5.3]
				Ohio	10.9 [6.8, 15.0]	Oregon	3.5 [1.2, 5.8]
				Arkansas	10.5 [4.3, 16.7]	California	3.7 [2.0, 5.3]
30 to 34	0.207 (0.009)	0.010 *	9.4 (7.5, 9.5)	West Virginia	18.2 [13.3, 23.0]	North Dakota	4.1 [1.8, 6.3]
				Tennessee	16.0 [10.2, 21.8]	Rhode Island	4.6 [1.6, 7.6]
				Indiana	14.4 [10.7, 18.2]	Nevada	4.9 [2.1, 7.7]
				Kentucky	13.9 [8.5, 19.3]	Puerto Rico	5.1 [2.2, 7.9]
				New Hampshire	13.5 [8.2, 18.8]	District of Columbia	5.4 [1.7, 9.0]
35 to 39	0.182 (0.009)	0.018 *	12.4 (10.6, 13.9)	West Virginia	22.9 [17.6, 28.2]	District of Columbia	5.6 [1.8, 9.3]
				Kentucky	22.3 [16.8, 27.7]	Connecticut	7.4 [1.8, 9.3]
				Alabama	21.6 [16.5, 26.7]	Texas	7.4 [4.5, 10.3]
				Ohio	21.0 [15.4, 26.5]	Hawaii	8.4 [5.0, 9.7]
				Oregon	18.2 [12.8, 23.7]	Minnesota	8.7 [6.9, 10.5]

40 to 44	0.177 (0.009)	0.020 *	17.3 (14.9, 19.7)	West Virginia	29.8 [24.8, 34.8]	Texas	10.6 [7.9, 13.3]
				Kentucky	28.0 [22.7, 33.2]	District of Columbia	11.8 [5.8, 17.8]
				Alabama	25.2 [20.8, 29.6]	Delaware	12.0 [7.7, 16.3]
				South Carolina	23.1 [18.0, 27.4]	Hawaii	12.2 [8.4, 15.9]
				Arkansas	22.4 [15.3, 29.4]	California	12.6 [9.2, 16.0]
45 to 49	0.307 (0.009)	< 0.001 *	22.6 (19.4, 25.7)	Kentucky	40.6 [35.4, 45.8]	District of Columbia	14.0 [8.8, 19.3]
				West Virginia	39.5 [34.5, 44.6]	Minnesota	15.5 [13.2, 17.7]
				Alabama	35.5 [30.4, 40.7]	Nevada	15.5 [9.5, 21.5]
				Michigan	29.5 [25.2, 33.8]	Connecticut	16.9 [13.2, 20.7]
				Ohio	29.1 [24.4, 33.8]	Puerto Rico	17.7 [13.6, 21.7]
50 to 54	0.405 (0.009)	< 0.001 *	29.4 (26.7, 34.1)	West Virginia	45.3 [40.6, 50.0]	California	21.7 [18.3, 25.1]
				Arkansas	44.6 [38.1, 51.1]	Minnesota	22.4 [20.2, 24.7]
				Tennessee	42.8 [36.9, 48.6]	Hawaii	22.7 [18.0, 27.3]
				Alabama	42.8 [38.5, 47.0]	New Jersey	23.2 [20.2, 26.2]
				Mississippi	38.5 [32.5, 44.4]	Nebraska	23.5 [20.9, 26.1]
55 to 59	0.387 (0.009)	< 0.001 *	36.3 (34.0, 40.4)	West Virginia	53.6 [49.5, 57.7]	Hawaii	28.2 [23.8, 32.7]
				Kentucky	50.0 [45.8, 54.2]	California	29.3 [25.3, 33.3]
				Alabama	47.9 [43.5, 52.3]	Idaho	29.4 [24.6, 34.3]
				Michigan	46.6 [42.8, 50.3]	Texas	31.1 [27.1, 35.1]
				Tennessee	46.2 [40.9, 51.5]	Montana	32.5 [28.3, 36.8]
60 to 64	0.388 (0.009)	< 0.001 *	43.8 (40.5, 47.6)	West Virginia	59.6 [55.5, 63.6]	Nevada	34.8 [27.4, 42.1]
				Alabama	55.7 [51.6, 59.7]	Alaska	36.1 [30.2, 42.1]
				Tennessee	54.0 [48.9, 59.1]	Hawaii	36.2 [31.8, 40.6]
				Mississippi	53.1 [47.0, 59.1]	Minnesota	37.1 [34.5, 39.7]
				Kentucky	52.6 [48.7, 56.6]	California	38.0 [33.4, 42.6]

65 to 69	0.171 (0.009)	0.023 *	49.3 (46.8, 52.0)	West Virginia	63.0 [59.0, 67.1]	Texas	40.6 [36.2, 45.0]
				Alabama	58.9 [55.0, 62.8]	Hawaii	41.2 [36.1, 46.2]
				Michigan	58.8 [55.1, 62.5]	New York	42.3 [37.5, 47.1]
				Tennessee	55.6 [50.5, 60.6]	Minnesota	43.5 [40.6, 46.4]
				Ohio	54.4 [50.2, 58.5]	District of Columbia	43.7 [37.2, 50.2]
70 & over	0.339 (0.009)	< 0.001 *	55.7 (52.9, 57.5)	West Virginia	67.5 [64.6, 70.4]	Hawaii	41.6 [37.8, 45.4]
				Pennsylvania	61.9 [59.4, 64.4]	Texas	48.6 [45.5, 51.7]
				Alabama	61.4 [58.6, 64.2]	Alaska	49.0 [43.6, 54.4]
				Michigan	60.8 [58.2, 63.4]	Minnesota	49.7 [47.5, 51.8]
				Mississippi	60.6 [56.7, 64.5]	New Jersey	50.8 [47.7, 53.9]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table XI: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2015

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.045 (0.009)	0.598	3.5 (2.3, 4.3)	Wyoming	7.4 [2.5, 12.4]	District of Columbia	0.0 [0.0, 0.0]
				Alabama	6.2 [3.9, 8.4]	Puerto Rico	0.4 [0.0, 1.0]
				Alaska	6.0 [1.6, 10.4]	New Hampshire	1.4 [0.0, 2.8]
				Delaware	5.4 [1.7, 9.1]	Iowa	1.4 [0.0, 3.1]
				Mississippi	5.2 [2.0, 8.5]	Massachusetts	1.8 [0.4, 3.2]
25 to 29	0.011 (0.009)	0.371	5.9 (4.8, 7.6)	Iowa	12.2 [6.7, 17.6]	North Dakota	2.5 [0.2, 4.8]
				Tennessee	10.9 [5.3, 16.6]	Hawaii	2.8 [0.8, 4.9]
				West Virginia	10.4 [6.6, 14.3]	Puerto Rico	3.1 [0.9, 5.2]
				Alabama	10.4 [6.0, 14.7]	California	3.2 [1.8, 4.6]
				Wyoming	10.3 [5.0, 15.6]	Colorado	3.9 [2.2, 5.7]
30 to 34	-0.039 (0.009)	0.576	7.8 (6.8, 10.4)	West Virginia	16.7 [11.9, 21.5]	District of Columbia	3.4 [0.1, 6.7]
				Alabama	15.4 [11.0, 19.7]	California	5.1 [3.4, 6.9]
				Kentucky	15.0 [9.9, 20.0]	Puerto Rico	5.3 [2.8, 7.8]
				Michigan	12.1 [8.8, 15.5]	Florida	5.5 [3.0, 8.1]
				Alaska	12.1 [7.0, 17.2]	Virginia	5.6 [3.4, 7.7]
35 to 39	0.075 (0.009)	0.158	12.1 (9.9, 14.2)	West Virginia	25.2 [20.0, 30.4]	Maryland	7.1 [4.7, 9.5]
				Arkansas	22.8 [14.8, 30.8]	California	7.4 [5.4, 9.5]
				Tennessee	20.5 [13.4, 27.6]	Florida	8.1 [5.0, 11.2]
				Montana	19.4 [13.3, 25.5]	Alaska	8.4 [4.7, 12.0]
				Mississippi	17.2 [12.0, 22.4]	Texas	8.5 [6.1, 10.8]

40 to 44	0.234 (0.009)	0.004 *	14.9 (13.5, 19.9)	West Virginia	31.6 [26.3, 36.9]	District of Columbia	6.0 [1.5, 10.5]
				Kentucky	26.2 [19.4, 32.9]	California	9.8 [7.6, 12.0]
				Alabama	26.0 [20.7, 31.2]	Minnesota	11.6 [9.2, 14.0]
				Missouri	25.0 [18.6, 31.4]	Illinois	11.7 [7.5, 15.8]
				Tennessee	23.9 [18.0, 29.9]	Arizona	12.0 [8.4, 15.6]
45 to 49	0.291 (0.009)	< 0.001 *	22.6 (20.1, 25.3)	West Virginia	39.0 [33.7, 44.3]	District of Columbia	15.6 [12.7, 20.7]
				Alabama	35.6 [30.6, 40.5]	California	15.6 [12.8, 18.4]
				Mississippi	32.9 [27.0, 38.8]	Alaska	16.5 [10.8, 22.2]
				Indiana	32.0 [25.8, 38.1]	Hawaii	16.7 [12.7, 20.7]
				Kentucky	31.9 [25.9, 37.8]	New Jersey	16.9 [13.8, 20.1]
50 to 54	0.255 (0.009)	0.002 *	28.7 (26.2, 34.2)	West Virginia	45.7 [41.0, 50.5]	Hawaii	19.8 [15.9, 23.7]
				Tennessee	44.6 [38.5, 50.7]	California	20.8 [17.9, 23.7]
				Kentucky	42.7 [37.6, 47.8]	Nevada	22.4 [14.3, 30.6]
				Alabama	38.4 [34.1, 42.7]	New York	23.5 [20.6, 26.4]
				Michigan	37.7 [33.7, 41.6]	Minnesota	24.2 [21.6, 26.8]
55 to 59	0.273 (0.009)	0.001 *	35.4 (33.1, 40.5)	West Virginia	55.2 [48.9, 57.4]	Nevada	23.4 [16.4, 30.4]
				Alabama	49.3 [44.8, 53.7]	Minnesota	27.8 [25.4, 30.2]
				Tennessee	46.0 [40.5, 51.5]	California	28.5 [24.9, 32.1]
				South Carolina	44.6 [40.6, 48.6]	Wisconsin	28.9 [24.4, 33.5]
				Kentucky	44.5 [39.3, 49.60]	Illinois	29.9 [25.4, 34.5]
60 to 64	0.326 (0.009)	< 0.001 *	41.3 (39.3, 45.6)	West Virginia	58.4 [54.3, 62.6]	Hawaii	29.0 [25.0, 33.0]
				Alabama	53.6 [49.3, 57.9]	Texas	34.3 [29.8, 38.9]
				Kentucky	52.9 [48.4, 57.4]	Minnesota	35.4 [32.8, 37.9]
				Arkansas	49.8 [43.9, 55.8]	Colorado	36.5 [33.3, 39.7]
				Pennsylvania	49.6 [44.7, 54.5]	Alaska	36.5 [29.2, 43.8]

65 to 69	0.297 (0.009)	< 0.001 *	47.5 (44.8, 50.2)	West Virginia	58.0 [53.7, 62.3]	Hawaii	36.1 [31.5, 40.7]
				Pennsylvania	55.2 [50.2, 60.1]	Puerto Rico	39.6 [34.5, 44.7]
				Louisiana	54.6 [49.2, 60.0]	Nevada	40.6 [31.9, 49.2]
				Michigan	53.5 [49.7, 57.4]	South Dakota	41.5 [36.1, 46.9]
				Alabama	53.3 [49.2, 57.4]	California	43.0 [38.5, 47.4]
70 & over	0.336 (0.009)	< 0.001 *	53.5 (52.5, 56.2)	West Virginia	60.7 [57.6, 63.9]	Hawaii	38.8 [35.4, 42.3]
				Louisiana	60.2 [56.4, 64.0]	Alaska	45.3 [38.5, 52.1]
				Alabama	59.2 [56.2, 62.3]	Arizona	47.5 [44.8, 50.2]
				Tennessee	58.4 [54.8, 61.9]	New Mexico	49.5 [45.8, 53.2
				Kentucky	58.0 [54.4, 61.5]	California	49.7 [46.4, 52.9]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table XII: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2016

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	0.008 (0.009)	0.381	3.1 (2.4, 4.3)	West Virginia	9.6 [5.9, 13.3]	District of Columbia	0.5 [0.0, 1.0]
				Arkansas	7.3 [1.1, 13.5]	Connecticut	1.4 [0.4, 2.4]
				Missouri	7.1 [2.6, 11.7]	Iowa	1.5 [0.4, 2.6]
				Maine	6.7 [3.0, 10.5]	California	1.8 [1.0, 2.7]
				Alabama	6.5 [3.6, 9.4]	Minnesota	1.8 [1.0, 2.7]
25 to 29	0.093 (0.010)	0.122	6.0 (4.7, 7.5)	Maine	11.5 [7.1, 15.9]	Alaska	2.1 [0.0, 4.6]
				Delaware	11.0 [3.4, 18.6]	California	2.4 [1.3, 3.5]
				Louisiana	9.8 [4.9, 14.7]	Puerto Rico	3.3 [1.1, 5.4]
				Oregon	9.8 [5.7, 13.8]	Wisconsin	3.4 [0.3, 6.5]
				Kentucky	9.5 [5.7, 13.4]	Connecticut	3.6 [1.6, 5.7]
30 to 34	0.084 (0.009)	0.140	9.1 (7.4, 10.7)	West Virginia	14.7 [10.8, 18.7]	District of Columbia	1.6 [0.1, 3.1]
				Maine	14.2 [9.6, 18.8]	New Jersey	3.2 [1.3, 5.2]
				Kentucky	14.0 [10.0, 18.0]	California	3.4 [1.9, 4.8]
				Arkansas	13.9 [7.8, 20.0]	Wisconsin	4.2 [1.5, 6.9]
				Connecticut	13.7 [9.3, 18.2]	Puerto Rico	4.2 [1.5, 6.9]
35 to 39	0.142 (0.009)	0.044 *	12.6 (10.6, 14.6)	Arkansas	25.9 [17.0, 34.9]	California	7.0 [4.8, 9.3]
				Alabama	24.2 [18.7, 29.8]	Puerto Rico	7.1 [4.0, 10.2]
				Kentucky	23.1 [17.5, 28.7]	Texas	7.3 [4.7, 9.8]
				West Virginia	21.4 [17.1, 25.6]	Rhode Island	8.0 [4.1, 11.8]
				Tennessee	18.2 [13.1, 23.3]	New Jersey	8.2 [4.5, 11.8]

40 to 44	0.297 (0.009)	< 0.001 *	16.7 [14.7, 20.4]	Arkansas	31.0 [21.7, 40.3]	New Jersey	9.4 [6.1, 14.9]
				West Virginia	27.3 [22.6, 32.1]	California	9.4 [6.9, 11.9]
				Mississippi	24.8 [18.7, 31.0]	District of Columbia	10.5 [6.1, 14.9]
				Kentucky	24.0 [19.4, 28.5]	Florida	11.1 [8.8, 13.3]
				Michigan	23.4 [19.6, 27.2]	Maryland	11.1 [8.8, 13.3]
45 to 49	0.219 (0.010)	0.007 *	22.7 (18.8, 25.7)	West Virginia	36.3 [31.6, 40.9]	California	13.4 [10.7, 16.1]
				Missouri	33.7 [27.4, 40.1]	District of Columbia	15.1 [10.7, 19.5]
				Mississippi	30.9 [25.4, 36.5]	Idaho	15.5 [10.7, 20.2]
				Maine	30.9 [25.8, 36.1]	Wisconsin	15.5 [11.1, 19.9]
				Alabama	30.0 [24.9, 35.1]	Minnesota	16.0 [13.7, 18.3]
50 to 54	0.227 (0.009)	0.005 *	30.6 (26.7, 33.3)	West Virginia	47.2 [42.9, 51.5]	District of Columbia	22.3 [17.4, 27.1]
				Kentucky	42.9 [38.2, 47.6]	California	22.4 [19.2, 25.7]
				Alabama	42.1 [37.3, 46.9]	Minnesota	23.3 [20.8, 25.7]
				Maine	42.0 [37.4, 46.7]	Hawaii	23.7 [19.4, 280.]
				Arkansas	41.9 [35.2, 48.6]	Colorado	24.5 [21.7, 27.4]
55 to 59	0.307 (0.009)	< 0.001 *	36.2 (34.1, 41.1)	West Virginia	53.0 [49.0, 57.0]	New Jersey	28.9 [24.3, 33.4]
				Kentucky	50.4 [45.8, 54.9]	Minnesota	29.5 [27.0, 31.9]
				Arkansas	49.5 [42.7, 56.2]	California	30.5 [26.6, 34.5]
				Alabama	49.2 [44.7, 53.7]	Wisconsin	30.7 [26.0, 35.4]
				South Carolina	47.6 [43.8, 51.5]	Hawaii	31.8 [27.5, 36.1]
60 to 64	0.344 (0.009)	< 0.001*	43.0 (40.0, 47.0)	Kentucky	58.6 [54.4, 62.7]	Hawaii	33.9 [29.7, 38.1]
				West Virginia	57.7 [54.1, 61.2]	District of Columbia	36.1 [30.7, 41.6]
				Tennessee	55.9 [51.1, 60.7]	Montana	36.3 [31.6, 41.0]
				Alabama	54.9 [50.5, 59.4]	California	36.8 [32.6, 40.9]
				Mississippi	51.4 [46.2, 56.5]	Florida	38.0 [34.5, 41.6]

65 to 69	0.240 (0.009)	0.004 *	48.1 (45.1, 50.3)	West Virginia	62.0 [58.4, 65.6]	California	38.8 [34.4, 43.3]
				Kentucky	57.0 [52.9, 61.2]	Hawaii	40.6 [36.3, 45.0]
				Mississippi	56.2 [51.1, 61.2]	Florida	40.9 [37.8, 44.1]
				Alabama	55.6 [51.4, 59.8]	South Dakota	43.1 [37.3, 48.9]
				Michigan	54.3 [51.0, 57.7]	Idaho	43.2 [38.1, 48.4]
70 & over	0.183 (0.010)	0.019 *	54.3 (53.0, 58.3)	West Virginia	64.6 [61.8, 67.5]	Hawaii	45.3 [41.8, 48.7]
				Mississippi	62.5 [58.9, 66.2]	Alaska	48.6 [40.1, 57.2]
				Missouri	61.6 [58.5, 64.8]	Nevada	48.8 [43.9, 59.7]
				Pennsylvania	61.4 [57.8, 65.0]	Puerto Rico	49.9 [46.3, 53.6]
				Michigan	61.2 [58.8, 63.5]	Minnesota	50.3 [48.3, 52.4]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table XIII: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2017

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[0])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	0.279 (0.010)	0.001 *	3.6 (2.6, 4.7)	Alaska	8.8 [3.0, 14.6]	District of Columbia	0.6 [0.0, 1.4]
				Arkansas	6.7 [1.2, 12.2]	North Carolina	0.8 [0.0, 1.8]
				West Virginia	5.9 [2.5, 9.2]	Georgia	1.2 [0.3, 2.2]
				New Hampshire	5.8 [1.7, 9.9]	Nevada	1.3 [0.0, 2.9]
				Maine	5.5 [2.4, 8.7]	Florida	1.6 [0.4, 2.8]
25 to 29	0.165 (0.009)	0.027 *	5.8 (4.4, 7.2)	Mississippi	12.7 [6.6, 18.8]	District of Columbia	1.5 [0.0, 3.3]
				Alabama	12.6 [7.0, 18.3]	Texas	1.9 [0.9, 3.0]
				West Virginia	12.1 [7.0, 17.2]	Puerto Rico	2.0 [0.4, 3.5]
				Kentucky	11.5 [7.1, 15.8]	Wisconsin	2.4 [0.7, 4.2]
				Michigan	9.8 [6.6, 12.9]	Wyoming	3.1 [0.6, 5.6]
30 to 34	0.190 (0.009)	0.015 *	9.2 (7.4, 11.3)	Arkansas	17.9 [8.2, 27.6]	District of Columbia	1.9 [0.4, 3.4]
				West Virginia	17.6 [12.2, 23.0]	South Dakota	2.8 [1.1, 4.4]
				Maine	14.6 [9.3, 19.9]	Puerto Rico	3.7 [1.3, 6.2]
				Louisiana	14.0 [9.7, 18.4]	California	4.5 [2.5, 6.6]
				Alabama	14.0 [10.0, 18.0]	Colorado	4.9 [3.0, 6.7]
35 to 39	-0.008 (0.009)	0.447	11.9 (9.4, 14.2)	West Virginia	26.2 [20.6, 31.9]	California	6.2 [4.1, 8.3]
				Arkansas	18.8 [11.7, 25.9]	Puerto Rico	6.4 [3.0, 9.8]
				Alabama	17.7 [13.1, 22.3]	District of Columbia	6.6 [3.4, 9.7]
				Kentucky	17.3 [12.7, 21.9]	Minnesota	7.3 [5.6, 9.0]
				Wisconsin	17.2 [11.7, 22.7]	Florida	7.9 [5.2, 10.6]

40 to 44	0.226 (0.009)	0.006 *	17.1 (12.8, 20.3)	Alabama	30.2 [24.1, 36.2]	District of Columbia	6.1 [3.0, 9.3]
				West Virginia	28.5 [22.8, 34.2]	California	10.0 [6.4, 13.6]
				Arkansas	26.6 [17.8, 35.3]	Idaho	10.6 [6.6, 14.5]
				Mississippi	26.1 [19.6, 32.6]	Nevada	10.7 [5.7, 15.7]
				Kentucky	25.5 [19.7, 31.2]	Utah	10.9 [8.5, 13.4]
45 to 49	0.190 (0.009)	0.015 *	20.2 (18.0, 25.5)	Kentucky	38.1 [31.8, 44.3]	District of Columbia	12.2 [8.0, 16.4]
				West Virginia	37.2 [31.9, 37.9]	Nevada	14.0 [8.5, 19.5]
				Alabama	32.3 [26.9, 37.7]	Massachusetts	14.6 [9.9, 19.2]
				Missouri	31.1 [25.7, 36.6]	Minnesota	14.6 [12.2, 17.1]
				Wyoming	30.9 [24.0, 37.9]	Hawaii	14.6 [10.6, 18.7]
50 to 54	0.269 (0.009)	0.001 *	29.0 (25.7, 32.3)	Kentucky	45.6 [39.9, 51.4]	Minnesota	17.5 [15.2, 19.7]
				West Virginia	45.5 [40.3, 50.7]	South Dakota	20.6 [14.7, 26.5]
				Tennessee	37.7 [32.1, 43.3]	California	22.6 [18.5, 26.8]
				Alabama	36.4 [31.5, 41.2]	Hawaii	23.5 [18.8, 28.2]
				Oklahoma	35.9 [30.7, 41.0]	District of Columbia	23.6 [18.2, 28.9]
55 to 59	0.262 (0.009)	0.001 *	34.5 (31.9, 40.5)	West Virginia	58.1 [53.5, 62.6]	Nevada	25.9 [18.5, 33.3]
				Alabama	51.6 [46.8, 56.4]	California	26.4 [22.5, 30.3]
				Arkansas	48.7 [41.9, 55.4]	District of Columbia	28.2 [22.7, 33.6]
				Tennessee	44.0 [38.5, 49.4]	Hawaii	28.7 [24.3, 33.1]
				Pennsylvania	43.0 [38.1, 47.9]	South Dakota	28.8 [22.9, 34.7]
60 to 64	0.195 (0.009)	0.011 *	41.6 [38.5, 43.5]	West Virginia	59.4 [55.3, 63.5]	Hawaii	31.1 [27.2, 35.0]
				Kentucky	50.7 [45.6, 55.9]	Minnesota	32.8 [30.2, 35.5]
				Michigan	49.5 [46.0, 52.9]	District of Columbia	33.7 [28.3, 39.2]
				Indiana	49.3 [46.2, 52.3]	Massachusetts	35.4 [29.5, 41.3]
				Rhode Island	48.1 [43.3, 52.8]	Puerto Rico	36.1 [29.8, 42.4]

65 to 69	0.308 (0.009)	< 0.001 *	45.9 (43.4, 45.0)	West Virginia	57.8 [53.6, 62.0]	South Dakota	35.5 [29.8, 41.2]
				Alabama	54.0 [49.6, 58.4]	Nevada	36.9 [29.7, 44.2]
				South Carolina	52.0 [48.7, 55.4]	Hawaii	37.6 [33.0, 42.2]
				Michigan	51.8 [48.4, 55.3]	Minnesota	37.8 [35.1, 40.5]
				Virginia	51.7 [47.7, 55.7]	Puerto Rico	38.8 [33.0, 44.6]
70 & over	0.302 (0.009)	< 0.001 *	51.6 (49.1, 53.6)	West Virginia	62.4 [59.2, 65.6]	District of Columbia	41.8 [37.5, 46.1]
				Alabama	61.2 [58.3, 64.1]	South Dakota	44.3 [40.0, 48.6]
				Michigan	59.8 [57.4, 62.3]	Delaware	45.8 [41.8, 49.8]
				Tennessee	59.4 [55.8, 63.3]	Minnesota	45.8 [43.8, 47.9]
				Pennsylvania	59.2 [55.4, 62.3]	Puerto Rico	45.8 [41.8, 49.9]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

[θ] IQR – Interquartile range

[α]Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

[π] A: Age group (years)

Table XIV: Spatial trends in the prevalence of rheumatic disorders[α] in US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS), per age category, in 2018

A[π]	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR[θ])	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
18 to 24	-0.003 (0.010)	0.426	3.8 (3.0, 4.6)	Arkansas	7.3 [2.6, 11.9]	Puerto Rico	0.54 [0.0, 1.2]
				Maine	7.0 [2.9, 11.2]	Texas	1.5 [0.64, 2.4]
				Oregon	6.7 [3.4, 10.0]	Louisiana	1.8 [0.5, 3.2]
				Kentucky	6.2 [3.5, 9.0]	California	1.9 [1.0, 2.8]
				Mississippi	6.1 [2.9, 9.2]	New Mexico	1.9 [0.7, 3.2]
25 to 29	0.068 (0.009)	0.177	6.0 (4.8, 7.8)	Alabama	15.8 [10.1, 21.5]	Puerto Rico	0.8 [0.0, 1.9]
				Maine	12.8 [7.3, 18.3]	New Jersey	3.0 [0.0, 7.2]
				New Hampshire	11.3 [5.4, 17.2]	Rhode Island	3.1 [1.0, 5.1]
				Delaware	10.8 [5.5, 16.2]	California	3.2 [2.0, 4.4]
				Michigan	10.5 [7.5, 13.5]	Montana	3.4 [0.5, 6.2]
30 to 34	0.158 (0.010)	0.034 *	9.0 (7.5, 12.6)	Kentucky	18.6 [12.7, 24.5]	Puerto Rico	2.1 [0.4, 3.6]
				West Virginia	18.2 [12.9, 23.6]	Texas	3.8 [1.7, 6.0]
				Mississippi	15.6 [10.8, 20.5]	New York	5.2 [3.9, 6.4]
				Missouri	15.4 [10.2, 20.6]	New Jersey	5.3 [2.0, 8.7]
				Tennessee	15.1 [10.0, 20.2]	Alaska	5.7 [1.5, 9.9]
35 to 39	0.114 (0.009)	0.083	13.3 (10.4, 15.8)	Michigan	22.7 [18.6, 26.8]	South Dakota	4.4 [1.1, 7.8]
				West Virginia	21.7 [16.2, 27.3]	New Jersey	5.8 [1.6, 10.1]
				Alabama	21.5 [16.1, 26.9]	District of Columbia	6.8 [3.7, 10.0]
				Maine	17.6 [12.6, 22.7]	Hawaii	8.0 [5.3, 10.6]
				Mississippi	17.6 [13.0, 22.2]	California	8.0 [5.9, 10.2]

40 to 44	0.373 (0.009)	< 0.001 *	16.8 (14.3, 19.6)	West Virginia	29.2 [22.9, 35.5]	California	8.4 [6.3, 10.6]
				Kentucky	27.1 [21.1, 33.2]	District of Columbia	10.3 [6.4, 14.1]
				Mississippi	25.9 [20.4, 31.4]	Nevada	11.4 [6.1, 16.6]
				Arkansas	24.9 [19.5, 29.4]	New York	11.7 [9.5, 14.0]
				Alabama	24.4 [19.5, 29.4]	Utah	12.2 [9.8, 14.5]
45 to 49	0.318 (0.009)	< 0.001 *	22.4 (20.4, 28.0)	West Virginia	40.7 [34.4, 46.9]	District of Columbia	15.0 [10.7, 19.3]
				Alabama	35.7 [30.4, 41.1]	Minnesota	15.5 [13.1, 17.9]
				Tennessee	34.4 [29.2, 39.5]	Massachusetts	15.8 [11.7, 20.0]
				Mississippi	34.4 [29.2, 39.5]	California	17.3 [14.4, 20.3
				Kentucky	34.2 [28.2, 40.2]	South Dakota	17.4 [11.4, 23.4]
50 to 54	0.379 (0.009)	< 0.001 *	29.2 (26.7, 33.9)	West Virginia	49.6 [44.1, 55.1]	New Jersey	22.3 [14.3, 30.2]
				Alabama	41.8 [36.7, 47.0]	California	22.7 [19.5, 26.0]
				Kentucky	40.6 [34.9, 46.2]	New York	23.7 [21.2, 26.1]
				Tennessee	39.5 [33.1, 45.9]	Hawaii	23.7 [19.5, 28.0]
				Arkansas	38.2 [31.9, 44.5]	Colorado	23.7 [20.1, 27.3]
55 to 59	0.170 (0.010)	0.026 *	38.1 (33.6, 42.8)	West Virginia	52.3 [47.2, 57.3]	Minnesota	28.4 [25.9, 30.9]
				Alabama	48.3 [43.4, 53.1]	Wyoming	29.0 [24.3, 33.6]
				Oregon	47.4 [42.0, 52.8]	Massachusetts	29.3 [25.2, 33.4]
				Michigan	47.3 [43.4, 51.1]	New Jersey	29.4 [21.7, 37.2]
				Missouri	47.2 [42.0, 52.8]	New York	30.7 [27.8, 33.5]
60 to 64	0.288 (0.009)	< 0.001 *	44.1 (41.5, 47.0)	West Virginia	60.1 [55.6, 64.7]	Connecticut	34.9 [31.6, 38.3]
				Arkansas	56.2 [51.1, 61.4]	Minnesota	35.0 [32.4, 37.5]
				Tennessee	56.1 [50.6, 61.6]	Hawaii	35.2 [30.6, 39.8]
				Alabama	52.8 [48.4, 57.1]	New Jersey	36.1 [27.5, 44.7]
				Mississippi	52.3 [47.4, 57.1]	Delaware	37.6 [32.7, 42.4]

65 to 69	0.138 (0.009)	0.050	48.4 (44.8, 51.0)	West Virginia	63.8 [59.5, 48.1]	Hawaii	35.6 [31.4, 39.8]
				Alabama	59.8 [55.5, 64.2]	Texas	41.7 [35.6, 47.8]
				Arkansas	58.0 [53.1, 62.8]	California	42.0 [37.5, 46.6]
				Idaho	56.1 [49.8, 62.3]	Minnesota	43.2 [40.5, 46.0]
				Kentucky	55.4 [50.5, 60.3]	Delaware	43.4 [38.3, 48.4]
70 & over	0.303 (0.009)	< 0.001 *	54.6 (51.9, 57.0)	West Virginia	66.7 [63.5, 69.9]	Hawaii	42.9 [39.1, 46.7]
				Alabama	61.0 [58.0, 64.0]	Minnesota	49.0 [46.9, 51.1]
				Kentucky	59.6 [55.7, 63.6]	Nevada	50.0 [44.2, 55.7]
				Missouri	59.6 [56.6, 62.6]	Delaware	50.2 [46.7, 53.7]
				Tennessee	59.0 [55.1, 63.0]	California	50.6 [46.8, 54.3]

* P < 0.05: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ A: Age group (years)

Table XV: Spatial trends in the prevalence of rheumatic disorders in male US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS)

Y^{π}	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR^{0})	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
2001	0.276 (0.010)	0.001 *	17.5 (16.3, 21.1)	West Virginia	26.3 [23.6, 28.9]	Hawaii	9.0 [7.5, 10.6]
				Kentucky	25.4 [23.1, 27.6]	Puerto Rico	12.4 [10.5, 14.3]
				Alabama	23.7 [20.9, 26.6]	Alaska	13.0 [10.6, 15.4]
				Michigan	23.7 [21.4, 26.0]	California	13.7 [11.8, 15.7]
				Arkansas	22.9 [20.2, 25.6]	Texas	14.6 [13.1, 16.1]
2003	0.197 (0.009)	0.011 *	22.7 (21.9, 24.8)	West Virginia	34.9 [32.1, 37.8]	Hawaii	15.2 [13.3, 17.1]
				Kentucky	31.3 [28.9, 33.8]	Utah	17.3 [15.1, 19.5]
				Alabama	29.7 [26.9, 32.6]	California	17.5 [15.6, 19.5]
				Michigan	29.4 [26.7, 32.0]	District of Columbia	18.3 [15.0, 21.6]
				Arkansas	27.8 [25.5, 32.0]	Puerto Rico	18.7 [16.4, 21.0]
2005	0.188 (0.009)	0.016 *	22.7 (21.0, 25.4)	West Virginia	31.2 [28.5, 33.9]	Puerto Rico	17.4 [15.1, 19.7]
				Mississippi	29.0 [26.4, 31.7]	California	17.7 [16.0, 19.5]
				Alabama	28.4 [25.3, 31.5]	District of Columbia	17.8 [15.3, 20.3]
				Missouri	28.0 [25.3, 30.8]	Texas	18.0 [16.3, 19.8]
				Pennsylvania	27.7 [25.9, 29.5]	Utah	19.5 [17.5, 21.4]
2007	0.266 (0.009)	0.002 *	23.4 (21.1, 25.8)	West Virginia	32.4 [29.8, 34.9]	California	16.0 [14.2, 17.8]
				Alabama	31.1 [28.5, 33.6]	Puerto Rico	16.6 [14.6, 18.6]
				Tennessee	29.9 [26.9, 32.9]	District of Columbia	18.8 [16.5, 21.2]
				Maine	28.9 [26.8, 31.0]	Utah	19.2 [17.2, 21.2]
				Missouri	28.6 [25.8, 31.4]	Texas	19.3 [18.0, 20.7]

2009	0.163 (0.009)	0.029 *	22.5 (20.0, 24.7)	Kentucky	33.3 [30.4, 36.1]	Puerto Rico	13.4 [11.6, 15.2]
				West Virginia	30.1 [27.7, 32.5]	District of Columbia	16.4 [14.4, 18.4]
				Alabama	29.6 [27.0, 32.3]	California	16.4 [15.3, 17.5]
				Maine	27.5 [25.6, 29.3]	Minnesota	17.1 [15.1, 19.1]
				Pennsylvania	47.4 [25.4, 29.5]	Utah	17.4 [16.0, 18.7]
2011	0.167 (0.009)	0.025 *	20.7 (19.5, 23.4)	West Virginia	32.0 [29.6, 34.3]	Puerto Rico	13.4 [11.9, 14.8]
				Kentucky	27.6 [25.6, 29.6]	Hawaii	16.2 [14.5, 17.9]
				Michigan	27.3 [25.5, 29.1]	Texas	16.2 [14.8, 17.6]
				Alabama	26.5 [24.4, 28.6]	Utah	16.5 [15.3, 17.7]
				Maine	25.6 [24.2, 27.1]	Minnesota	16.6 [15.4, 17.7]
2012	0.213 (0.009)	0.008 *	21.7 (20.3, 24.7)	West Virginia	32.6 [30.4, 34.8]	Utah	16.4 [15.2, 17.5]
				Kentucky	31.4 [29.3, 33.4]	Texas	16.7 [15.3, 18.1]
				Alabama	29.1 [27.0, 31.2]	Hawaii	17.3 [15.4, 19.1]
				Mississippi	28.0 [25.9, 30.2]	New Jersey	17.3 [16.1, 18.5]
				Michigan	28.0 [26.3, 29.7]	California	17.8 [16.6, 19.0]
2013	0.214 (0.009)	0.007 *	21.6 (19.6, 23.8)	West Virginia	33.8 [31.7, 35.9]	California	16.0 [14.7, 17.3]
				Kentucky	28.7 [26.7, 29.4]	Utah	16.1 [15.0, 17.2]
				Michigan	27.9 [26.3, 29.4]	District of Columbia	16.2 [14.0, 18.4]
				Alabama	27.8 [25.5, 30.1]	Puerto Rico	16.4 [14.6, 18.4]
				Mississippi	26.5 [24.3, 28.7]	Texas	16.8 [15.3, 18.3]
2014	0.273 (0.009)	0.001 *	22.2 (20.0, 23.6)	West Virginia	36.2 [34.1, 38.4]	Texas	15.8 [14.5, 17.2]
				Kentucky	31.1 [28.9, 33.2]	District of Columbia	16.1 [13.6, 18.6]
				Alabama	29.4 [27.4, 31.5]	California	16.1 [14.8, 17.5]
				Tennessee	29.1 [26.5, 31.8]	Utah	16.5 [15.5, 17.4]
				Michigan	28.1 [26.4, 29.9]	Puerto Rico	17.3 [15.5, 19.1]

2015	0.195 (0.009)	0.011 *	21.4 (19.0, 24.3)	West Virginia	36.3 [34.2, 38.4]	District of Columbia	14.7 [11.9, 17.6]
				Alabama	29.1 [27.1, 31.1]	California	15.7 [14.5, 16.9]
				Kentucky	28.1 [25.8, 30.3]	Texas	15.8 [14.3, 17.2]
				Tennessee	28.1 [25.5, 30.6]	Puerto Rico	16.4 [14.5, 18.2]
				Maine	26.7 [24.9, 28.5]	Utah	16.6 [15.4, 17.7]
2016	0.200 (0.009)	0.011 *	21.7 (20.1, 24.9)	West Virginia	35.9 [34.0, 37.8]	District of Columbia	13.1 [11.3, 14.8]
				Arkansas	30.3 [27.1, 33.6]	California	14.5 [13.4, 15.7]
				Kentucky	29.1 [27.2, 31.1]	Utah	16.6 [15.4, 17.9]
				Alabama	29.0 [26.9, 31.0]	Puerto Rico	17.4 [15.4, 19.5]
				Maine	28.9 [26.9, 30.8]	Texas	17.5 [15.7, 19.3]
2017	0.190 (0.009)	0.013	20.7 (18.7, 23.8)	West Virginia	36.0 [33.7, 38.3]	District of Columbia	11.8 [10.2, 13.4]
				Alabama	29.6 [27.5, 31.8]	Puerto Rico	15.3 [13.1, 17.5]
				Maine	29.6 [27.6, 31.7]	Texas	15.5 [13.6, 17.3]
				Kentucky	28.4 [26.2, 31.6]	California	15.5 [14.1, 16.9]
				Michigan	25.8 [24.3, 27.3]	Utah	16.4 [15.2, 17.6]
2018	0.217 (0.009)	0.007 *	22.7 (20.9, 25.1)	West Virginia	36.3 [33.9, 38.7]	District of Columbia	15.5 [13.8, 17.3]
				Alabama	30.4 [28.2, 32.6]	California	16.3 [15.1, 17.5]
				Kentucky	29.3 [27.0, 31.6]	Texas	17.8 [15.7, 19.9]
				Arkansas	28.8 [26.3, 31.4]	New York	17.9 [16.9, 18.9]
				Maine	28.6 [26.6, 30.5]	Puerto Rico	18.0 [16.0, 20.0]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ Y: Year

Table XVI: Spatial trends in the prevalence of rheumatic disorders in female US residents diagnosed by medical and healthcare practitioners, according to the Behavioural Risk Factor Surveillance Survey (BRFSS)

Y^{π}	Global Moran's I (variance)	P-value	Median prevalence estimate (IQR^{0})	Five states/regions with the highest prevalence		Five states/regions with the lowest prevalence	
				State name	*Prevalence [95% CI] (%)*	*State name*	*Prevalence [95% CI] (%)*
2001	0.359 (0.009)	< 0.001 *	26.7 (24.7, 29.8)	Alabama	36.1 [33.7, 38.7]	Hawaii	14.7 [12.8, 16.5]
				West Virginia	34.4 [32.0, 36.7]	Alaska	20.9 [18.1, 23.7]
				Kentucky	34.2 [32.3, 36.1]	Wyoming	22.2 [20.1, 24.2]
				Michigan	33.3 [31.1, 35.4]	Colorado	22.4 [19.7, 25.0]
				Indiana	31.6 [29.6, 33.7]	Puerto Rico	23.0 [21.0, 24.9]
2003	0.304 (0.010)	< 0.001 *	30.7 (29.1, 33.0)	West Virginia	39.3 [37.0, 41.7]	Hawaii	20.6 [18.7, 22.5]
				Alabama	37.7 [35.4, 40.0]	Alaska	26.2 [23.1, 29.2]
				Kentucky	37.6 [35.6, 39.6]	California	24.2 [24.3, 28.2]
				Indiana	35.7 [33.9, 37.5]	Colorado	26.6 [24.6, 28.5]
				Pennsylvania	35.5 [33.3, 37.7]	District of Columbia	27.2 [24.1, 30.2]
2005	0.252 (0.010)	0.003 *	30.6 (29.3, 33.1)	West Virginia	38.3 [36.0, 40.7]	Hawaii	24.5 [22.7, 26.2]
				Alabama	37.0 [34.7, 39.4]	Alaska	24.9 [21.9, 27.8]
				Missouri	35.9 [33.5, 38.4]	Utah	25.8 [23.9, 27.7]
				Michigan	35.3 [34.1, 36.5]	Texas	26.4 [24.9, 28.0]
				Pennsylvania	35.3 [33.8, 36.8]	District of Columbia	26.5 [24.3, 28.7]
2007	0.375 (0.010)	< 0.001 *	31.1 (29.5, 34.2)	West Virginia	38.5 [36.4, 40.7]	Utah	24.4 [22.5, 26.3]
				Alabama	38.0 [36.1, 39.9]	Minnesota	24.8 [23.1, 26.5]
				Tennessee	37.8 [35.5, 40.2]	California	25.5 [23.7, 27.2]
				Pennsylvania	36.4 [34.7, 38.1]	Hawaii	26.4 [24.5, 28.2]
				Ohio	36.0 [34.5, 37.4]	Colorado	26.7 [25.5, 27.8]

2009	0.238 (0.010)	0.004 *	29.7 (27.4, 33.6)	Alabama	37.8 [35.9, 39.8]	Puerto Rico	22.3 [20.6, 24.0]
				Kentucky	37.7 [35.7, 39.7]	Hawaii	22.9 [21.3, 24.6]
				West Virginia	37.4 [35.4, 39.4]	California	24.1 [23.1, 25.2]
				Arkansas	35.9 [33.3, 38.6]	Minnesota	24.6 [23.0, 26.3]
				Michigan	35.4 [33.8, 37.0]	District of Columbia	24.8 [22.8, 26.8]
2011	0.344 (0.009)	< 0.001 *	28.0 (26.3, 31.0)	West Virginia	39.7 [37.7, 41.7]	Hawaii	20.3 [18.7, 21.9]
				Kentucky	35.9 [34.1, 37.6]	Alaska	22.8 [20.4, 25.2]
				Michigan	34.4 [32.8, 36.1]	Utah	23.0 [21.9, 24.2]
				Mississippi	34.3 [32.7, 35.9]	District of Columbia	23.9 [21.9, 26.0]
				Arkansas	34.0 [31.5, 36.4]	Colorado	24.0 [22.8, 25.2]
2012	0.303 (0.009)	< 0.001 *	28.9 (27.2, 32.2)	West Virginia	40.1 [38.1, 42.0]	Hawaii	23.4 [21.4, 25.3]
				Kentucky	38.5 [36.8, 40.2]	Utah	23.6 [22.5, 24.8]
				Alabama	38.4 [36.7, 40.1]	Minnesota	24.1 [22.8, 25.3]
				Michigan	35.4 [33.9, 37.0]	Alaska	25.2 [22.8, 27.6]
				Arkansas	34.7 [32.8, 36.9]	Massachusetts	25.5 [24.5, 26.6]
2013	0.267 (0.009)	0.002 *	29.0 (27.2, 30.9)	West Virginia	38.4 [36.5, 40.3]	Hawaii	20.3 [18.6, 22.0]
				Alabama	36.2 [34.3, 38.1]	Minnesota	22.3 [20.6, 24.0]
				Kentucky	34.9 [33.2, 36.6]	District of Columbia	22.4 [20.3, 24.5]
				Michigan	34.6 [33.2, 36.0]	Utah	22.9 [21.8, 24.1]
				Pennsylvania	34.2 [32.7, 35.7]	Nevada	24.0 [21.4, 26.6]
2014	0.318 (0.009)	< 0.001 *	29.9 (28.0, 31.7)	West Virginia	43.6 [41.7, 45.5]	District of Columbia	21.9 [19.4, 24.4]
				Alabama	38.2 [36.5, 40.0]	Texas	23.0 [21.6, 24.3]
				Kentucky	36.7 [34.9, 38.5]	Hawaii	23.4 [21.5, 25.3]
				Tennessee	35.9 [33.6, 38.1]	Utah	23.7 [22.6, 24.7]
				Pennsylvania	35.6 [34.0, 37.3]	California	24.5 [22.9, 26.0]

2015	0.278 (0.009)	0.001 *	28.8 (26.9, 32.0)	West Virginia	39.6 [37.7, 41.5]	Hawaii	20.2 [18.6, 21.9]
				Alabama	37.1 [35.3, 38.9]	District of Columbia	21.8 [19.3, 24.4]
				Kentucky	35.7 [33.6, 37.7]	California	22.4 [21.1, 23.7]
				Tennessee	35.6 [33.3, 38.0]	Utah	22.6 [21.3, 23.8]
				Maine	35.1 [33.2, 36.9]	Texas	24.2 [22.6, 25.7]
2016	0.291 (0.009)	< 0.001 *	29.0 (27.4, 32.3)	West Virginia	41.7 [40.0, 43.5]	District of Columbia	20.3 [18.5, 22.1]
				Maine	38.4 [36.5, 40.4]	Utah	22.9 [21.5, 24.2]
				Alabama	37.8 [35.9, 39.6]	California	23.2 [21.8, 24.6]
				Kentucky	37.7 [35.8, 39.5]	Hawaii	24.4 [22.6, 26.2]
				Arkansas	36.3 [33.4, 39.2]	Texas	25.7 [23.7, 27.6]
2017	0.286 (0.009)	< 0.001 *	28.4 (26.9, 31.6)	West Virginia	42.2 [40.1, 44.3]	District of Columbia	16.4 [14.8, 18.1]
				Alabama	36.7 [33.8, 39.6]	Utah	22.3 [21.0, 23.6]
				Arkansas	36.7 [33.8, 39.6]	Nevada	22.7 [20.3, 25.2]
				Kentucky	36.1 [34.0, 38.3]	Minnesota	22.8 [21.7, 23.8]
				Michigan	34.9 [33.4, 36.4]	California	23.2 [21.5, 24.8]
2018	0.296 (0.009)	< 0.001 *	30.3 (28.2, 33.4)	West Virginia	43.9 [41.6, 46.1]	District of Columbia	21.6 [19.7, 23.5]
				Alabama	38.7 [36.7, 40.7]	Hawaii	23.6 [21.8, 25.4]
				Kentucky	37.2 [35.0, 39.4]	New Jersey	24.1 [20.8, 27.3]
				Arkansas	36.9 [34.6, 39.2]	California	24.6 [23.1, 26.1]
				Maine	36.6 [34.7, 38.4]	Texas	24.6 [22.5, 26.8]

* $P < 0.05$: for the establishment of a spatial correlation in the rheumatic disorder diagnosis prevalence and state proximity

$^{\theta}$ IQR – Interquartile range

$^{\alpha}$Rheumatic disorders include: Arthritis (including rheumatism, polymyalgia rheumatic, osteoarthritis, tendonitis, bursitis, bunion, tennis elbow, carpal tunnel syndrome, tarsal tunnel syndrome, joint infection, Reiter's syndrome, ankylosing spondylitis, spondylosis, rotator cuff syndrome, connective tissue disease, scleroderma, polymyositis, Raynaud's syndrome, vasculitis, giant cell arteritis, Henoch-Schonlein purpura, Wegener's granulomatosis, polyarteritis nodosa); Rheumatoid Arthritis; Gout; Lupus; Fibromyalgia

$^{\pi}$ Y: Year

Table XVII: Prevalence of rheumatic disorder diagnoses in the overall US population, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	30.32	33.94	32.90	34.68	33.95	30.19	33.93	32.19	34.01	33.25	33.55	33.32	34.72
Alaska	16.80	24.61	23.17	24.92	23.45	21.25	22.51	22.72	21.94	21.19	23.86	22.39	23.48
Arizona	23.69	26.28	26.10	25.28	24.29	23.41	24.97	23.97	24.89	23.63	25.97	24.33	25.67
Arkansas	27.37	31.59	30.66	30.74	31.29	28.66	30.26	29.96	30.43	29.72	33.42	30.88	32.99
California	18.85	21.96	22.29	20.78	20.31	21.50	22.04	20.38	20.35	19.12	18.95	19.39	20.53
Colorado	19.91	24.60	23.26	23.91	23.82	21.79	23.18	22.24	22.81	22.72	23.01	21.36	22.61
Connecticut	20.78	25.91	25.46	25.52	24.93	22.50	24.28	23.72	24.00	24.5	25.12	23.17	25.99
Delaware	23.41	28.00	29.25	31.00	27.47	26.30	27.97	26.22	26.60	28.07	26.73	25.31	26.05
District of Columbia	20.45	23.05	22.41	23.57	20.85	20.94	--	19.51	19.17	18.48	16.87	14.27	18.75
Florida	25.47	27.81	27.36	24.29	26.96	26.87	26.42	26.02	26.96	25.89	24.78	24.83	26.49
Georgia	23.16	26.72	25.76	27.49	23.70	23.32	23.97	24.15	25.22	24.56	25.43	22.21	25.31
Hawaii	11.81	17.88	22.14	24.14	21.18	18.23	20.33	19.93	20.72	18.89	21.94	21.03	22.24
Idaho	21.91	25.61	25.51	25.79	23.72	23.07	26.00	24.12	24.78	25.28	24.03	24.35	26.28
Illinois	22.09	24.34	24.85	26.93	26.55	24.26	25.43	23.54	25.05	23.33	24.78	24.44	24.85
Indiana	26.80	30.42	29.29	30.41	29.30	27.45	27.83	27.98	29.15	27.58	27.78	28.42	28.5
Iowa	21.16	26.64	27.42	27.06	25.27	24.35	25.92	24.29	25.95	25.88	25.50	24.68	25.44
Kansas	23.45	24.64	26.92	27.49	24.11	23.10	24.02	23.94	25.37	24.52	25.03	24.14	25.68
Kentucky	29.96	34.60	28.81	31.56	35.56	31.85	35.04	31.88	33.94	31.97	33.51	32.36	33.36
Louisiana	22.99	27.52	26.67	25.39	26.02	25.32	27.98	26.40	27.10	27.91	27.82	27.34	29.22
Maine	25.62	29.33	30.54	32.24	30.90	29.67	29.55	30.43	31.44	31.02	33.80	31.19	32.81
Maryland	21.54	26.26	27.45	27.75	25.90	23.26	23.53	23.62	25.57	23.54	24.54	24.93	26.39
Massachusetts	20.75	25.58	25.95	27.48	24.83	23.56	23.10	24.29	27.33	24.15	25.23	23.9	24.16
Michigan	28.68	32.31	30.8	31.44	30.85	30.98	31.81	31.33	31.91	30.00	31.95	30.48	32.06
Minnesota	20.28	25.64	25.54	22.92	20.92	20.47	21.45	19.90	21.84	21.58	22.43	19.75	21.98
Mississippi	26.02	31.31	32.11	30.53	30.80	29.10	30.78	29.96	29.22	28.58	31.27	29.21	32.20
Missouri	27.00	30.10	32.14	31.88	31.01	28.76	29.56	28.39	27.98	29.33	30.57	27.83	31.09
Montana	24.16	26.31	26.41	29.05	27.49	26.42	27.83	27.27	26.03	26.82	27.62	25.59	28.56
Nebraska	20.37	26.96	26.15	28.02	25.90	23.43	24.63	24.73	24.57	23.45	24.57	23.98	25.22
Nevada	21.30	27.01	25.12	25.16	24.33	22.85	24.02	20.89	23.09	21.55	23.73	20.30	24.82

New Hampshire	21.13	26.43	26.88	28.67	27.02	25.77	27.25	26.63	27.16	26.59	27.57	26.55	29.76
New Jersey	21.33	24.99	24.43	26.67	22.74	22.26	21.84	22.77	22.68	22.93	23.22	22.90	23.10
New Mexico	21.81	25.54	24.39	27.21	25.75	24.24	23.92	24.38	25.83	24.51	27.75	25.39	26.97
New York	22.61	27.54	26.06	28.07	25.63	24.42	25.01	24.9	24.15	23.41	23.65	22.63	22.74
North Carolina	23.28	28.51	27.33	29.11	27.57	25.13	26.11	26.36	27.67	26.95	26.09	24.4	27.62
North Dakota	20.95	27.47	26.02	26.89	27.41	24.08	24.52	26.09	25.00	22.90	23.27	24.24	25.94
Ohio	25.79	29.78	30.10	32.2	30.83	29.24	30.01	29.85	30.81	28.40	30.47	29.05	30.80
Oklahoma	26.97	27.95	30.27	30.31	30.43	27.72	27.95	27.22	27.53	27.69	28.29	27.71	28.55
Oregon	21.93	27.04	27.05	26.40	27.23	26.49	28.04	27.76	26.10	26.79	27.17	26.6	29.05
Pennsylvania	26.41	31.59	31.67	32.10	31.26	28.36	29.07	29.78	30.31	29.25	30.14	29.17	28.74
Rhode Island	26.12	28.33	28.17	29.27	29.27	26.56	26.77	27.46	27.37	26.91	26.95	27.44	28.19
South Carolina	24.08	30.35	30.81	29.55	30.67	27.92	28.93	30.24	29.99	29.13	30.08	28.17	30.34
South Dakota	22.10	28.78	27.89	26.81	25.57	23.48	23.66	25.29	26.02	24.31	25.82	22.21	25.12
Tennessee	26.43	31.57	29.71	33.99	25.89	25.86	29.77	26.43	32.62	31.99	31.02	30.16	32.45
Texas	19.78	24.05	22.30	23.67	22.48	20.22	21.32	20.74	19.45	20.03	21.65	21.37	21.35
Utah	19.78	22.32	22.66	21.82	21.39	19.77	20.03	19.51	20.06	19.58	19.79	19.33	21.58
Vermont	21.65	27.29	27.36	28.43	28.57	26.57	27.19	27.78	27.97	26.98	28.04	27.81	28.42
Virginia	22.95	27.22	27.63	26.80	25.89	25.73	25.46	25.01	26.16	23.23	25.52	25.01	25.96
Washington	20.59	26.70	26.15	27.37	26.45	23.74	25.21	25.43	25.70	24.46	24.57	24.01	24.46
West Virginia	30.53	37.22	34.86	35.55	33.85	35.94	36.43	36.15	39.99	38.00	38.89	39.16	40.14
Wisconsin	24.82	26.85	27.72	27.83	25.17	25.30	25.71	25.07	25.69	24.72	24.76	25.54	26.29
Wyoming	19.73	28.49	27.36	27.86	26.91	24.22	24.75	25.14	25.60	25.85	26.45	25.31	25.31
Guam	12.54	16.44	--	13.67	10.68	10.58	--	16.13	15.67	15.80	17.11	15.57	13.9
Puerto Rico	17.97	24.37	23.86	22.10	18.14	19.68	--	23.35	24.56	22.77	23.84	21.46	24.57
Virgin Islands	--	--	16.55	16.99	15.21	--	--	--	--	--	17.27	--	--

Table XVIII: Prevalence of rheumatic disorder diagnoses in the US population aged 18 to 24 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	7.01	5.66	11.13	4.77	5.12	5.59	7.20	1.69	4.83	6.16	6.53	4.20	3.59
Alaska	1.89	5.59	2.34	1.48	8.53	4.60	2.22	2.31	2.88	5.96	5.50	8.82	4.36
Arizona	3.97	8.28	4.18	2.72	0.10	2.68	4.11	1.57	1.50	2.42	3.03	3.06	4.27
Arkansas	4.88	7.35	7.46	5.83	6.92	4.36	4.63	4.79	2.77	4.18	7.31	6.68	7.25
California	2.15	3.42	2.34	3.41	2.06	1.99	2.90	2.36	1.49	1.84	1.83	1.93	1.89
Colorado	3.29	5.76	4.17	5.98	4.39	1.65	4.17	2.82	2.59	4.00	2.65	2.52	2.40
Connecticut	3.33	6.31	3.08	5.10	2.60	2.94	2.29	2.20	2.15	2.80	1.37	1.74	3.12
Delaware	1.76	5.51	4.58	7.85	6.26	2.47	6.31	5.02	1.42	5.39	2.12	4.02	4.40
District of Columbia	1.20	7.83	1.38	3.10	3.98	3.25	2.19	3.08	6.46	0.00	0.35	0.56	2.26
Florida	4.62	2.38	4.68	2.76	4.64	3.43	3.31	2.95	3.12	1.85	3.30	1.61	4.30
Georgia	3.88	5.47	3.81	5.55	0.69	3.48	4.47	4.16	2.24	3.77	2.71	1.23	3.75
Hawaii	2.66	2.41	3.68	4.42	2.37	0.34	1.44	2.35	2.87	1.83	2.46	2.01	3.26
Idaho	3.83	5.13	3.99	3.48	2.46	3.74	4.56	1.89	4.60	2.18	3.07	4.71	3.03
Illinois	3.70	4.73	5.66	7.77	3.70	6.47	2.44	2.89	3.39	3.25	3.34	3.46	3.18
Indiana	5.18	7.28	6.40	9.00	4.08	4.00	4.60	4.21	2.94	4.41	3.17	5.30	4.62
Iowa	2.59	4.43	5.90	6.95	1.49	2.63	2.90	3.10	4.76	1.40	1.53	4.19	4.05
Kansas	5.75	5.27	7.04	7.62	3.32	3.26	4.02	3.27	3.06	3.50	2.97	3.39	4.25
Kentucky	4.89	12.02	7.56	6.20	10.94	5.55	6.08	5.63	5.05	4.12	3.64	5.35	6.22
Louisiana	2.30	6.65	6.01	3.15	4.15	4.72	4.25	4.36	5.17	4.59	5.25	4.50	1.83
Maine	3.84	5.31	8.34	10.43	2.50	3.73	4.13	2.98	2.93	4.79	6.73	5.54	7.00
Maryland	3.52	4.27	6.15	7.49	3.07	2.67	2.66	1.94	2.25	3.17	2.51	3.58	4.57
Massachusetts	2.83	4.82	5.27	3.57	1.95	2.65	2.26	4.15	3.73	1.81	1.85	2.62	3.90
Michigan	6.71	6.54	5.30	4.69	5.92	4.19	4.11	5.36	4.81	4.24	5.98	4.70	5.23
Minnesota	3.22	11.24	8.51	2.91	5.28	2.89	3.93	1.69	3.18	3.10	1.83	2.69	3.44
Mississippi	5.02	4.40	5.90	6.62	6.48	3.52	4.78	4.75	2.67	5.23	5.60	4.49	6.06
Missouri	3.99	6.39	8.33	9.73	2.29	5.21	4.12	3.15	3.07	3.79	7.13	3.08	2.99
Montana	8.68	8.05	6.00	6.92	2.80	4.47	5.67	3.92	3.20	3.98	2.41	5.22	5.24
Nebraska	4.21	3.88	3.80	3.91	3.61	2.95	3.06	4.22	2.48	2.23	3.72	3.95	4.76
Nevada	1.62	8.82	7.24	2.75	3.00	1.07	2.81	1.73	2.35	4.55	3.94	1.33	4.47

New Hampshire	2.32	6.54	4.88	7.51	5.94	5.11	3.12	2.05	3.33	1.37	2.92	5.80	5.69
New Jersey	4.19	5.03	4.33	0.55	0.94	3.18	2.68	4.19	1.98	3.08	4.90	3.07	5.28
New Mexico	4.93	5.21	2.77	4.49	4.42	3.62	2.05	2.36	5.44	2.94	3.58	3.71	1.94
New York	3.92	5.49	4.19	5.08	1.59	1.92	4.88	4.87	2.37	3.46	2.74	1.89	2.45
North Carolina	5.08	7.42	5.46	6.35	4.11	4.17	3.68	3.37	3.23	4.27	3.30	0.77	2.97
North Dakota	3.30	5.56	3.79	5.79	4.88	6.67	1.51	4.07	2.97	4.82	2.09	4.32	2.17
Ohio	3.13	6.80	4.93	6.23	5.49	4.21	4.14	5.11	2.76	3.54	3.81	5.02	4.92
Oklahoma	5.38	6.31	4.59	5.39	6.06	3.33	5.03	5.16	5.50	4.19	2.60	5.52	5.91
Oregon	2.82	7.31	2.97	1.62	9.82	5.85	3.86	5.32	2.11	3.11	3.20	4.98	6.71
Pennsylvania	4.38	6.61	7.02	5.37	7.54	4.72	4.33	3.76	6.11	4.34	3.28	4.03	4.34
Rhode Island	6.92	5.07	3.98	7.90	2.71	2.02	3.82	4.62	2.34	4.51	5.97	2.48	2.45
South Carolina	2.64	8.13	9.87	4.18	5.89	3.98	3.51	4.27	4.67	3.93	2.09	2.93	2.46
South Dakota	5.23	6.87	4.85	5.55	5.66	3.33	3.82	2.38	4.36	2.25	4.45	3.09	3.16
Tennessee	4.74	7.72	6.66	11.45	3.08	0.51	4.79	3.25	6.20	4.56	3.51	4.17	4.03
Texas	2.44	6.18	6.11	4.51	6.65	2.58	1.61	2.12	1.76	2.21	2.00	2.61	1.49
Utah	2.53	8.05	6.90	4.63	4.52	3.87	3.17	3.39	2.49	2.50	2.82	4.51	3.09
Vermont	4.26	5.34	5.91	8.53	6.05	3.90	1.98	3.53	3.81	4.03	4.26	2.69	2.62
Virginia	4.80	6.23	6.10	6.47	4.41	4.94	4.59	3.82	3.05	4.50	2.18	3.42	3.20
Washington	2.43	6.14	5.29	3.94	4.08	3.38	3.89	3.27	3.20	3.09	3.03	3.49	3.30
West Virginia	2.82	7.36	5.36	12.42	3.14	9.11	4.35	3.18	8.17	3.38	9.62	5.86	4.39
Wisconsin	3.96	4.34	4.39	7.29	2.74	3.19	3.07	2.47	3.16	1.95	4.37	4.21	3.35
Wyoming	3.93	7.88	4.31	5.89	5.31	3.74	2.18	2.65	3.48	7.41	4.42	4.78	4.40
Guam	3.73	0.74	--	2.76	0.00	0.14	1.70	1.19	2.52	2.27	2.88	0.37	1.03
Puerto Rico	1.08	2.85	2.43	2.76	2.56	0.33	2.45	1.27	2.67	0.39	2.26	2.11	0.54
Virgin Islands	2.69	4.20	2.07	3.61	2.60	--	--	--	--	--	0.00	--	--

Table XIX: Prevalence of rheumatic disorder diagnoses in the US population aged 25 to 29 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	4.71	12.48	6.86	12.65	6.72	9.94	7.19	5.07	9.46	10.35	7.80	12.64	15.79
Alaska	8.19	10.35	5.54	9.73	8.52	3.43	5.87	8.16	6.50	3.94	2.05	4.41	4.08
Arizona	5.73	8.79	6.31	3.81	5.80	2.95	5.69	6.82	3.22	7.00	6.75	5.56	4.94
Arkansas	11.15	11.60	5.85	8.43	16.82	6.50	11.33	8.91	10.51	5.91	7.64	6.94	8.57
California	4.26	5.81	4.62	2.23	3.69	4.92	5.20	3.86	3.65	3.19	2.36	3.87	3.20
Colorado	5.55	8.26	8.40	5.19	3.53	8.26	8.39	6.43	5.49	3.92	6.02	4.93	4.41
Connecticut	3.77	5.51	4.12	6.03	6.98	4.57	5.39	2.96	4.80	5.00	3.62	4.02	5.07
Delaware	6.93	5.18	12.87	12.43	6.70	9.02	7.99	6.02	7.68	7.02	11.02	6.66	10.83
District of Columbia	0.55	3.26	6.85	4.03	2.88	5.85	1.57	6.23	3.81	5.38	3.71	1.47	4.70
Florida	4.01	4.16	7.13	5.66	5.66	7.12	6.60	4.65	4.61	4.86	3.90	4.34	4.53
Georgia	7.99	8.69	5.96	11.08	7.11	7.70	2.56	5.73	6.80	6.47	7.42	4.90	3.74
Hawaii	2.89	3.56	7.31	7.25	5.43	3.65	6.36	5.85	3.19	2.84	4.43	4.22	6.24
Idaho	4.66	6.03	6.15	7.71	9.49	7.91	7.15	7.29	9.33	7.19	4.67	5.60	9.22
Illinois	8.39	8.03	7.21	6.03	12.06	6.27	6.93	8.44	5.40	7.39	7.79	7.17	5.05
Indiana	5.89	8.65	11.97	8.15	7.00	6.63	7.61	7.98	12.06	6.16	7.42	8.87	9.75
Iowa	4.51	9.69	9.04	4.43	3.80	6.46	7.97	6.38	5.71	12.18	6.56	7.30	6.22
Kansas	5.86	7.09	7.86	8.73	7.23	6.52	6.02	5.88	4.60	4.47	5.66	5.75	6.50
Kentucky	12.45	12.56	10.70	11.35	10.73	8.72	12.78	9.39	11.53	7.87	9.53	11.48	6.26
Louisiana	4.90	8.29	10.03	8.54	8.42	4.44	7.92	8.74	8.02	7.50	9.81	7.64	3.86
Maine	10.14	11.22	8.36	12.00	8.25	10.84	6.31	7.91	8.69	7.55	11.49	8.36	12.81
Maryland	4.61	7.87	9.09	6.52	6.86	5.68	4.61	6.87	6.82	8.68	5.77	5.54	5.97
Massachusetts	4.79	7.82	5.88	8.39	5.02	4.60	5.17	4.05	8.14	4.69	4.45	5.79	5.03
Michigan	9.11	8.23	10.61	11.79	7.61	9.86	8.75	9.57	8.72	7.96	7.58	9.78	10.54
Minnesota	6.21	8.53	8.09	5.42	6.57	6.48	5.20	4.25	6.44	5.02	5.11	5.58	4.98
Mississippi	6.18	11.69	10.05	8.89	6.68	8.38	6.40	9.72	9.44	4.19	9.26	12.69	10.07
Missouri	8.46	8.78	12.00	8.09	13.36	9.95	4.76	7.22	9.07	9.18	4.88	4.14	4.94
Montana	8.61	9.12	8.45	11.83	5.21	5.29	7.72	6.71	5.68	6.85	5.72	6.38	3.38
Nebraska	1.20	4.84	6.93	11.16	7.26	5.51	3.26	5.01	4.90	5.38	6.98	4.90	5.13
Nevada	6.33	3.93	9.88	12.69	7.70	4.15	4.54	4.61	9.55	6.19	3.63	4.85	5.32

New Hampshire	10.24	11.87	9.52	6.95	3.60	4.82	6.20	4.35	6.88	8.35	8.85	4.27	11.31
New Jersey	3.48	6.23	5.26	6.03	5.03	4.53	2.54	5.69	4.42	4.81	6.43	6.16	2.97
New Mexico	4.52	8.06	6.36	7.83	9.86	8.80	5.71	7.54	8.15	4.25	7.07	6.79	7.46
New York	3.87	8.35	7.21	7.51	7.83	5.52	6.14	5.80	3.73	4.66	5.24	3.18	5.46
North Carolina	5.39	7.31	8.13	8.24	9.13	6.00	7.05	5.84	5.68	5.37	8.22	7.72	7.16
North Dakota	7.07	10.13	9.35	8.56	11.78	5.28	4.21	8.12	4.87	2.50	6.15	6.21	5.91
Ohio	7.78	10.85	13.74	10.77	8.66	8.97	8.57	9.68	10.88	6.04	6.02	8.85	6.23
Oklahoma	6.13	6.23	12.38	9.29	7.70	7.23	5.25	8.47	7.49	8.07	7.20	7.82	9.11
Oregon	3.83	9.54	9.46	8.01	5.44	5.98	7.75	9.20	3.47	8.62	9.76	7.75	8.70
Pennsylvania	5.54	5.79	9.47	12.23	9.00	5.98	6.61	9.13	6.30	6.49	6.85	6.02	8.04
Rhode Island	10.52	8.99	8.76	5.67	6.57	9.32	6.06	5.97	9.21	5.40	4.68	5.22	3.05
South Carolina	2.73	9.22	8.39	7.76	8.66	6.29	7.78	7.54	6.47	4.68	5.99	5.76	8.85
South Dakota	6.70	9.38	9.49	6.91	6.54	1.89	5.76	8.27	4.30	4.79	4.80	5.79	6.47
Tennessee	3.70	12.47	9.77	13.44	5.13	10.24	11.24	9.13	9.90	10.93	5.11	6.62	6.72
Texas	4.86	6.35	5.43	6.98	6.94	4.26	5.85	7.35	4.02	5.52	5.53	1.93	3.63
Utah	4.74	7.30	7.91	7.97	4.61	5.30	5.64	5.43	5.48	6.08	4.94	4.54	4.81
Vermont	7.70	8.75	11.20	6.78	6.86	3.66	3.92	7.76	7.77	5.10	7.87	5.20	7.29
Virginia	5.27	11.11	7.39	7.43	7.16	6.72	4.67	4.87	6.09	5.03	5.54	4.14	5.83
Washington	5.93	8.34	6.46	9.20	6.81	7.73	7.75	6.83	5.56	5.69	4.27	6.67	5.19
West Virginia	17.68	12.51	9.39	7.88	13.09	10.65	10.59	7.41	12.90	10.43	9.20	12.09	7.80
Wisconsin	4.59	10.37	6.54	6.84	1.64	5.39	9.03	5.26	4.75	7.68	3.44	2.42	7.17
Wyoming	6.46	11.85	8.17	11.80	8.92	9.60	11.26	5.76	8.83	10.29	7.28	3.09	7.00
Guam	0.71	7.11	--	0.94	2.58	2.76	2.88	2.13	7.11	0.27	5.47	5.18	2.12
Puerto Rico	0.36	2.84	2.79	1.57	1.06	2.53	2.97	2.32	2.06	3.05	3.27	1.96	0.75
Virgin Islands	2.62	6.81	6.90	2.82	2.54	--	--	--	--	--	2.73	--	--

Table XX: Prevalence of rheumatic disorder diagnoses in the US population aged 30 to 34 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	9.60	13.83	12.01	14.37	11.94	13.02	15.67	15.07	11.08	15.36	11.01	14.01	14.12
Alaska	4.38	10.80	12.13	14.84	12.42	7.53	10.15	9.23	12.78	12.10	9.11	9.46	5.69
Arizona	5.69	9.29	5.68	4.41	5.18	8.71	10.62	5.97	12.95	10.52	8.82	9.65	10.93
Arkansas	10.88	16.37	12.58	10.31	12.88	10.87	8.80	9.53	8.00	8.06	13.87	17.86	12.94
California	5.45	6.13	4.82	6.49	4.86	6.79	7.62	3.63	5.52	5.12	3.38	4.54	6.69
Colorado	5.17	12.04	8.35	8.45	9.96	9.03	8.31	8.03	7.61	7.44	10.21	4.86	5.87
Connecticut	7.65	9.76	11.25	5.41	5.40	5.73	5.42	6.59	8.68	7.03	13.74	5.86	9.36
Delaware	7.42	13.11	11.29	18.37	7.31	12.29	10.22	9.56	7.21	7.24	8.87	12.34	7.48
District of Columbia	6.86	3.50	5.31	6.83	2.92	6.82	4.85	7.06	5.35	3.35	1.58	1.94	6.08
Florida	8.88	4.61	8.56	7.51	6.77	6.03	9.66	8.29	9.75	5.52	8.56	5.75	7.35
Georgia	10.07	11.17	7.99	8.86	7.57	6.22	8.35	4.17	6.62	10.56	9.89	8.45	8.63
Hawaii	1.25	8.36	11.98	10.37	5.72	5.87	9.54	5.85	11.52	6.86	8.61	9.02	8.96
Idaho	6.63	8.12	10.42	14.18	7.76	7.14	17.67	6.33	9.46	10.42	6.28	9.37	6.99
Illinois	9.86	13.91	7.50	7.29	11.02	6.23	7.54	4.08	7.31	5.60	5.06	10.07	8.01
Indiana	7.51	15.32	13.30	12.08	14.70	9.08	8.72	12.12	14.44	8.31	11.82	10.58	8.30
Iowa	5.09	7.79	11.78	11.06	10.67	8.65	9.59	6.23	9.39	8.30	7.90	9.97	9.02
Kansas	9.02	12.06	11.96	10.21	8.95	8.34	8.18	9.40	10.37	10.53	9.19	8.89	10.28
Kentucky	15.77	15.28	13.99	11.98	15.60	11.66	14.89	13.13	13.92	14.98	14.00	13.23	18.60
Louisiana	9.88	10.40	7.18	7.49	10.45	6.33	7.44	12.20	10.49	8.55	11.74	14.04	12.58
Maine	11.43	6.41	14.31	11.23	12.35	11.34	11.78	11.01	12.67	11.06	14.20	14.59	13.26
Maryland	4.86	10.12	8.52	8.96	8.59	8.56	5.90	8.13	10.05	7.31	9.22	6.47	7.54
Massachusetts	5.32	10.13	9.97	10.18	7.15	7.13	8.29	5.79	9.41	9.10	8.62	11.70	8.66
Michigan	8.71	16.42	11.74	12.79	8.72	13.90	10.36	10.91	13.31	12.13	12.80	11.17	12.87
Minnesota	5.98	6.75	11.64	8.74	9.64	5.88	5.57	7.47	6.53	6.48	7.74	6.17	5.90
Mississippi	11.33	10.73	14.95	13.06	14.46	12.49	13.82	14.70	7.10	8.87	10.10	10.19	15.64
Missouri	8.17	14.17	13.24	14.61	13.79	13.41	13.08	11.71	11.87	10.32	9.49	9.73	15.37
Montana	7.55	10.51	10.41	14.94	9.25	11.58	13.64	9.77	8.11	10.74	11.38	8.83	11.52
Nebraska	6.75	10.38	10.03	12.01	8.26	6.99	7.22	7.53	8.85	6.20	8.77	8.71	8.56
Nevada	8.62	10.62	10.28	9.11	9.93	7.39	9.50	6.41	4.91	6.93	6.89	6.22	8.11

New Hampshire	7.55	12.28	11.96	9.20	9.10	14.71	6.48	9.72	13.50	5.74	10.70	13.70	10.97
New Jersey	6.46	8.85	6.26	7.90	7.44	6.28	7.38	6.91	7.25	6.97	3.24	8.44	5.33
New Mexico	8.69	10.85	6.76	11.63	7.97	8.11	6.57	10.12	12.32	8.56	12.00	7.77	7.46
New York	7.08	6.78	7.62	10.17	7.77	6.26	4.53	6.31	9.59	6.05	6.20	6.07	5.17
North Carolina	7.25	10.70	11.01	9.80	11.96	7.62	9.46	8.56	11.08	7.79	6.75	6.93	9.11
North Dakota	4.22	10.68	4.96	12.77	9.13	6.56	7.91	8.38	4.06	10.18	9.96	11.30	10.88
Ohio	10.37	13.62	16.20	12.41	11.23	15.02	14.81	13.40	13.50	6.94	9.91	11.78	12.34
Oklahoma	11.12	11.62	13.23	9.99	10.83	13.58	12.52	14.72	9.68	10.91	10.53	12.18	14.69
Oregon	7.47	8.83	10.21	8.70	13.78	7.25	15.40	13.73	10.02	9.25	11.28	8.54	11.69
Pennsylvania	11.81	17.17	13.67	11.13	13.47	9.62	9.79	11.99	9.41	7.75	8.75	8.40	13.18
Rhode Island	7.64	12.16	11.38	8.22	10.33	12.12	10.31	8.30	4.62	10.88	9.16	11.84	13.04
South Carolina	10.40	13.88	11.11	12.81	12.20	8.24	10.58	13.04	12.86	9.33	11.63	9.79	7.73
South Dakota	6.86	14.86	11.00	10.11	9.84	10.08	6.10	8.32	8.05	8.11	10.08	2.75	12.71
Tennessee	12.47	17.91	10.72	12.27	13.33	11.79	12.94	9.86	15.97	11.01	8.96	12.34	15.06
Texas	5.64	10.97	7.43	8.03	8.19	6.20	5.98	6.18	7.60	6.77	6.08	7.88	3.83
Utah	9.14	9.75	9.01	9.37	7.23	9.53	7.29	8.84	7.71	6.20	7.28	5.92	8.77
Vermont	5.65	7.70	12.28	12.06	12.55	9.41	9.99	5.27	10.39	7.84	7.50	10.35	11.30
Virginia	5.49	12.54	11.82	6.82	12.79	6.91	8.15	6.91	7.74	5.55	7.35	7.60	8.58
Washington	7.96	10.02	9.66	11.21	8.47	9.06	8.25	8.05	10.13	7.75	7.89	9.17	5.99
West Virginia	15.47	21.11	14.51	21.46	16.22	13.53	14.66	17.52	18.16	16.65	14.73	17.64	18.23
Wisconsin	8.39	12.10	9.93	8.92	6.36	9.28	8.82	8.58	7.49	5.85	4.16	7.39	9.84
Wyoming	7.34	11.24	16.15	10.43	12.11	7.34	4.93	10.89	9.09	7.61	9.32	10.65	11.73
Guam	0.56	7.91	--	4.97	1.90	1.59	6.56	11.37	5.54	5.36	4.02	9.11	4.95
Puerto Rico	2.57	6.50	5.76	6.86	4.70	5.23	5.99	4.88	5.09	5.29	4.22	3.71	2.05
Virgin Islands	1.90	5.37	5.54	8.39	1.48	--	--	--	--	--	9.19	--	--

Table XXI: Prevalence of rheumatic disorder diagnoses in the US population aged 35 to 39 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	14.94	17.52	19.88	20.40	22.21	16.99	19.91	17.36	21.62	16.24	24.24	17.71	21.48
Alaska	9.64	13.23	14.88	15.66	12.37	13.41	7.81	12.81	11.26	8.36	15.08	11.39	14.83
Arizona	13.64	14.23	17.46	10.73	11.27	12.91	14.73	8.05	12.66	9.61	12.14	11.40	10.07
Arkansas	15.25	17.56	21.43	17.64	11.93	13.52	17.93	17.13	16.35	22.76	25.94	18.77	15.03
California	7.56	12.30	9.84	11.69	7.94	8.23	9.11	6.84	9.97	7.41	7.03	6.23	8.01
Colorado	8.69	13.41	12.95	13.95	14.09	10.98	12.42	10.67	11.17	11.78	12.70	10.77	12.18
Connecticut	8.27	11.15	10.67	12.16	12.34	8.55	12.60	7.27	7.37	11.66	11.74	10.49	14.64
Delaware	12.97	14.62	15.17	13.71	17.26	9.33	7.25	8.92	11.59	9.71	12.74	12.93	13.12
District of Columbia	7.15	10.00	8.20	9.98	10.06	6.58	8.41	8.46	5.57	12.13	8.21	6.58	6.84
Florida	9.14	12.57	10.86	10.39	10.37	12.19	9.09	11.08	9.18	8.11	10.68	7.86	11.05
Georgia	9.15	16.14	13.17	13.47	13.19	10.96	8.46	12.75	13.37	8.48	11.81	11.29	14.60
Hawaii	6.03	6.66	11.41	14.78	9.00	11.17	9.90	8.97	8.37	9.94	10.67	12.68	7.99
Idaho	10.47	16.76	13.19	12.03	10.65	9.67	11.97	14.12	13.74	10.43	10.07	11.33	15.98
Illinois	11.60	14.71	11.14	10.62	12.87	9.99	8.69	8.21	10.35	8.47	10.02	8.04	13.13
Indiana	17.06	17.77	16.30	14.81	16.89	14.47	12.97	12.51	15.04	9.71	14.82	15.28	13.44
Iowa	10.64	14.09	13.27	13.96	7.55	14.53	10.88	13.16	11.42	10.53	13.16	12.19	12.17
Kansas	8.53	14.79	14.65	13.77	10.94	10.08	13.55	11.68	11.92	13.20	12.69	11.86	11.60
Kentucky	16.77	22.80	18.48	18.87	22.88	22.53	24.82	21.27	22.26	16.43	23.10	17.29	16.09
Louisiana	10.66	19.70	16.17	11.57	13.76	12.24	14.79	9.52	12.42	14.24	14.39	12.59	16.57
Maine	10.15	20.42	16.97	14.67	16.70	18.61	14.89	18.58	17.32	14.16	17.64	14.43	17.64
Maryland	8.59	9.63	14.38	14.98	12.92	11.51	10.73	7.65	11.83	7.11	11.15	10.85	13.28
Massachusetts	9.16	13.46	14.40	12.52	15.07	9.95	8.93	11.89	12.19	13.28	13.40	9.32	13.38
Michigan	16.68	17.05	16.82	12.47	16.39	15.29	16.71	14.34	17.83	16.95	17.55	10.35	22.71
Minnesota	9.14	11.84	11.96	7.74	7.12	8.83	9.17	10.76	8.67	10.51	11.29	7.30	9.31
Mississippi	15.20	16.59	23.31	18.76	15.60	15.79	17.39	11.34	13.57	17.17	13.98	13.32	17.60
Missouri	15.45	17.72	18.82	16.84	14.50	16.80	13.04	17.05	12.70	13.68	14.93	13.61	14.83
Montana	9.46	15.72	16.24	15.69	12.80	12.52	15.52	15.34	11.80	19.38	13.12	12.75	16.86
Nebraska	8.87	13.83	11.08	10.91	12.42	10.87	10.08	11.44	11.00	12.16	10.59	8.89	11.39
Nevada	13.70	23.26	9.86	12.24	11.90	9.22	11.80	12.20	9.62	10.66	12.92	10.03	9.87

New Hampshire	10.18	14.00	12.72	15.57	9.89	13.01	17.02	15.21	11.14	14.03	10.60	8.24	15.81
New Jersey	7.96	11.59	11.44	13.76	8.52	9.24	9.39	8.71	10.06	9.04	8.15	7.91	5.84
New Mexico	11.07	14.57	12.03	13.17	13.58	13.99	12.99	10.82	17.84	14.17	11.12	16.20	16.50
New York	9.01	13.83	14.42	13.84	10.43	9.29	9.77	10.19	9.15	10.38	10.52	9.44	10.38
North Carolina	10.99	16.43	11.96	15.25	12.88	12.76	10.84	12.79	13.93	15.35	12.58	11.32	11.81
North Dakota	12.99	17.59	18.39	13.57	15.72	13.56	13.63	12.98	13.60	11.11	8.23	14.13	17.03
Ohio	11.02	14.47	18.19	17.36	13.24	14.21	14.73	13.79	20.97	14.52	18.02	14.04	17.25
Oklahoma	14.03	15.08	19.01	18.36	18.93	17.04	12.92	15.50	13.70	12.53	13.66	12.61	17.33
Oregon	10.05	13.93	15.19	10.78	14.66	7.32	11.65	17.62	18.24	15.90	12.70	11.48	15.16
Pennsylvania	12.23	20.12	16.57	16.25	17.73	13.31	16.79	14.32	13.65	11.40	13.51	14.19	8.58
Rhode Island	13.98	11.53	13.98	13.90	13.58	12.75	8.42	10.51	11.77	14.57	7.96	14.04	12.56
South Carolina	14.31	16.94	20.06	13.89	20.68	14.15	19.08	14.78	13.61	14.86	14.15	11.56	14.28
South Dakota	12.12	14.77	17.57	16.28	14.16	14.25	12.29	14.28	11.46	11.10	9.62	15.08	4.43
Tennessee	13.15	22.92	17.33	21.72	17.91	14.83	12.51	14.72	17.81	20.51	18.19	15.43	13.83
Texas	8.52	12.85	9.83	12.71	7.82	7.92	10.95	10.45	7.37	8.46	7.25	9.01	8.90
Utah	9.32	15.73	13.77	9.05	14.44	9.26	9.10	10.25	10.60	10.39	10.19	8.88	11.85
Vermont	12.64	14.53	11.20	14.10	16.45	13.81	16.74	17.19	14.42	15.81	11.24	14.35	14.74
Virginia	10.51	16.31	13.73	11.75	15.78	12.94	8.77	13.88	13.27	10.06	11.95	14.54	13.52
Washington	8.03	14.11	16.32	16.52	13.43	12.72	10.92	10.85	13.88	9.23	11.22	13.65	12.49
West Virginia	17.56	22.29	23.68	25.27	18.86	22.11	17.85	21.07	22.92	25.18	21.36	26.23	21.73
Wisconsin	9.54	14.80	15.68	12.55	14.09	13.96	10.39	12.27	13.26	12.90	14.69	17.19	10.15
Wyoming	12.64	16.48	14.66	17.16	19.05	13.32	8.64	13.60	14.78	13.93	17.68	14.63	10.58
Guam	6.73	10.65	--	8.15	9.42	6.33	10.62	8.59	5.29	6.05	7.71	6.75	9.92
Puerto Rico	8.54	10.75	10.30	11.25	4.99	7.29	7.67	10.03	9.84	12.11	7.10	6.39	8.65
Virgin Islands	5.23	9.98	6.14	4.30	22.21	--	--	--	--	--	15.68	--	--

Table XXII: Prevalence of rheumatic disorder diagnoses in the US population aged 40 to 44 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	25.43	28.87	28.43	29.53	27.54	21.72	29.64	24.89	25.19	25.96	22.30	30.17	24.41
Alaska	15.53	19.61	24.86	23.43	14.74	18.52	16.09	18.67	15.47	13.84	20.40	23.89	18.79
Arizona	17.98	16.92	13.09	19.08	9.72	14.70	17.12	12.83	17.38	12.02	15.28	13.95	15.68
Arkansas	19.87	23.90	22.74	24.91	26.85	23.25	18.65	25.38	22.38	21.79	31.01	26.55	24.92
California	11.72	15.06	15.52	12.79	13.43	10.70	12.70	10.55	12.59	9.81	9.38	10.00	8.42
Colorado	16.96	18.05	20.01	16.81	15.32	12.87	14.28	12.92	14.32	15.05	13.55	12.81	13.34
Connecticut	10.77	16.22	16.31	19.31	16.46	11.53	12.19	12.63	14.47	14.26	15.70	12.97	16.68
Delaware	14.47	20.21	20.62	19.51	24.82	21.34	21.73	14.67	12.01	14.89	15.32	13.43	14.01
District of Columbia	12.24	17.44	21.96	16.06	12.48	11.41	9.86	11.81	11.80	5.99	10.45	6.13	10.27
Florida	17.65	21.16	16.87	16.73	14.04	15.19	15.90	18.05	14.86	13.92	11.05	14.03	16.83
Georgia	15.70	19.13	27.64	23.46	17.09	14.01	14.19	15.51	17.46	13.51	20.63	14.43	19.31
Hawaii	5.26	13.96	12.61	15.52	14.57	12.52	14.38	11.85	12.16	12.51	15.59	12.44	14.93
Idaho	14.04	19.03	20.07	20.16	20.00	13.19	18.81	19.28	17.39	14.66	15.85	10.56	13.88
Illinois	10.32	14.88	17.02	19.37	15.59	12.17	15.43	9.80	18.58	11.67	18.20	12.35	12.43
Indiana	19.85	24.90	23.60	23.49	23.21	20.77	19.23	21.77	21.14	18.92	18.13	18.89	17.02
Iowa	9.61	17.19	17.94	17.96	14.08	13.54	18.58	13.56	17.52	15.21	14.54	12.62	14.86
Kansas	14.75	16.95	20.39	19.98	18.22	15.20	14.46	14.34	16.26	13.83	16.22	17.35	18.80
Kentucky	23.81	30.81	21.95	23.22	31.81	23.15	31.72	25.47	27.95	26.15	23.95	25.47	27.14
Louisiana	16.39	20.15	19.81	17.69	16.39	22.36	18.45	18.67	20.35	22.25	19.54	17.06	22.05
Maine	18.59	20.49	23.76	23.67	20.92	17.03	18.95	18.46	17.10	22.21	21.84	20.60	19.61
Maryland	15.06	23.79	18.67	19.60	15.53	14.85	15.05	12.03	16.43	12.86	11.05	17.28	15.85
Massachusetts	14.57	19.13	18.10	16.89	15.44	15.73	15.44	13.32	18.09	15.11	15.31	14.15	14.31
Michigan	20.97	20.23	21.53	24.33	24.26	24.86	20.37	20.94	20.60	20.23	23.39	22.57	20.81
Minnesota	16.55	18.56	18.83	17.80	14.47	12.14	11.65	13.43	13.12	11.60	13.64	11.51	14.12
Mississippi	18.31	23.55	27.36	26.74	27.22	20.14	19.82	22.99	21.16	21.47	24.84	26.07	25.89
Missouri	20.50	24.23	27.20	23.60	21.18	17.81	23.38	17.83	16.59	25.01	22.94	17.86	23.81
Montana	14.58	15.00	17.78	19.96	17.03	15.78	20.29	22.31	17.82	16.45	16.72	21.81	15.47
Nebraska	12.85	20.15	17.96	21.22	17.58	13.13	16.01	14.62	16.74	13.77	14.86	15.81	15.40
Nevada	15.29	14.31	16.92	19.49	12.90	20.22	13.68	16.41	18.78	13.78	14.52	10.72	11.38

New Hampshire	13.85	16.52	18.77	20.69	18.56	14.94	18.04	15.20	17.25	16.98	18.47	14.70	16.64
New Jersey	13.17	15.84	16.73	17.91	13.31	11.90	11.75	13.40	13.55	12.28	8.40	11.86	13.31
New Mexico	14.54	19.49	16.34	19.51	16.74	17.79	18.47	14.36	13.12	14.09	18.60	19.57	17.51
New York	11.23	20.48	17.04	16.39	15.94	16.72	15.82	13.88	16.24	15.03	13.13	11.22	11.74
North Carolina	18.68	19.36	20.28	22.62	17.76	16.86	17.03	21.37	17.00	16.59	18.69	19.22	17.26
North Dakota	15.76	17.46	17.51	20.90	17.54	15.09	16.06	18.93	16.68	13.21	14.62	22.98	19.44
Ohio	20.13	21.80	22.46	24.50	21.05	19.51	21.94	21.39	19.03	19.80	20.51	18.58	21.23
Oklahoma	17.16	20.88	23.85	23.21	21.73	21.24	19.78	17.90	20.57	19.85	21.09	20.39	17.62
Oregon	15.41	16.75	19.10	21.43	17.82	12.44	20.89	19.87	21.69	17.36	19.18	19.43	16.43
Pennsylvania	18.55	23.30	21.41	22.48	23.14	20.29	20.40	19.81	17.54	21.03	20.88	19.02	17.80
Rhode Island	17.87	17.08	17.09	19.01	20.12	18.84	18.09	21.90	18.87	14.07	14.82	20.32	19.03
South Carolina	18.55	24.30	26.37	24.60	23.33	16.51	22.21	24.71	23.13	19.92	18.69	20.40	21.58
South Dakota	12.26	20.78	16.87	18.27	14.05	16.21	17.67	13.46	15.51	13.04	15.47	16.35	17.20
Tennessee	19.83	29.23	25.28	28.30	19.62	18.18	23.12	18.98	22.35	23.91	22.44	25.36	23.60
Texas	11.91	19.96	17.73	14.81	13.14	11.94	13.79	15.29	10.60	10.21	15.25	12.46	16.27
Utah	13.87	18.21	20.53	16.26	16.34	12.47	13.96	12.05	14.22	13.02	12.05	10.92	12.16
Vermont	15.37	15.32	19.31	18.10	18.63	17.32	18.87	18.09	15.45	17.25	18.29	16.50	14.72
Virginia	18.33	21.85	21.57	18.76	19.09	18.33	16.58	14.74	17.68	13.81	16.07	15.71	17.20
Washington	11.85	18.33	17.95	20.06	19.22	18.44	17.01	14.02	19.68	12.03	16.70	14.61	14.27
West Virginia	21.28	34.40	27.28	24.23	29.44	32.12	31.97	28.21	29.78	31.57	27.33	28.48	29.19
Wisconsin	17.89	22.35	20.49	16.17	19.40	14.42	15.05	17.61	17.34	17.54	17.23	18.18	21.24
Wyoming	18.22	23.79	22.38	20.01	16.35	15.36	16.57	16.76	20.25	19.98	20.27	17.21	21.22
Guam	7.76	8.52	--	13.42	9.46	15.29	9.77	9.92	11.76	13.60	12.83	10.37	6.69
Puerto Rico	7.64	13.59	16.08	13.71	8.57	12.24	12.66	9.37	13.15	14.34	19.37	18.64	14.31
Virgin Islands	11.74	9.50	15.06	13.75	9.94	--	--	--	--	--	2.05	--	--

Table XXIII: Prevalence of rheumatic disorder diagnoses in the US population aged 45 to 49 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	31.27	39.55	34.14	35.56	34.10	28.80	34.80	32.15	35.53	35.56	30.01	32.34	35.74
Alaska	21.34	29.99	26.59	31.77	17.54	25.00	29.10	22.66	24.68	16.47	24.05	16.04	23.72
Arizona	23.81	27.16	25.78	20.40	25.26	23.04	18.25	19.93	18.21	26.72	22.79	21.60	20.63
Arkansas	22.87	29.99	35.49	31.48	28.19	31.96	32.94	30.18	28.08	24.10	28.36	27.63	31.30
California	20.47	16.84	21.85	16.06	18.33	17.85	17.47	15.77	18.14	15.61	13.38	17.32	17.32
Colorado	18.57	28.33	24.57	23.79	20.96	20.32	19.48	18.79	20.32	20.98	18.71	16.57	19.69
Connecticut	15.71	24.66	20.26	21.34	23.30	19.31	17.63	16.63	16.94	19.13	19.30	17.25	22.37
Delaware	23.81	26.75	26.39	29.62	21.08	20.49	23.79	29.48	20.66	25.28	25.49	17.59	24.76
District of Columbia	20.55	25.10	21.83	16.80	18.14	16.79	17.17	15.65	14.00	14.51	15.10	12.19	15.04
Florida	20.52	27.03	22.51	18.95	24.93	22.91	22.35	23.84	20.80	21.08	20.56	17.97	19.45
Georgia	23.19	30.47	28.64	25.89	20.37	22.97	23.78	26.18	24.98	25.32	21.12	19.56	24.97
Hawaii	11.43	15.63	21.70	19.53	16.85	17.36	15.04	16.07	17.71	16.66	20.12	14.63	20.43
Idaho	20.34	30.36	27.47	24.11	21.60	16.60	24.28	17.92	23.31	18.99	15.46	18.79	21.64
Illinois	22.39	23.79	24.08	22.13	23.76	22.64	17.39	21.72	18.64	22.26	22.86	20.90	17.49
Indiana	26.78	31.81	28.97	28.63	29.04	28.88	27.03	26.70	27.36	31.99	23.39	28.06	27.98
Iowa	21.05	22.39	25.63	23.35	24.81	19.64	22.02	19.76	20.08	24.15	17.92	18.26	21.24
Kansas	22.11	27.25	25.04	26.65	22.06	20.87	20.36	23.07	21.58	21.59	19.10	19.93	22.04
Kentucky	32.62	37.83	30.44	28.36	35.61	32.44	33.88	29.34	40.61	31.85	28.15	38.05	34.17
Louisiana	21.10	28.61	23.56	24.89	25.88	26.54	26.57	22.75	26.08	25.87	25.74	27.66	31.76
Maine	25.61	25.92	25.07	27.80	27.51	23.51	26.96	28.01	28.70	24.81	30.92	28.79	29.65
Maryland	20.35	26.30	27.96	24.92	25.49	20.89	21.59	17.95	23.18	18.96	22.65	20.05	20.45
Massachusetts	21.65	20.33	26.50	24.35	23.64	21.58	20.08	20.44	23.93	21.96	17.75	14.56	15.84
Michigan	30.82	33.92	32.86	28.69	32.30	27.75	32.78	25.23	29.50	25.77	27.42	28.61	25.80
Minnesota	16.24	22.19	22.89	20.09	17.80	16.01	17.82	17.59	15.45	16.96	16.01	14.61	15.49
Mississippi	25.69	37.31	34.17	29.07	27.51	29.90	31.72	27.01	27.76	32.91	30.94	25.39	34.35
Missouri	24.92	33.74	31.67	26.78	26.75	29.17	31.94	24.75	20.53	29.57	33.72	31.13	31.68
Montana	23.40	26.48	22.46	23.83	22.86	24.67	22.85	22.52	22.05	22.74	22.09	21.05	20.82
Nebraska	15.42	25.27	23.61	23.35	18.43	22.65	20.56	23.16	20.34	21.79	18.90	18.56	19.58
Nevada	17.79	23.68	21.68	22.03	26.89	22.73	24.48	15.80	15.49	21.44	25.29	13.97	22.26

New Hampshire	21.38	26.30	24.47	25.10	23.44	20.65	26.15	23.38	24.22	21.88	21.44	18.38	28.63
New Jersey	18.87	22.51	22.66	24.47	19.22	19.84	16.62	18.06	18.04	16.93	17.91	20.30	20.72
New Mexico	18.95	24.00	22.88	28.02	24.25	22.64	17.57	23.14	22.59	22.91	25.71	25.45	23.43
New York	20.30	27.66	24.84	28.44	24.61	19.55	27.44	20.95	18.92	20.08	19.09	18.22	17.50
North Carolina	22.97	29.18	27.37	30.50	25.61	26.34	25.10	23.16	24.63	24.19	23.68	24.15	25.42
North Dakota	17.96	25.99	26.77	26.81	28.87	21.36	22.92	21.35	25.18	22.58	21.72	19.94	25.70
Ohio	24.11	29.67	26.85	32.40	28.87	26.01	26.15	25.24	29.13	30.93	29.74	25.51	29.40
Oklahoma	26.72	25.80	25.48	27.46	29.85	31.38	26.93	23.45	23.92	24.24	28.73	28.19	22.81
Oregon	20.78	26.19	26.12	23.43	19.43	24.90	28.13	23.63	23.02	25.03	17.98	20.00	22.41
Pennsylvania	25.20	24.87	29.91	29.92	31.08	26.52	25.58	27.49	27.35	24.26	24.59	24.08	21.68
Rhode Island	22.46	28.17	25.33	23.07	27.34	22.33	24.39	17.88	25.65	21.81	23.28	25.00	28.74
South Carolina	22.68	29.64	31.35	29.21	33.35	29.08	26.54	28.41	26.09	25.70	28.36	24.02	30.42
South Dakota	18.77	28.83	26.79	23.08	23.80	19.22	19.28	19.44	20.22	21.59	16.86	20.78	17.40
Tennessee	28.53	28.54	35.87	33.44	24.96	23.55	30.00	28.22	28.41	31.77	28.12	25.47	34.40
Texas	19.39	21.36	23.41	22.70	19.48	20.02	16.99	19.21	19.04	19.54	20.23	20.20	18.98
Utah	22.15	20.63	26.22	22.56	21.77	18.77	18.72	19.33	21.40	16.97	17.43	15.97	23.64
Vermont	20.31	30.38	27.79	22.43	23.51	21.20	24.08	21.60	23.50	22.62	23.57	29.79	25.14
Virginia	18.52	29.87	31.36	22.88	21.72	23.30	23.96	21.24	22.20	18.90	22.62	23.37	22.56
Washington	18.97	28.73	27.18	25.62	23.87	20.16	22.76	23.20	20.93	21.42	23.07	18.60	18.71
West Virginia	34.32	35.43	39.34	33.84	32.07	36.45	35.76	35.57	39.54	38.98	36.26	37.16	40.68
Wisconsin	27.37	23.49	27.17	28.41	19.63	21.29	25.43	23.96	19.36	24.03	15.48	19.67	22.27
Wyoming	18.19	25.77	27.06	26.82	24.25	21.95	23.87	18.90	22.73	24.66	28.33	30.93	21.48
Guam	11.62	25.11	--	13.78	13.48	10.40	16.84	13.08	12.86	20.06	17.66	14.46	14.30
Puerto Rico	16.51	27.87	22.02	20.90	15.83	17.93	19.63	21.71	17.69	20.13	22.94	15.74	22.75
Virgin Islands	12.52	18.39	17.09	17.32	17.62	--	--	--	--	--	16.71	--	--

Table XXIV: Prevalence of rheumatic disorder diagnoses in the US population aged 50 to 54 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	33.89	39.32	41.86	44.87	41.64	38.88	44.43	42.13	42.76	38.42	42.10	36.36	41.83
Alaska	26.84	35.97	27.94	25.40	37.90	27.61	32.25	32.17	27.47	33.83	27.82	28.15	27.69
Arizona	25.47	37.48	35.26	28.47	35.84	31.10	32.89	30.76	29.21	28.47	30.62	29.23	33.75
Arkansas	29.20	40.01	38.74	41.86	41.09	38.93	39.33	32.99	44.62	37.19	41.90	31.24	38.19
California	24.64	28.64	31.31	29.89	27.83	25.74	25.68	25.55	21.66	20.79	22.44	22.63	22.72
Colorado	22.00	29.16	31.51	31.90	28.54	26.84	27.20	24.99	26.56	27.53	24.53	24.39	23.71
Connecticut	25.21	26.79	33.61	27.83	24.78	24.53	24.57	29.31	24.87	27.88	27.27	24.21	26.37
Delaware	26.46	34.95	35.77	39.49	32.11	29.03	31.76	31.02	34.02	35.90	27.79	29.21	30.12
District of Columbia	20.69	28.59	33.21	31.74	35.05	29.22	30.38	26.35	25.70	26.53	22.27	23.56	29.05
Florida	26.63	36.53	32.28	28.36	30.46	30.89	27.48	27.29	32.75	27.58	24.83	24.82	27.99
Georgia	29.91	39.99	36.73	35.96	30.15	29.01	30.23	30.40	33.95	27.03	31.30	24.37	31.92
Hawaii	12.94	21.96	26.57	28.84	27.31	21.32	23.11	24.71	22.66	19.83	23.69	23.47	23.70
Idaho	28.46	31.61	35.31	27.38	26.9	34.09	27.60	28.90	27.28	32.42	33.24	28.67	25.78
Illinois	26.13	31.40	31.37	34.80	31.86	28.66	33.31	28.99	32.08	25.74	28.72	30.82	28.43
Indiana	37.08	40.13	38.29	42.08	36.61	33.32	35.40	35.31	35.55	35.10	34.04	32.28	34.16
Iowa	23.94	30.21	32.63	34.19	27.43	27.80	25.06	27.26	26.49	32.18	28.90	25.16	30.28
Kansas	26.45	32.23	34.56	31.77	30.25	27.44	26.04	27.48	32.42	29.28	25.97	26.65	26.74
Kentucky	36.13	43.80	40.72	44.26	46.51	37.08	42.87	36.34	38.45	42.70	42.89	45.63	40.55
Louisiana	32.92	35.78	33.45	28.06	33.16	27.72	35.64	32.48	29.40	28.68	29.42	34.06	34.96
Maine	32.27	32.35	37.73	36.15	36.34	34.08	30.08	33.93	36.72	35.93	42.02	33.44	33.85
Maryland	29.84	32.66	34.14	31.38	29.37	28.51	25.38	27.98	28.71	27.79	26.20	30.06	30.51
Massachusetts	24.50	32.79	31.00	31.79	27.35	28.44	27.60	27.30	33.02	27.94	28.11	25.70	27.98
Michigan	37.02	44.69	37.88	39.74	38.58	35.76	37.11	34.50	34.22	37.66	36.33	32.15	36.78
Minnesota	24.23	33.05	29.74	28.82	23.74	22.11	25.54	24.66	22.42	24.15	23.26	17.45	23.81
Mississippi	37.29	46.15	40.48	36.43	37.07	36.73	39.03	40.87	38.49	34.48	36.52	35.60	37.30
Missouri	31.41	35.02	41.66	40.45	42.07	36.25	32.77	36.70	32.90	34.22	36.09	32.90	36.53
Montana	31.02	28.11	30.36	33.96	34.89	33.87	33.74	32.69	28.23	29.42	36.85	27.77	28.57
Nebraska	23.72	32.53	33.08	33.57	31.84	25.28	26.60	27.40	23.48	24.93	25.00	27.41	29.50
Nevada	31.96	37.71	31.50	34.69	27.47	23.75	28.58	27.24	28.75	22.41	26.45	25.56	26.75

New Hampshire	25.47	30.40	31.77	34.21	33.76	27.08	31.50	31.39	27.22	30.90	30.83	32.85	26.16
New Jersey	26.76	33.75	28.40	28.34	24.87	25.92	25.13	24.83	23.19	26.06	30.02	25.86	22.26
New Mexico	32.74	31.61	33.36	34.97	32.04	28.84	26.55	31.39	28.36	26.78	31.12	27.78	29.24
New York	30.81	33.91	33.88	38.72	32.76	33.53	26.26	30.30	26.79	23.53	25.98	26.33	23.66
North Carolina	27.83	41.40	38.59	37.24	36.03	28.59	29.50	31.53	35.01	32.26	30.51	29.06	28.81
North Dakota	22.77	32.93	31.69	30.36	33.76	29.82	24.94	30.44	30.75	24.31	30.92	31.92	27.40
Ohio	29.61	36.71	35.52	41.00	37.39	37.16	33.79	32.77	35.54	34.18	36.64	31.15	35.97
Oklahoma	30.64	39.53	42.13	40.71	36.31	30.69	35.59	33.14	31.10	36.02	33.98	35.86	34.13
Oregon	24.08	32.29	33.42	36.50	35.37	28.89	30.10	32.35	26.66	26.25	31.75	33.26	30.91
Pennsylvania	28.96	37.21	42.64	37.53	35.24	31.37	32.43	31.09	34.05	33.76	32.18	32.69	31.40
Rhode Island	31.87	35.84	33.43	38.75	33.67	29.46	26.47	32.91	31.35	29.00	30.71	32.35	30.29
South Carolina	30.82	39.78	38.65	35.93	34.77	34.95	32.43	35.48	36.90	37.35	33.37	32.08	35.30
South Dakota	24.26	29.90	33.44	30.04	26.54	27.16	25.77	28.19	27.86	28.89	29.84	20.62	28.83
Tennessee	37.44	41.16	38.32	42.88	34.10	32.78	38.11	33.08	42.79	44.60	36.29	37.66	39.49
Texas	27.19	35.36	28.94	32.71	31.21	27.97	27.11	25.00	24.07	24.56	27.79	28.74	30.44
Utah	23.12	32.97	28.97	33.39	30.45	27.79	27.71	26.16	26.01	26.63	26.31	25.33	25.54
Vermont	23.98	30.78	31.39	34.08	32.68	31.22	31.38	30.39	31.31	34.15	30.87	27.36	27.01
Virginia	30.82	34.71	31.60	36.66	32.06	30.85	31.14	32.42	32.07	26.19	31.89	29.82	31.79
Washington	27.06	34.26	31.25	34.62	33.38	24.92	28.66	33.00	29.16	30.68	27.71	28.95	28.63
West Virginia	35.54	45.83	40.67	41.24	42.53	40.95	42.53	44.09	45.30	45.73	47.21	45.49	49.60
Wisconsin	31.98	28.12	37.24	32.66	30.02	30.30	28.94	23.05	28.78	25.08	26.44	26.18	24.91
Wyoming	19.86	33.72	34.93	34.88	32.65	29.42	30.08	32.60	25.31	25.40	32.94	29.05	29.21
Guam	17.06	30.97	--	20.61	17.61	14.87	25.82	17.96	22.51	25.99	28.14	25.73	22.08
Puerto Rico	22.75	27.15	37.33	26.53	23.33	24.16	29.64	30.38	34.51	27.39	31.15	24.76	25.65
Virgin Islands	20.19	27.31	13.86	22.71	19.96	--	--	--	--	--	21.20	--	--

Table XXV: Prevalence of rheumatic disorder diagnoses in the US population aged 55 to 59 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	51.68	60.18	55.06	54.32	48.12	45.00	48.66	48.34	47.93	49.27	49.22	51.61	48.25
Alaska	29.90	41.91	40.35	49.35	40.35	32.48	30.64	36.50	32.53	30.61	43.11	30.18	32.64
Arizona	31.91	34.93	45.54	49.88	41.33	31.67	33.39	35.99	33.96	34.45	38.78	33.98	36.92
Arkansas	37.77	48.20	48.17	46.08	42.94	42.25	45.17	43.05	43.96	43.82	49.46	48.66	47.14
California	27.06	36.99	41.43	35.76	36.30	35.90	33.70	35.43	29.27	28.49	30.53	26.40	32.06
Colorado	28.52	35.26	38.16	37.49	40.09	33.35	34.84	34.81	34.92	34.00	33.48	33.76	34.06
Connecticut	33.20	40.24	36.82	37.57	39.49	32.90	35.40	34.42	36.33	32.07	35.83	31.85	37.23
Delaware	42.36	41.26	46.50	43.79	41.51	40.96	36.03	39.86	38.87	37.26	34.12	32.17	35.03
District of Columbia	38.79	38.88	39.17	38.62	36.50	34.67	29.09	36.98	35.80	34.86	35.47	28.15	33.10
Florida	35.03	34.94	40.85	34.86	36.62	38.10	38.80	32.46	37.23	33.16	34.48	31.70	33.60
Georgia	42.75	44.66	43.96	47.72	39.81	39.13	44.30	40.87	36.68	41.20	42.43	34.19	36.78
Hawaii	14.62	28.30	33.21	35.51	29.98	24.84	28.68	27.36	28.24	32.08	31.79	28.70	34.08
Idaho	37.19	40.72	40.24	41.93	37.38	34.40	33.76	34.57	29.44	36.50	35.49	34.12	35.34
Illinois	35.21	40.30	42.09	43.28	37.44	37.00	39.05	34.40	36.86	29.91	35.40	33.61	36.51
Indiana	40.05	49.30	41.26	51.00	43.82	39.27	42.36	40.55	40.71	39.74	40.07	41.51	42.79
Iowa	34.40	36.69	41.11	41.58	37.72	32.86	36.60	34.75	36.22	33.93	34.73	31.97	32.15
Kansas	32.63	41.22	43.63	42.16	35.61	34.47	36.03	34.42	35.03	36.04	38.99	34.60	34.68
Kentucky	45.43	56.44	44.61	49.18	50.65	45.78	49.68	45.19	50.03	44.45	50.38	40.50	44.28
Louisiana	43.19	46.99	46.86	38.57	39.85	41.46	42.65	41.52	42.31	40.45	42.16	41.51	43.31
Maine	39.63	46.96	42.03	44.79	45.10	41.95	37.65	40.39	41.79	40.46	39.93	41.02	41.58
Maryland	35.64	44.12	45.23	44.61	39.42	36.03	33.28	37.99	35.91	33.12	33.35	33.91	39.69
Massachusetts	36.92	37.73	38.30	42.50	36.81	35.90	33.08	37.29	40.11	35.25	33.98	36.01	29.32
Michigan	46.34	57.23	48.54	48.32	47.10	45.66	46.78	49.16	46.56	41.83	45.76	42.45	47.27
Minnesota	36.76	43.24	41.76	35.48	32.86	31.36	29.78	30.06	33.98	27.79	29.49	29.11	28.39
Mississippi	43.00	51.69	56.30	48.08	48.04	47.14	46.36	42.91	42.74	43.53	47.21	42.92	44.46
Missouri	46.13	42.60	43.87	47.47	44.34	43.62	44.96	44.34	40.42	42.50	39.33	41.11	47.16
Montana	38.20	33.47	37.80	39.65	40.66	36.46	37.98	33.43	32.52	33.13	37.90	30.21	45.30
Nebraska	29.01	45.20	41.13	44.44	40.16	35.97	37.42	34.15	34.54	31.60	34.05	36.01	38.40
Nevada	34.05	44.98	41.68	36.50	41.72	37.30	36.21	28.57	33.17	23.37	32.59	25.89	32.52

New Hampshire	36.63	43.70	41.76	44.83	44.66	35.96	37.12	35.42	34.41	33.72	37.43	36.58	38.92
New Jersey	31.74	37.57	38.66	39.86	35.55	32.73	29.58	29.54	33.59	31.91	28.88	29.68	29.42
New Mexico	40.09	39.28	39.73	44.27	40.47	36.64	37.96	37.23	33.88	36.09	35.99	34.53	41.25
New York	33.92	47.35	39.95	45.44	43.18	37.97	37.81	36.47	35.13	35.37	34.36	33.99	30.68
North Carolina	40.66	47.82	44.70	44.25	41.60	39.21	39.32	41.91	42.21	41.05	36.45	33.96	39.23
North Dakota	30.16	39.65	35.79	42.01	40.85	35.75	36.22	36.61	38.89	33.96	34.89	30.86	38.07
Ohio	44.42	46.84	49.45	47.48	45.58	40.72	42.31	40.63	40.58	38.69	41.40	38.26	41.39
Oklahoma	41.80	42.14	46.51	48.40	47.56	40.83	38.35	38.96	39.29	39.61	38.45	40.66	38.10
Oregon	30.43	42.32	43.24	38.87	37.46	41.91	42.43	29.81	36.42	44.08	41.94	35.28	47.35
Pennsylvania	39.30	43.06	46.02	47.20	43.53	39.92	38.85	41.11	39.67	40.02	43.86	43.00	43.62
Rhode Island	39.62	47.77	41.28	48.24	47.53	40.24	39.80	40.51	39.14	39.72	34.76	37.47	40.75
South Carolina	43.05	46.84	45.56	47.52	46.64	41.40	42.69	45.54	43.20	44.62	47.62	41.52	43.56
South Dakota	32.33	42.58	44.86	39.42	36.63	29.24	35.76	37.00	32.52	32.13	32.26	28.79	32.40
Tennessee	38.60	46.52	46.47	44.75	36.89	37.60	37.82	38.88	46.20	45.97	43.39	43.96	46.31
Texas	29.52	43.26	41.45	37.65	36.75	32.10	34.67	30.99	31.12	30.90	32.69	30.53	33.63
Utah	33.64	41.90	45.10	41.40	36.17	35.62	33.74	34.22	35.15	33.06	33.59	33.31	35.21
Vermont	33.05	43.93	40.27	42.36	40.81	35.38	35.80	38.67	32.97	35.99	40.06	37.74	39.65
Virginia	40.24	40.87	44.94	47.61	37.92	43.22	40.70	37.19	38.85	33.73	37.74	34.10	35.49
Washington	32.70	41.25	42.41	40.68	41.81	35.56	38.92	37.08	35.94	38.47	37.19	35.79	34.96
West Virginia	42.83	51.93	49.18	50.99	45.00	48.80	53.44	48.98	53.62	53.16	53.00	58.06	52.26
Wisconsin	36.92	41.79	39.56	43.19	38.99	38.55	31.46	34.06	34.55	28.93	30.68	39.62	38.40
Wyoming	32.45	41.77	38.71	38.76	38.35	40.22	40.93	36.16	33.42	34.25	34.39	35.59	28.95
Guam	24.07	35.83	--	37.79	21.20	22.17	29.28	24.86	28.09	28.84	35.62	28.88	29.78
Puerto Rico	39.64	43.76	37.89	45.73	31.43	34.79	39.19	35.08	39.74	36.71	36.50	35.23	39.10
Virgin Islands	17.02	22.15	26.05	27.78	20.13	--	--	--	--	--	25.89	--	--

Table XXVI: Prevalence of rheumatic disorder diagnoses in the US population aged 60 to 64 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	50.61	58.06	52.51	58.50	52.82	51.78	55.05	53.73	55.65	53.63	54.94	47.88	52.75
Alaska	35.35	53.48	48.37	41.53	40.44	40.28	42.13	36.44	36.12	36.51	48.98	37.43	46.83
Arizona	43.14	37.10	50.70	54.92	44.30	41.68	43.96	44.42	44.05	39.35	44.14	41.74	42.88
Arkansas	44.17	54.41	48.74	49.75	51.73	46.58	50.71	50.38	51.15	49.83	51.03	46.92	56.21
California	40.74	42.60	40.73	40.86	40.35	38.63	45.20	37.34	37.97	36.87	36.75	38.47	37.57
Colorado	38.13	47.11	43.33	44.76	45.85	39.14	39.70	40.34	40.47	36.49	39.41	37.17	41.79
Connecticut	39.03	40.04	49.37	43.39	42.09	37.79	40.82	36.80	38.07	40.46	41.15	37.46	34.92
Delaware	46.32	50.91	52.23	50.47	44.26	48.25	49.69	38.55	46.16	47.22	42.89	40.33	37.55
District of Columbia	33.04	48.08	46.54	46.67	44.84	44.95	36.09	39.26	39.44	41.29	36.13	33.73	40.56
Florida	40.52	44.34	48.00	39.77	44.15	45.32	46.28	39.94	39.55	41.96	38.02	42.98	41.47
Georgia	45.94	46.35	48.03	50.14	47.17	45.75	42.36	44.67	45.51	45.62	42.51	40.42	41.75
Hawaii	27.94	28.27	36.57	42.66	40.53	29.01	35.24	31.99	36.21	29.00	33.85	31.09	35.19
Idaho	46.63	45.74	48.79	47.10	42.76	39.09	43.93	42.32	40.39	42.01	39.68	43.47	44.07
Illinois	45.52	43.44	46.85	52.14	47.42	41.99	48.15	39.45	39.98	44.33	44.58	43.06	42.53
Indiana	48.05	51.08	57.29	52.11	47.50	52.12	44.11	43.15	48.08	46.48	49.41	49.25	47.56
Iowa	38.98	43.39	45.37	43.20	46.10	38.50	40.76	38.81	41.09	40.48	40.39	40.23	40.26
Kansas	41.25	38.70	50.91	51.36	42.68	40.14	42.80	40.88	42.96	40.56	43.69	39.59	45.10
Kentucky	50.73	50.44	49.00	54.24	55.78	55.24	53.33	54.68	52.62	52.90	58.57	50.72	51.96
Louisiana	42.59	43.72	53.67	46.09	45.36	43.43	53.38	42.41	47.99	46.75	42.50	40.47	45.85
Maine	41.65	49.71	46.76	50.19	47.30	45.33	44.41	43.87	50.18	44.31	46.96	45.51	44.79
Maryland	45.77	50.35	49.02	50.28	50.18	38.53	42.78	41.41	43.82	36.70	43.15	42.67	42.81
Massachusetts	38.82	46.64	47.17	48.13	43.34	41.84	39.57	43.14	44.48	42.17	44.15	35.39	38.56
Michigan	44.53	55.90	53.89	59.10	51.55	48.66	52.38	53.40	50.16	43.37	50.00	49.47	46.98
Minnesota	37.77	44.82	40.37	42.78	37.08	37.17	36.58	32.70	37.07	35.35	38.98	32.83	34.96
Mississippi	43.44	54.56	57.73	53.97	49.20	49.98	53.37	49.62	53.07	46.18	51.35	47.29	52.26
Missouri	51.26	51.70	53.82	52.35	57.50	46.15	50.39	43.64	46.61	45.55	47.87	41.47	44.10
Montana	36.97	38.87	47.47	45.79	46.97	41.50	42.33	42.99	44.35	41.79	36.33	42.79	44.71
Nebraska	42.32	47.82	48.16	46.75	48.25	40.98	44.30	41.63	44.83	40.29	44.89	39.03	44.59
Nevada	28.67	50.44	49.43	43.95	42.99	47.02	50.15	31.78	34.75	37.21	45.03	36.70	48.99

New Hampshire	38.39	39.01	50.38	47.17	45.79	41.05	39.14	42.30	41.48	40.71	41.10	40.36	47.05
New Jersey	35.82	45.21	41.77	48.30	42.77	39.63	38.06	39.75	38.59	37.95	38.50	37.36	36.11
New Mexico	39.58	44.82	45.41	46.23	45.58	40.65	40.22	40.34	43.49	41.16	43.83	42.15	41.56
New York	44.23	45.93	47.27	46.94	48.65	45.99	45.53	41.93	41.71	41.32	42.04	41.58	37.76
North Carolina	40.42	51.57	48.16	54.30	48.52	43.60	43.87	44.68	48.24	46.53	46.96	37.49	44.75
North Dakota	31.84	51.47	49.08	41.01	41.29	40.28	41.63	43.03	44.18	37.74	40.17	41.52	47.05
Ohio	47.84	56.58	50.61	55.71	52.78	47.08	48.85	49.16	47.63	45.21	47.45	46.64	48.96
Oklahoma	48.33	46.63	50.88	50.04	50.37	47.14	50.07	45.07	45.69	44.28	47.26	45.11	47.04
Oregon	47.45	45.67	45.20	45.20	45.41	45.94	45.24	43.56	41.14	43.43	39.63	44.97	44.02
Pennsylvania	41.30	51.33	50.29	55.13	49.26	42.04	48.74	46.95	48.26	49.58	46.40	42.43	47.13
Rhode Island	48.60	56.50	53.84	53.99	55.21	44.08	45.67	43.01	43.81	41.88	44.58	48.07	46.47
South Carolina	44.31	55.09	50.28	48.89	47.93	49.88	46.13	48.77	48.40	47.46	49.83	42.66	48.69
South Dakota	40.76	43.62	48.03	49.63	47.55	44.13	36.31	41.55	41.32	39.79	43.27	43.01	37.93
Tennessee	44.51	52.69	45.90	55.97	38.77	42.20	50.15	43.14	53.99	48.20	55.89	46.80	56.10
Texas	44.80	45.83	39.27	46.13	40.80	42.08	45.29	40.48	40.62	34.34	41.84	39.63	39.04
Utah	50.15	46.17	52.68	48.18	48.71	41.16	43.51	36.76	38.16	39.20	40.75	42.33	43.84
Vermont	48.13	46.36	50.86	46.82	44.17	43.43	39.58	45.07	45.76	38.55	44.92	42.30	44.03
Virginia	46.19	49.83	45.34	43.54	45.87	41.96	47.10	45.61	47.31	43.79	42.31	43.22	45.16
Washington	39.27	49.17	48.34	48.86	46.51	42.08	45.63	42.31	42.29	40.08	41.05	39.61	41.51
West Virginia	52.84	58.72	57.98	52.55	54.19	56.56	55.86	55.40	59.57	58.44	57.66	59.40	60.13
Wisconsin	49.88	54.12	55.86	53.60	43.32	41.02	37.66	43.96	42.11	40.81	39.97	37.85	44.08
Wyoming	31.04	48.70	47.69	47.48	46.25	46.23	37.42	43.35	42.60	39.97	42.09	41.24	41.66
Guam	44.64	43.57	--	40.13	31.52	15.48	25.19	37.59	35.96	39.28	35.54	35.71	28.27
Puerto Rico	36.99	50.07	43.72	39.29	38.88	39.71	45.25	41.89	40.95	36.91	39.06	36.11	41.77
Virgin Islands	30.59	41.90	28.97	27.03	32.91	--	--	--	--	--	25.43	--	--

Table XXVII: Prevalence of rheumatic disorder diagnoses in the US population aged 65 to 69 years, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	60.07	58.92	53.11	58.20	60.60	48.85	55.71	53.62	58.92	53.30	55.64	54.00	59.84
Alaska	41.57	52.71	53.12	52.42	42.14	52.10	47.49	46.76	50.03	50.75	45.14	47.51	44.07
Arizona	51.22	54.56	53.80	49.28	52.87	44.65	43.29	45.31	47.56	45.79	47.81	44.82	44.09
Arkansas	51.87	55.62	57.14	55.92	49.95	50.69	49.38	53.41	48.97	51.41	54.22	51.61	57.96
California	46.69	49.39	56.68	44.91	44.34	46.54	48.59	46.30	45.60	42.96	38.83	43.13	42.04
Colorado	52.49	50.43	43.84	51.66	49.44	45.42	46.48	47.01	45.51	44.33	46.33	43.39	45.59
Connecticut	40.62	49.59	56.13	46.60	48.45	46.09	43.49	47.89	45.39	45.92	43.26	42.99	44.84
Delaware	42.91	58.48	59.80	51.09	51.79	44.87	52.68	45.71	51.19	47.64	48.02	50.30	43.35
District of Columbia	52.50	61.94	52.39	56.79	45.73	44.82	45.95	44.06	43.69	44.65	43.40	39.07	46.13
Florida	42.70	57.58	50.82	43.62	49.22	49.63	42.41	45.14	48.88	47.87	40.91	45.92	44.56
Georgia	56.08	54.59	50.20	55.83	52.65	49.72	48.98	46.33	51.55	52.37	49.91	46.80	49.14
Hawaii	23.32	34.94	38.18	40.34	42.45	35.37	36.75	34.80	41.16	36.10	40.63	37.60	35.63
Idaho	41.45	48.64	48.13	53.42	47.57	44.23	51.12	49.19	48.14	48.82	43.24	44.98	56.06
Illinois	40.86	38.47	52.70	49.90	56.96	50.79	46.19	52.10	49.00	45.32	46.15	47.08	46.42
Indiana	54.43	50.06	56.45	53.86	53.65	50.05	51.47	50.28	51.11	48.94	48.30	47.43	50.88
Iowa	39.24	53.17	45.25	49.98	46.53	47.78	50.49	44.21	48.30	47.46	49.49	47.29	48.69
Kansas	53.08	35.16	48.80	49.34	45.38	46.12	42.06	45.76	47.92	45.20	45.80	44.57	44.46
Kentucky	59.81	52.79	48.87	54.34	56.76	56.34	56.84	55.01	53.11	51.62	57.04	51.56	55.40
Louisiana	47.90	52.34	51.32	50.72	50.20	52.28	54.69	53.04	52.26	54.58	53.53	51.03	54.60
Maine	51.98	52.13	47.32	56.60	54.56	47.68	51.50	50.60	50.65	48.22	53.52	47.44	51.55
Maryland	47.26	53.98	53.52	57.73	53.41	47.58	47.61	46.34	45.65	44.90	50.71	45.18	46.41
Massachusetts	44.51	50.52	49.83	53.52	50.38	45.93	46.53	47.74	51.95	43.46	48.43	42.67	43.87
Michigan	59.75	66.11	59.66	60.36	59.41	52.87	58.17	57.06	58.81	53.54	54.34	51.82	55.35
Minnesota	39.45	45.17	50.56	47.43	40.51	42.59	46.63	37.48	43.45	43.40	45.52	37.78	43.22
Mississippi	47.68	57.53	57.81	57.38	59.60	54.82	54.49	51.99	49.56	49.43	56.16	50.86	53.71
Missouri	44.89	53.63	58.45	55.52	54.83	49.62	53.16	52.54	53.03	50.23	51.34	48.96	51.14
Montana	49.07	50.83	42.87	52.26	48.82	44.28	44.98	46.90	45.36	44.24	49.54	44.03	51.66
Nebraska	47.13	48.77	56.22	52.12	50.09	46.55	47.10	50.70	49.26	47.67	49.92	47.39	45.09
Nevada	41.12	52.86	48.37	48.61	50.38	49.78	46.15	40.00	51.97	40.55	43.33	36.94	45.91

New Hampshire	44.20	49.14	52.55	50.96	49.56	50.86	52.38	50.84	51.06	46.89	46.53	44.65	49.21
New Jersey	42.53	46.23	48.65	52.09	48.84	42.93	45.67	43.06	46.78	43.15	46.36	43.23	50.99
New Mexico	49.33	55.56	49.83	49.46	49.75	44.53	47.24	44.77	46.13	48.56	50.31	44.27	48.36
New York	48.25	49.18	45.04	53.86	46.07	44.55	44.31	50.37	42.32	47.01	46.48	45.22	43.96
North Carolina	44.72	53.10	54.06	53.91	49.66	47.12	49.11	45.42	51.60	49.93	47.68	41.49	53.72
North Dakota	50.69	41.04	42.15	47.22	53.43	48.56	50.95	53.14	48.78	43.35	45.11	45.35	50.49
Ohio	48.53	51.72	54.83	61.28	56.97	50.08	54.70	55.02	54.38	48.45	50.10	50.71	50.51
Oklahoma	51.61	47.55	57.41	56.32	57.17	50.64	50.80	46.11	52.14	48.77	50.21	47.47	49.43
Oregon	38.97	49.23	50.64	52.93	47.71	53.96	47.36	53.72	50.73	47.55	49.20	45.96	49.44
Pennsylvania	52.38	56.03	53.73	56.01	54.36	52.03	52.08	53.09	53.51	55.15	50.26	47.49	45.48
Rhode Island	45.94	55.16	57.35	53.68	58.33	48.24	50.64	53.07	53.10	50.89	46.35	44.50	47.12
South Carolina	48.42	56.26	56.54	55.71	48.76	49.45	50.03	54.83	52.94	51.69	53.84	52.03	48.97
South Dakota	44.94	54.53	49.15	47.59	50.51	44.46	41.95	47.22	48.89	41.51	43.13	35.47	50.62
Tennessee	48.64	55.03	50.64	59.16	47.46	46.47	53.03	45.80	55.56	52.33	53.67	47.32	53.20
Texas	45.53	47.20	49.84	51.77	47.04	49.41	48.53	46.00	40.59	45.91	43.91	50.28	41.74
Utah	45.58	56.44	52.28	57.20	51.15	47.36	48.14	46.77	47.66	44.83	43.98	43.26	49.76
Vermont	49.83	50.81	49.20	53.87	53.47	49.99	51.32	47.30	50.88	46.04	46.63	45.89	50.20
Virginia	50.17	51.49	47.96	57.48	51.97	50.97	48.72	45.83	49.24	45.03	49.06	51.68	46.23
Washington	42.23	50.19	52.56	54.75	51.27	46.53	48.88	52.24	49.75	50.90	48.15	44.60	48.26
West Virginia	51.28	62.07	57.87	55.17	55.63	59.55	55.20	58.63	63.04	58.00	62.01	57.79	63.78
Wisconsin	45.72	48.54	53.23	59.54	49.97	52.37	51.33	49.48	47.78	44.80	49.82	47.98	44.03
Wyoming	42.59	50.57	48.76	45.85	52.73	46.54	47.46	44.22	49.47	46.37	44.29	43.08	46.18
Guam	38.14	33.37	--	23.67	18.84	24.20	38.92	39.43	44.94	33.89	42.50	45.85	40.47
Puerto Rico	40.64	54.86	48.60	47.80	41.77	45.65	51.47	46.26	46.24	39.60	48.23	38.80	46.51
Virgin Islands	38.62	30.28	45.21	40.14	35.72	--	--	--	--	--	36.54	--	--

Table XXVIII: Prevalence of rheumatic disorder diagnoses in the US population aged 70 and above, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	66.94	62.99	61.86	64.98	58.12	57.54	58.88	61.74	61.40	59.24	60.78	61.21	60.99
Alaska	39.25	53.44	48.20	55.51	59.47	48.97	55.01	51.34	48.99	45.31	48.61	53.00	55.69
Arizona	57.90	57.63	58.35	58.65	54.59	53.75	53.97	55.44	52.86	47.50	53.87	49.08	51.50
Arkansas	60.14	57.38	54.30	57.60	56.03	52.95	55.44	54.75	56.51	55.97	55.56	54.49	58.25
California	52.01	61.14	56.84	52.66	51.77	52.24	54.97	53.38	50.86	49.68	50.46	48.74	50.55
Colorado	53.89	59.75	56.21	58.90	57.23	52.02	54.15	52.59	53.65	53.67	53.08	51.50	52.78
Connecticut	52.41	57.85	52.47	57.18	56.52	52.66	58.52	54.45	54.40	52.87	53.02	51.59	55.55
Delaware	53.76	59.83	59.29	65.13	54.38	52.86	55.63	53.83	54.72	56.25	53.43	45.81	50.21
District of Columbia	60.28	57.22	54.01	58.04	54.85	56.51	54.25	52.15	53.72	52.99	50.37	41.79	52.39
Florida	54.83	54.22	54.99	49.03	53.95	53.05	52.69	53.55	54.15	53.38	51.43	49.98	51.85
Georgia	54.57	62.11	59.41	59.53	55.71	55.92	57.97	53.70	55.74	52.89	53.05	49.39	51.94
Hawaii	31.25	40.56	47.71	49.91	44.12	41.88	41.66	44.67	41.61	38.82	45.25	46.35	42.94
Idaho	49.32	57.20	56.16	58.12	54.33	54.09	54.70	53.42	53.80	54.42	55.65	51.65	54.66
Illinois	57.30	54.94	56.41	63.48	61.05	57.94	60.01	57.32	56.94	55.21	53.19	52.51	56.06
Indiana	57.41	59.78	55.92	58.33	60.53	55.87	57.65	57.01	56.46	55.59	54.93	54.60	56.32
Iowa	49.12	59.97	59.98	56.32	57.73	53.88	56.05	53.35	56.15	54.41	56.11	51.34	51.77
Kansas	55.55	52.23	53.84	57.31	51.70	51.53	53.58	51.66	55.50	52.60	54.74	51.78	54.12
Kentucky	57.37	64.71	51.71	59.04	59.00	61.96	62.48	58.33	60.03	57.97	58.63	53.86	59.61
Louisiana	55.08	57.51	57.60	58.06	53.43	54.75	56.81	54.34	54.53	60.20	57.75	53.56	57.51
Maine	52.57	56.88	61.26	62.01	59.04	57.22	57.11	55.92	54.56	57.24	56.99	52.59	56.97
Maryland	53.04	54.41	58.93	59.96	57.89	52.38	55.10	55.75	57.99	55.40	55.17	55.20	56.54
Massachusetts	47.03	56.27	55.90	58.18	55.90	51.80	50.75	52.66	55.98	50.99	56.40	53.13	53.30
Michigan	61.10	62.45	64.08	64.68	60.79	63.43	61.57	61.03	60.81	57.80	61.16	59.84	58.12
Minnesota	47.40	55.75	57.29	54.31	46.48	48.59	48.29	42.47	49.68	50.42	50.33	45.84	48.97
Mississippi	60.95	64.12	59.34	62.52	60.86	59.07	62.33	59.78	60.62	56.46	62.51	55.61	57.83
Missouri	56.23	59.26	60.23	66.39	57.18	55.50	56.98	53.64	57.07	57.05	61.63	55.81	59.60
Montana	49.42	57.64	55.69	56.76	56.38	52.14	51.83	51.98	52.28	52.78	55.06	45.85	51.35
Nebraska	49.44	60.70	57.67	60.79	56.69	54.32	56.82	55.33	55.22	52.91	53.03	51.84	52.41
Nevada	50.59	54.99	57.37	56.68	52.63	50.70	49.17	49.85	52.24	50.30	48.79	47.75	49.97

New Hampshire	50.08	57.11	53.65	57.57	54.88	54.60	55.30	53.39	56.04	55.36	56.83	51.49	55.57
New Jersey	53.37	54.62	55.10	58.05	52.72	51.61	50.43	52.49	50.81	52.03	53.79	48.87	51.68
New Mexico	47.50	51.96	54.15	55.39	53.50	50.51	50.65	48.94	51.99	49.49	57.88	47.65	53.72
New York	54.44	61.09	60.27	58.84	57.13	53.46	55.96	56.25	58.44	52.68	53.77	49.85	54.58
North Carolina	54.02	57.51	58.46	61.25	59.12	55.20	57.96	55.78	56.35	55.50	52.82	53.03	58.12
North Dakota	48.91	59.53	56.84	54.95	56.42	50.72	56.05	55.53	53.35	53.24	51.80	49.54	53.44
Ohio	58.69	55.62	56.97	59.71	61.74	59.39	57.74	58.15	59.82	56.23	59.98	57.00	58.41
Oklahoma	60.43	59.59	60.80	59.25	59.73	54.41	56.34	54.41	56.27	57.08	58.43	53.33	55.91
Oregon	51.42	59.87	58.09	55.82	53.95	56.62	54.58	55.24	51.80	51.51	53.89	50.81	56.01
Pennsylvania	56.57	66.27	59.90	61.58	57.95	58.82	56.24	59.09	61.89	55.33	61.38	59.15	55.74
Rhode Island	55.18	55.43	62.35	60.23	61.20	57.43	59.23	58.46	56.91	56.55	58.83	53.30	57.42
South Carolina	57.13	59.06	60.50	59.22	57.96	57.99	60.04	56.50	58.36	56.44	59.53	56.11	58.81
South Dakota	50.31	60.69	57.59	56.65	50.90	49.39	52.14	53.46	60.03	55.14	59.57	44.33	53.76
Tennessee	57.18	57.04	57.40	58.86	43.10	51.84	54.49	49.21	59.17	58.35	61.08	59.54	59.04
Texas	54.88	55.56	55.58	55.79	57.81	48.70	52.15	50.14	48.62	51.33	53.78	50.61	51.94
Utah	53.04	55.52	53.26	55.57	55.26	53.17	53.74	51.14	51.91	53.20	53.64	49.18	55.17
Vermont	48.40	59.18	54.75	58.37	57.14	56.17	55.89	56.62	55.71	52.60	53.57	53.40	54.13
Virginia	55.46	52.48	64.48	58.24	55.57	55.01	55.72	55.95	57.18	52.45	58.92	51.65	54.86
Washington	53.02	59.07	57.25	58.72	58.14	52.09	53.86	55.94	57.07	53.52	53.11	50.14	53.87
West Virginia	54.77	62.30	60.34	60.32	57.63	60.23	61.72	62.27	67.48	60.74	64.63	62.43	66.67
Wisconsin	56.83	55.81	58.23	56.98	57.00	55.36	58.76	54.38	57.47	54.85	56.77	51.15	51.89
Wyoming	43.34	60.40	54.04	57.18	52.99	47.14	54.48	51.42	52.80	53.50	52.01	48.82	51.63
Guam	41.87	43.97	--	37.62	35.60	35.01	50.75	55.25	44.24	45.02	46.23	38.30	40.43
Puerto Rico	58.89	60.29	60.39	53.54	47.83	51.00	60.67	55.15	57.57	51.43	49.94	45.83	54.64
Virgin Islands	52.58	50.01	45.56	45.16	41.30	--	--	--	--	--	35.97	--	--

Table XXIX: Prevalence of rheumatic disorder diagnoses in the male US population, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	23.74	29.71	28.36	31.05	29.64	26.47	29.09	27.82	29.42	29.08	28.95	29.63	30.38
Alaska	12.98	23.15	21.58	21.67	20.96	19.84	20.06	20.78	19.39	18.18	21.38	18.98	18.76
Arizona	20.59	22.64	22.07	20.88	19.93	19.68	21.60	18.38	20.70	19.43	21.33	20.13	21.50
Arkansas	22.92	27.84	26.51	25.75	26.32	22.97	25.44	25.61	25.98	25.86	30.34	24.79	28.82
California	13.73	17.54	17.74	16.01	16.42	17.61	17.82	16.02	16.12	15.73	14.54	15.50	16.31
Colorado	17.37	22.64	19.77	21.17	20.95	19.55	20.31	18.97	20.74	19.96	19.97	18.61	18.62
Connecticut	15.63	21.24	21.25	21.03	20.03	18.24	20.98	20.19	18.53	20.51	21.33	18.66	21.25
Delaware	18.09	22.71	23.73	26.28	23.47	22.57	23.84	21.33	22.82	23.93	22.44	21.26	21.39
District of Columbia	16.43	18.31	17.79	18.84	16.38	17.52	--	16.16	16.07	14.72	13.06	11.83	15.54
Florida	20.01	22.74	22.45	20.75	23.83	22.70	23.81	21.98	22.86	21.39	20.22	21.18	22.07
Georgia	18.41	23.21	22.29	22.68	19.86	19.12	20.44	20.46	21.58	19.96	21.61	19.11	21.16
Hawaii	9.02	15.19	19.83	21.85	19.41	16.18	17.25	19.60	18.05	17.58	19.57	18.69	20.90
Idaho	18.55	21.94	21.72	23.27	19.16	20.09	23.87	21.71	21.45	21.95	20.61	19.80	23.89
Illinois	17.31	19.73	20.13	22.91	22.31	20.69	21.50	18.91	19.25	18.67	21.15	20.27	22.11
Indiana	21.53	24.78	25.81	25.76	24.41	23.03	22.50	23.77	24.35	24.58	22.82	23.75	25.05
Iowa	16.60	22.01	23.22	24.47	21.68	20.34	21.64	20.24	21.28	22.35	22.10	20.54	21.52
Kansas	19.71	20.66	23.56	23.50	20.64	19.52	20.30	20.58	21.60	20.92	21.28	20.40	21.23
Kentucky	25.35	31.33	23.71	28.26	33.25	27.58	31.38	28.65	31.05	28.07	29.13	28.35	29.31
Louisiana	17.41	22.43	24.41	20.37	21.41	21.57	23.19	21.91	22.83	23.31	23.40	22.81	23.81
Maine	21.07	25.48	26.58	28.86	27.45	25.62	26.06	26.43	27.68	26.71	28.86	29.62	28.55
Maryland	17.29	22.18	23.50	24.68	21.78	19.50	19.13	19.28	21.07	19.02	20.62	20.59	21.53
Massachusetts	15.30	21.98	20.83	23.39	19.59	20.04	20.42	20.19	23.36	19.43	21.26	19.55	19.39
Michigan	23.66	29.35	26.03	28.11	25.99	27.30	27.96	27.86	28.10	25.22	27.97	25.78	27.52
Minnesota	16.40	22.61	20.69	20.99	17.13	16.58	18.76	17.43	18.45	18.20	19.05	16.64	18.77
Mississippi	21.09	27.21	29.04	26.38	26.03	23.43	28.04	26.47	25.02	24.86	26.69	25.09	27.65
Missouri	22.65	25.62	28.03	28.62	26.27	24.80	24.76	26.46	23.26	25.15	25.66	22.88	26.75
Montana	18.34	22.39	22.50	25.90	24.84	24.94	25.01	24.18	22.20	24.39	25.58	23.76	26.72
Nebraska	16.68	22.94	22.41	25.10	22.78	20.12	21.45	21.56	21.62	19.68	21.70	20.64	21.26
Nevada	15.63	22.53	21.97	20.50	22.57	20.95	20.89	17.81	19.68	18.65	19.48	17.87	20.06

New Hampshire	17.69	22.68	22.66	23.01	23.02	22.87	23.07	23.47	23.23	24.07	23.64	22.61	25.05
New Jersey	16.31	19.45	20.10	20.90	17.69	18.96	17.32	17.95	19.30	18.78	18.66	18.63	22.07
New Mexico	18.17	21.83	20.61	24.10	22.56	22.06	21.51	21.43	21.76	22.66	22.88	20.99	23.19
New York	17.54	22.63	21.03	23.29	21.13	20.53	20.14	20.37	20.01	19.04	19.29	18.02	17.87
North Carolina	17.37	22.25	22.71	24.91	22.44	21.01	22.62	23.61	23.56	23.67	23.00	20.72	23.76
North Dakota	16.01	21.85	21.75	22.64	23.71	19.58	20.42	22.95	21.21	19.28	20.07	19.28	22.70
Ohio	22.22	25.18	26.08	28.12	26.19	24.47	25.44	25.46	26.75	24.25	26.61	23.99	26.06
Oklahoma	22.37	22.83	26.07	26.14	26.11	23.82	24.69	23.55	23.26	22.83	24.99	24.49	24.82
Oregon	16.91	23.05	21.83	21.77	22.55	21.89	24.48	23.31	22.12	22.55	22.72	22.22	24.32
Pennsylvania	21.22	27.25	27.73	27.43	27.43	23.64	24.80	25.05	24.60	24.66	25.93	24.84	22.86
Rhode Island	21.63	24.18	23.89	25.09	24.02	23.61	23.55	23.43	23.48	22.80	23.15	23.58	24.04
South Carolina	19.85	26.27	27.12	24.76	26.18	23.52	24.89	25.96	26.28	25.47	26.70	23.87	27.21
South Dakota	19.60	24.85	25.35	23.44	22.52	19.68	21.14	23.36	23.00	20.67	24.17	18.36	23.27
Tennessee	22.57	27.58	26.08	29.89	23.16	20.58	27.13	21.61	29.13	28.07	25.77	25.57	28.23
Texas	14.59	20.68	18.02	19.32	17.68	16.21	16.72	16.84	15.83	15.76	17.48	15.45	17.81
Utah	14.65	17.29	19.47	19.19	17.37	16.48	16.38	16.05	16.45	16.58	16.64	16.39	18.21
Vermont	17.43	23.25	24.85	24.65	25.57	23.76	23.87	25.21	24.03	23.95	24.77	24.83	25.44
Virginia	17.38	24.13	22.97	21.61	22.77	20.69	22.43	21.21	22.43	19.39	21.63	21.50	21.65
Washington	15.72	22.65	21.56	23.11	22.14	19.35	21.45	20.61	21.33	20.18	20.41	19.78	20.74
West Virginia	26.25	34.94	31.21	32.37	30.07	31.95	32.56	33.81	36.22	36.32	35.91	35.96	36.27
Wisconsin	22.43	23.35	23.90	24.91	22.18	20.33	23.05	21.31	22.48	20.22	21.40	21.12	23.55
Wyoming	17.26	26.61	25.18	25.74	24.00	21.06	21.70	23.70	23.38	22.69	24.56	23.75	23.62
Guam	13.00	15.19		11.89	10.03	9.66	--	15.81	15.29	15.91	17.00	17.40	14.48
Puerto Rico	12.37	18.69	17.42	16.61	13.42	13.35	--	16.37	17.28	16.38	17.44	15.30	18.01
Virgin Islands	11.05	13.60	12.60	14.60	11.72	--	--	--	--	--	14.97	--	--

Table XXX: Prevalence of rheumatic disorder diagnoses in the female US population, by state, according to the Behavioural Risk Factor Surveillance System (BRFSS), in years where the rheumatic disorder diagnosis question was included in the core questionnaire and asked to all states

State	Year												
	2001	*2003*	*2005*	*2007*	*2009*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*
Alabama	36.18	37.73	37.03	37.99	37.84	33.57	38.37	36.20	38.23	37.09	37.75	36.69	38.67
Alaska	20.92	26.19	24.87	28.39	26.16	22.77	25.18	24.83	24.73	24.55	26.63	26.03	28.67
Arizona	26.65	29.82	29.98	29.58	28.53	27.07	28.23	29.42	28.95	27.72	30.48	28.41	29.51
Arkansas	31.39	35.07	34.54	35.43	35.94	33.97	34.73	34.08	34.63	33.36	36.33	36.68	36.94
California	23.89	26.24	26.73	25.48	24.14	25.17	26.14	24.61	24.46	22.39	23.21	23.16	24.60
Colorado	22.36	26.57	26.77	26.65	26.67	24.04	26.00	25.50	24.87	25.46	26.04	24.14	26.59
Connecticut	25.49	30.11	29.32	29.63	29.47	26.44	27.31	26.99	29.07	28.21	28.65	27.40	30.31
Delaware	28.28	32.82	34.33	35.35	31.14	29.71	31.74	30.70	30.06	31.86	30.64	29.02	30.30
District of Columbia	23.87	27.18	26.47	27.67	24.79	23.91	--	22.42	21.87	21.80	20.28	16.43	21.57
Florida	30.45	32.51	31.96	27.60	29.87	30.80	28.86	29.80	30.80	30.11	29.04	28.24	30.64
Georgia	27.54	30.05	29.06	32.11	27.26	27.27	27.24	27.57	28.60	28.83	28.97	25.06	29.14
Hawaii	14.65	20.57	24.45	26.37	22.94	20.28	23.36	20.27	23.39	20.22	24.35	23.42	23.56
Idaho	25.14	29.26	29.27	28.28	28.22	26.00	28.08	26.48	28.03	28.56	27.42	28.83	28.63
Illinois	26.34	28.41	29.29	30.70	30.57	27.64	29.13	27.90	30.53	27.73	28.20	28.40	27.50
Indiana	31.63	35.70	32.57	34.75	33.94	31.65	32.85	31.95	33.71	30.42	32.49	32.85	31.78
Iowa	25.35	30.95	31.36	29.50	28.70	28.18	30.03	28.19	30.46	29.28	28.80	28.74	29.25
Kansas	26.99	28.43	30.14	31.33	27.44	26.56	27.60	27.18	29.03	28.03	28.68	27.79	30.02
Kentucky	34.17	37.58	33.58	34.59	37.67	35.86	38.48	34.94	36.68	35.65	37.65	36.14	37.17
Louisiana	28.01	32.07	28.74	29.96	30.22	28.77	32.45	30.61	31.08	32.20	31.96	31.58	34.10
Maine	29.86	32.85	34.21	35.36	34.08	33.44	32.80	34.18	34.98	35.05	38.43	32.67	36.56
Maryland	25.44	29.92	31.04	30.55	29.64	26.70	27.52	27.59	29.68	27.67	28.12	28.88	30.87
Massachusetts	25.68	28.78	30.61	31.18	29.54	26.80	25.53	28.03	30.96	28.47	28.90	27.93	28.59
Michigan	33.26	35.10	35.29	34.55	35.44	34.44	35.44	34.59	35.50	34.52	35.72	34.92	36.33
Minnesota	23.94	28.54	30.23	24.79	24.63	24.26	24.05	22.29	25.12	24.85	25.71	22.76	25.14
Mississippi	30.42	35.00	34.91	34.29	35.08	34.25	33.28	33.16	33.10	32.01	35.48	32.99	36.35
Missouri	30.93	34.21	35.93	34.95	35.32	32.43	34.06	30.18	32.40	33.27	35.15	32.48	35.16
Montana	29.71	30.16	30.23	32.12	30.08	27.88	30.62	30.36	29.86	29.25	29.66	27.38	30.41
Nebraska	23.80	30.76	29.71	30.82	28.87	26.63	27.69	27.80	27.43	27.13	27.37	27.27	29.10
Nevada	27.02	31.61	28.39	29.99	26.14	24.83	27.15	23.99	26.52	24.45	27.98	22.72	29.56

New Hampshire	24.36	29.96	30.90	34.02	30.88	28.53	31.22	29.66	30.92	29.01	31.35	30.34	34.47
New Jersey	25.90	30.06	28.40	31.97	27.39	25.35	26.01	27.24	25.82	26.77	27.44	26.88	24.07
New Mexico	25.25	29.02	27.99	30.16	28.79	26.33	26.22	27.22	29.74	26.29	32.43	29.64	30.51
New York	27.14	31.95	30.56	32.43	29.69	27.99	29.42	29.02	27.95	27.42	27.65	26.89	27.04
North Carolina	28.69	34.37	31.68	33.07	32.43	28.99	29.32	28.89	31.46	29.97	28.94	27.72	31.25
North Dakota	25.77	32.98	30.24	31.05	31.05	28.60	28.66	29.28	28.92	26.72	26.65	29.54	29.42
Ohio	29.02	34.01	33.80	35.95	35.09	33.67	34.25	33.94	34.59	32.28	34.10	33.80	35.19
Oklahoma	31.20	32.77	34.24	34.27	34.53	31.46	31.07	30.76	31.65	32.37	31.46	30.81	32.13
Oregon	26.69	30.90	32.11	30.90	31.65	30.97	31.45	32.06	29.93	30.87	31.47	30.75	33.43
Pennsylvania	31.07	35.49	35.26	36.36	34.78	32.71	33.03	34.19	35.62	33.55	34.07	33.21	34.20
Rhode Island	30.14	32.03	31.96	33.03	34.01	29.27	29.68	31.12	30.90	30.68	30.43	31.04	32.00
South Carolina	27.92	34.08	34.20	33.92	34.80	31.96	32.64	34.19	33.39	32.51	33.21	32.08	33.27
South Dakota	24.47	32.55	30.35	30.03	28.54	27.23	26.15	27.20	29.00	27.92	27.45	26.05	26.78
Tennessee	29.90	35.21	33.09	37.83	28.44	30.77	32.21	30.88	35.86	35.63	35.86	34.43	36.38
Texas	24.71	27.32	26.44	27.85	27.09	24.13	25.76	24.51	22.95	24.17	25.68	26.99	24.63
Utah	24.66	27.27	25.78	24.40	25.40	23.04	23.63	22.94	23.66	22.56	22.87	22.29	24.87
Vermont	25.60	31.07	29.70	32.01	31.42	29.23	30.35	30.22	31.73	29.88	31.15	30.68	31.30
Virginia	28.16	30.11	32.04	31.74	28.87	30.51	28.29	28.60	29.68	26.86	29.19	28.34	29.98
Washington	25.29	30.63	30.63	31.53	30.63	28.04	28.88	30.16	29.98	28.66	28.67	28.24	28.17
West Virginia	34.37	39.32	38.25	38.52	37.39	39.67	40.10	38.40	43.61	39.62	41.74	42.23	43.85
Wisconsin	27.07	30.19	31.37	30.64	28.10	30.12	28.30	28.69	28.80	29.10	28.02	29.84	28.96
Wyoming	22.15	30.37	29.52	29.98	29.84	27.43	27.88	26.62	27.91	29.12	28.40	26.94	27.08
Guam	12.03	17.74		15.55	11.35	11.54	--	16.45	16.06	15.68	17.22	13.67	13.30
Puerto Rico	22.95	29.40	29.58	26.96	22.30	25.28	--	29.50	30.96	28.42	29.47	26.89	30.36
Virgin Islands	19.03	20.44	20.04	19.11	18.23	--	--	--	--	--	19.30	--	--

APPENDIX L

Geospatial trends: region-specific trends of joint symptoms (NHIS)

Table I: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in the overall US population, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	32.0 (30.8, 33.2)	28.1 (26.8, 29.5)	29.3 (28.3, 30.3)	28.3 (27.1, 29.6)
	OR (95% CI)	0.190 (0.167, 0.216)	0.780 (0.714, 0.852)	0.860 (0.797, 0.928)	0.832 (0.762, 0.909)
	p-value		< 0.001*	< 0.001*	< 0.001*
2003	WP[α] (95% CI)	35.6 (34.3, 36.9)	30.2 (28.9, 31.6)	31.2 (29.2, 31.6)	29.5 (28.2, 30.7)
	OR (95% CI)	0.208 (0.183, 0.237)	0.728 (0.665, 0.795)	0.796 (0.739, 0.858)	0.768 (0.706, 0.837)
	p-value		< 0.001*	< 0.001*	< 0.001*
2005	WP[α] (95% CI)	34.9 (33.7, 36.1)	30.2 (28.8, 31.6)	30.1 (29.2, 31.1)	29.2 (28.0, 30.4)
	OR (95% CI)	0.198 (0.172, 0.226)	0.721 (0.659, 0.789)	0.782 (0.726, 0.843)	0.754 (0.693, 0.822)
	p-value		< 0.001*	< 0.001*	< 0.001*
2006	WP[α] (95% CI)	34.2 (32.7, 35.7)	28.2 (26.5, 29.8)	28.3 (27.2, 29.4)	28.6 (27.2, 30.0)
	OR (95% CI)	0.164 (0.141, 0.192)	0.722 (0.647, 0.806)	0.752 (0.687, 0.823)	0.761 (0.688, 0.842)
	p-value		< 0.001*	< 0.001*	< 0.001*
2007	WP[α] (95% CI)	29.2 (27.7, 30.7)	26.7 (25.0, 28.3)	26.6 (25.5, 27.7)	28.4 (26.9, 29.8)
	OR (95% CI)	0.119 (0.100, 0.141)	0.841 (0.750, 0.944)	0.884 (0.804, 0.972)	0.976 (0.877, 1.09)
	p-value		0.003*	0.011*	0.650
2008	WP[α] (95% CI)	33.9 (32.3, 35.4)	30.0 (28.2, 31.8)	31.4 (30.2, 32.6)	29.4 (27.9, 30.9)
	OR (95% CI)	0.210 (0.178, 0.248)	0.773 (0.689, 0.867)	0.881 (0.803, 0.968)	0.811 (0.731, 0.901)
	p-value		< 0.001*	0.008*	< 0.001*
2009	WP[α] (95% CI)	36.7 (35.3, 38.2)	30.4 (28.6, 32.1)	33.0 (31.9, 34.2)	31.1 (29.6, 32.6)
	OR (95% CI)	0.206 (0.176, 0.240)	0.703 (0.631, 0.783)	0.845 (0.775, 0.922)	0.776 (0.703, 0.857)
	p-value		< 0.001*	< 0.001*	< 0.001*
2010	WP[α] (95% CI)	37.1 (35.7, 38.6)	30.8 (29.1, 32.4)	33.7 (32.6, 34.8)	30.8 (29.5, 32.2)
	OR (95% CI)	0.213 (0.184, 0.247)	0.696 (0.617, 0.772)	0.845 (0.777, 0.918)	0.767 (0.670, 0.842)
	p-value		< 0.001*	< 0.001*	< 0.001*
2011	WP[α] (95% CI)	35.5 (34.2, 36.8)	29.8 (28.3, 31.3)	35.4 (34.3, 36.4)	32.1 (30.9, 33.3)
	OR (95% CI)	0.174 (0.153, 0.199)	0.708 (0.645, 0.778)	0.977 (0.905, 1.05)	0.864 (0.796, 0.939)
	p-value		< 0.001*	0.541	< 0.001*

2012	WP[α] (95% CI)	32.6 (31.3, 34.0)	27.3 (25.8, 28.8)	30.6 (29.6, 31.6)	30.4 (29.2, 31.7)
	OR (95% CI)	0.171 (0.149, 0.197)	0.728 (0.659, 0.804)	0.884 (0.815, 0.959)	0.908 (0.831, 0.992)
	p-value		< 0.001*	0.003*	0.032*
2013	WP[α] (95% CI)	33.8 (32.4, 35.2)	30.3 (28.7, 31.9)	32.2 (31.1, 33.2)	31.9 (30.7, 33.1)
	OR (95% CI)	0.165 (0.141, 0.192)	0.774 (0.698, 0.858)	0.891 (0.820, 0.968)	0.927 (0.848, 1.01)
	p-value		< 0.001*	0.006*	0.095
2014	WP[α] (95% CI)	36.1 (34.6, 37.7)	31.9 (30.3, 33.6)	32.2 (31.1, 33.2)	31.0 (29.8, 32.3)
	OR (95% CI)	0.196 (0.169, 0.227)	0.763 (0.687, 0.847)	0.817 (0.751, 0.887)	0.806 (0.737, 0.887)
	p-value		< 0.001*	< 0.001*	< 0.001*
2015	WP[α] (95% CI)	36.4 (34.9, 37.9)	32.9 (31.2, 34.6)	33.6 (32.5, 34.7)	32.5 (31.1, 33.8)
	OR (95% CI)	0.183 (0.156, 0.214)	0.796 (0.716, 0.885)	0.857 (0.788, 0.932)	0.860 (0.785, 0.944)
	p-value		< 0.001*	< 0.001*	0.001*
2016	WP[α] (95% CI)	37.0 (35.6, 38.4)	31.4 (29.8, 33.0)	34.1 (32.9, 35.2)	32.3 (30.9, 33.7)
	OR (95% CI)	0.185 (0.160, 0.214)	0.728 (0.658, 0.804)	0.862 (0.795, 0.935)	0.836 (0.763, 0.915)
	p-value		< 0.001*	< 0.001*	< 0.001*
2017	WP[α] (95% CI)	38.0 (36.6, 39.4)	33.9 (32.1, 35.7)	33.1 (32.0, 34.2)	33.0 (31.5, 34.5)
	OR (95% CI)	0.197 (0.169, 0.230)	0.791 (0.713, 0.878)	0.791 (0.729, 0.859)	0.807 (0.735, 0.886)
	p-value		< 0.001*	< 0.001*	< 0.001*
2018	WP[α] (95% CI)	36.8 (35.4, 38.3)	32.7 (31.0, 34.5)	34.1 (32.9, 35.2)	33.5 (32.0, 35.0)
	OR (95% CI)	0.184 (0.155, 0.219)	0.755 (0.681, 0.838)	0.852 (0.782, 0.928)	0.868 (0.788, 0.956)
	p-value		< 0.001*	< 0.001*	0.004*

[α] WP: Weighted prevalence

* Significant at P < 0.05

Table II: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 18 to 24 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	19.2 (16.0, 22.4)	11.2 (8.3,14.2)	11.8 (9.6, 14.0)	15.0 (11.7, 18.3)
	OR (95% CI)	0.220 (0.175, 0.275)	0.533 (0.371, 0.764)	0.559 (0.415, 0.753)	0.743 (0.532, 1.04)
	p-value		< 0.001*	< 0.001*	0.082
2003	WP[α] (95% CI)	19.1 (15.7, 22.5)	13.6 (10.2, 17.0)	12.5 (10.2, 14.7)	14.0 (11.1, 16.8)
	OR (95% CI)	0.215 (0.167, 0.276)	0.668 (0.464, 0.961)	0.602 (0.447, 0.812)	0.686 (0.496, 0.948)
	p-value		0.030*	0.001*	0.023*
2005	WP[α] (95% CI)	17.4 (14.3, 20.5)	12.6 (8.5, 16.7)	12.5 (10.1, 14.8)	13.4 (9.9, 16.9)
	OR (95% CI)	0.226 (0.176, 0.290)	0.684 (0.444, 1.05)	0.679 (0.500, 0.923)	0.737 (0.508, 1.07)
	p-value		0.084	0.013*	0.109
2006	WP[α] (95% CI)	16.9 (13.3, 20.6)	10.2 (6.8, 13.6)	7.8 (6.0, 9.6)	14.0 (10.6, 17.4)
	OR (95% CI)	0.219 (0.163, 0.295)	0.556 (0.355, 0.871)	0.417 (0.291, 0.598)	0.802 (0.546, 1.18)
	p-value		0.010*	< 0.001*	0.261
2007	WP[α] (95% CI)	13.2 (10.0, 16.4)	10.7 (6.9, 14.5)	7.6 (5.7, 9.5)	9.7 (6.3, 13.1)
	OR (95% CI)	0.157 (0.113, 0.217)	0.794 (0.487, 1.29)	0.542 (0.366, 0.803)	0.711 (0.442, 1.14)
	p-value		0.353	0.002*	0.161
2008	WP[α] (95% CI)	21.1 (16.5, 25.7)	10.0 (6.0, 14.0)	14.4 (11.2, 17.6)	15.2 (11.2, 19.1)
	OR (95% CI)	0.273 (0.202, 0.368)	0.416 (0.247, 0.702)	0.628 (0.430, 0.917)	0.668 (0.442, 1.01)
	p-value		0.001*	0.016*	0.056
2009	WP[α] (95% CI)	19.9 (15.3, 23.5)	9.6 (6.3, 12.8)	12.8 (10.2, 15.3)	16.6 (12.1, 21.0)
	OR (95% CI)	0.217 (0.162, 0.290)	0.436 (0.276, 0.689)	0.607 (0.429, 0.858)	0.821 (0.543, 1.24)
	p-value		< 0.001*	0.005*	0.349
2010	WP[α] (95% CI)	18.8 (14.8, 22.8)	14.2 (9.6, 18.8)	14.5 (11.8, 17.3)	13.1 (10.0, 16.2)
	OR (95% CI)	0.227 (0.171, 0.301)	0.716 (0.454, 1.13)	0.735 (0.523, 1.03)	0.651 (0.446, 0.951)
	p-value		0.152	0.077	0.026*
2011	WP[α] (95% CI)	15.4 (12.4, 18.5)	10.9 (7.6, 14.1)	14.7 (12.1, 17.2)	12.5 (9.9, 15.1)
	OR (95% CI)	0.167 (0.127, 0.219)	0.672 (0.446, 1.01)	0.944 (0.691, 1.29)	0.780 (0.558, 1.09)
	p-value		0.057	0.716	0.147

2012	WP[α] (95% CI)	16.7 (13.2, 20.2)	10.2 (6.7, 13.6)	11.8 (9.6, 14.0)	14.2 (11.3, 17.0)
	OR (95% CI)	0.205 (0.155, 0.270)	0.564 (0.359, 0.888)	0.667 (0.481, 0.924)	0.822 (0.585, 1.16)
	p-value		0.013*	0.015*	0.261
2013	WP[α] (95% CI)	14.5 (11.0, 18.1)	9.4 (5.6, 13.2)	12.8 (10.1, 15.6)	14.1 (11.3, 17.0)
	OR (95% CI)	0.190 (0.139, 0.260)	0.603 (0.356, 1.02)	0.859 (0.589, 1.25)	0.983 (0.677, 1.43)
	p-value		0.061	0.432	0.927
2014	WP[α] (95% CI)	17.8 (13.9, 21.8)	14.8 (10.1, 19.5)	11.4 (9.1, 13.6)	14.5 (11.4, 17.6)
	OR (95% CI)	0.204 (0.152, 0.274)	0.795 (0.502, 1.26)	0.593 (0.418, 0.841)	0.777 (0.537, 1.12)
	p-value		0.326	0.003*	0.180
2015	WP[α] (95% CI)	14.6 (11.1, 18.1)	14.2 (806, 19.7)	11.4 (8.8, 14.1)	16.6 (13.0, 20.2)
	OR (95% CI)	0.174 (0.124, 0.244)	0.964 (0.562, 1.65)	0.754 (0.512, 1.11)	1.16 (0.791, 1.30)
	p-value		0.894	0.153	0.444
2016	WP[α] (95% CI)	14.6 (11.3, 17.9)	13.1 (9.1, 17.0)	12.6 (9.8, 15.3)	15.2 (12.0, 18.4)
	OR (95% CI)	0.184 (0.138, 0.244)	0.879 (0.568, 1.36)	0.843 (0.587, 1.21)	1.05 (0.730, 1.50)
	p-value		0.560	0.353	0.801
2017	WP[α] (95% CI)	17.1 (13.2, 20.9)	15.0 (10.1, 19.9)	11.7 (9.2, 14.3)	14.8 (11.3, 18.4)
	OR (95% CI)	0.234 (0.173, 0.317)	0.840 (0.525, 1.34)	0.650 (0.451, 0.938)	0.838 (0.566, 1.24)
	p-value		0.468	0.021*	0.378
2018	WP[α] (95% CI)	15.6 (11.5, 19.7)	10.3 (6.0, 14.6)	12.5 (9.4, 14.6)	16.1 (11.9, 20.4)
	OR (95% CI)	0.167 (0.114, 0.244)	0.619 (0.354, 1.08)	0.760 (0.502, 1.15)	1.03 (0.663, 1.59)
	p-value		0.093	0.195	0.901

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table III: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 25 to 29 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	18.0 (14.4, 21.6)	11.9 (8.3, 15.6)	14.1 (11.4, 16.7)	15.6 (12.2, 19.0)
	OR (95% CI)	0.194 (0.149, 0.253)	0.612 (0.400, 0.937)	0.746 (0.537, 1.04)	0.833 (0.585, 1.19)
	p-value		0.024*	0.080	0.311
2003	WP[α] (95% CI)	22.9 (19.1, 26.7)	13.1 (9.0, 17.1)	16.2 (13.6, 18.8)	17.6 (14.2, 20.9)
	OR (95% CI)	0.282 (0.220, 0.363)	0.503 (0.332, 0.763)	0.652 (0.488, 0.871)	0.715 (0.521, 0.981)
	p-value		0.001*	0.004*	0.038*
2005	WP[α] (95% CI)	20.4 (16.6, 24.2)	14.0 (10.0, 18.1)	14.0 (11.3, 16.6)	14.6 (11.3, 17.9)
	OR (95% CI)	0.222 (0.171, 0.288)	0.658 (0.436, 0.993)	0.641 (0.465, 0.884)	0.672 (0.471, 0.957)
	p-value		0.046*	0.007*	0.028*
2006	WP[α] (95% CI)	20.7 (16.5, 25.0)	16.8 (12.1, 21.5)	15.5 (12.1, 18.9)	13.7 (10.3, 17.0)
	OR (95% CI)	0.240 (0.177, 0.326)	0.784 (0.512, 1.20)	0.709 (0.492, 1.02)	0.608 (0.413, 0.895)
	p-value		0.263	0.066	0.012*
2007	WP[α] (95% CI)	13.6 (8.5, 18.7)	13.6 (8.9, 18.3)	11.2 (8.6, 13.9)	16.4 (12.4, 20.3)
	OR (95% CI)	0.153 (0.102, 0.229)	0.998 (0.555, 1.80)	0.803 (0.484, 1.33)	1.24 (0.740, 2.08)
	p-value		0.996	0.396	0.413
2008	WP[α] (95% CI)	19.7 (15.0, 24.5)	16.5 (11.3, 21.8)	15.9 (12.9, 18.9)	16.5 (12.7, 20.4)
	OR (95% CI)	0.206 (0.149, 0.287)	0.825 (0.509, 1.34)	0.775 (0.533, 1.13)	0.821 (0.544, 1.24)
	p-value		0.435	0.183	0.349
2009	WP[α] (95% CI)	21.7 (17.5, 25.9)	17.2 (11.0, 23.4)	15.2 (12.0, 18.4)	17.5 (13.7, 21.3)
	OR (95% CI)	0.237 (0.178, 0.315)	0.757 (0.459, 1.25)	0.652 (0.458, 0.929)	0.761 (0.530, 1.09)
	p-value		0.275	0.018*	0.140
2010	WP[α] (95% CI)	18.4 (14.4, 22.3)	16.9 (11.7, 22.1)	17.6 (14.7, 20.6)	19.0 (15.4, 22.7)
	OR (95% CI)	0.199 (0.150, 0.263)	0.893 (0.568, 1.40)	0.953 (0.683, 1.33)	1.03 (0.721, 1.47)
	p-value		0.623	0.775	0.868
2011	WP[α] (95% CI)	18.7 (15.2, 22.1)	12.8 (9.3, 16.3)	16.8 (14.1, 19.6)	17.8 (14.6, 21.1)
	OR (95% CI)	0.202 (0.156, 0.262)	0.635 (0.431, 0.937)	0.886 (0.657, 1.19)	0.942 (0.686, 1.29)
	p-value		0.022*	0.428	0.711
2012	WP[α] (95% CI)	17.0 (13.1, 21.0)	11.1 (7.5, 14.7)	14.7 (11.7, 17.7)	18.5 (15.0, 21.9)
	OR (95% CI)	0.168 (0.125, 0.224)	0.607 (0.383, 0.963)	0.842 (0.584, 1.21)	1.11 (0.774, 1.60)
	p-value		0.034*	0.357	0.564

2013	WP[α] (95% CI)	16.2 (12.6, 19.8)	13.0 (8.8, 17.2)	17.4 (14.3, 20.5)	16.8 (13.6, 20.1)
	OR (95% CI)	0.177 (0.132, 0.237)	0.777 (0.491, 1.23)	1.09 (0.775, 1.54)	1.05 (0.739, 1.50)
	p-value		0.283	0.614	0.777
2014	WP[α] (95% CI)	22.1 (17.7, 26.5)	17.9 (13.0, 22.8)	17.0 (14.2, 19.8)	18.0 (14.6, 21.3)
	OR (95% CI)	0.261 (0.199, 0.344)	0.772 (0.507, 1.18)	0.717 (0.519, 0.991)	0.769 (0.546, 1.08)
	p-value		0.229	0.044*	0.133
2015	WP[α] (95% CI)	21.2 (16.7, 25.6)	17.8 (12.7, 22.9)	18.7 (15.6, 21.8)	17.5 (13.9, 21.0)
	OR (95% CI)	0.285 (0.212, 0.382)	0.800 (0.517, 1.28)	0.848 (0.607, 1.18)	0.780 (0.542, 1.12)
	p-value		0.317	0.333	0.179
2016	WP[α] (95% CI)	19.7 (15.7, 23.6)	13.2 (8.5, 17.9)	17.1 (13.9, 20.3)	17.2 (13., 20.9)
	OR (95% CI)	0.281 (0.216, 0.365)	0.635 (0.393, 1.03)	0.845 (0.602, 1.18)	0.854 (0.593, 1.23)
	p-value		0.063	0.328	0.395
2017	WP[α] (95% CI)	21.9 (17.8, 26.0)	12.8 (8.6, 16.9)	18.6 (15.3, 22.0)	19.2 (14.8, 23.5)
	OR (95% CI)	0.286 (0.219, 0.375)	0.519 (0.332, 0.810)	0.813 (0.587, 1.12)	0.843 (0.583, 1.22)
	p-value		0.003*	0.211	0.366
2018	WP[α] (95% CI)	23.5 (18.8, 28.3)	11.7 (7.3, 16.1)	16.2 (12.9, 19.6)	17.5 (13.3, 21.7)
	OR (95% CI)	0.278 (0.207, 0.354)	0.434 (0.262, 0.719)	0.634 (0.442, 0.910)	0.688 (0.464, 1.02)
	p-value		0.001*	0.013*	0.064

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table IV: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 30 to 34 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP$^{\alpha}$ (95% CI)	20.1 (16.9, 23.2)	16.2 (12.5, 19.9)	17.6 (14.9, 20.2)	21.7 (18.2, 25.1)
	OR (95% CI)	0.225 (0.179, 0.282)	0.771 (0.552, 1.08)	0.854 (0.652, 1.12)	1.11 (0.835, 1.47)
	p-value		0.126	0.252	0.476
2003	WP$^{\alpha}$ (95% CI)	22.8 (19.2, 26.3)	20.6 (16.6, 24.6)	15.9 (13.5, 18.4)	16.7 (13.7, 19.8)
	OR (95% CI)	0.319 (0.256, 0.399)	0.875 (0.638, 1.20)	0.643 (0.491, 0.843)	0.683 (0.508, 0.918)
	p-value		0.410	0.001*	0.012*
2005	WP$^{\alpha}$ (95% CI)	22.4 (18.7, 26.0)	19.1 (14.9, 23.2)	15.4 (13.0, 17.8)	17.0 (13.8, 20.2)
	OR (95% CI)	0.276 (0.220, 0.347)	0.821 (0.582, 1.16)	0.634 (0.478, 0.841)	0.713 (0.523, 0.971)
	p-value		0.262	0.002*	0.032*
2006	WP$^{\alpha}$ (95% CI)	23.4 (18.3, 28.5)	16.2 (11.7, 20.7)	15.8 (12.9, 18.7)	18.6 (14.7, 22.6)
	OR (95% CI)	0.255 (0.189, 0.344)	0.637 (0.413, 0.984)	0.618 (0.433, 0.882)	0.752 (0.513, 1.10)
	p-value		0.042*	0.008*	0.144
2007	WP$^{\alpha}$ (95% CI)	17.0 (13.2, 20.8)	15.9 (10.9, 20.8)	16.6 (13.7, 19.6)	16.4 (12.5, 20.3)
	OR (95% CI)	0.203 (0.151, 0.274)	0.920 (0.583, 1.45)	0.971 (0.690, 1.37)	0.954 (0.647, 1.41)
	p-value		0.721	0.868	0.811
2008	WP$^{\alpha}$ (95% CI)	23.3 (18.8, 27.8)	12.8 (7.6, 18.0)	17.2 (14.0, 20.3)	21.5 (17.2, 25.8)
	OR (95% CI)	0.292 (0.221, 0.385)	0.484 (0.284, 0.823)	0.684 (0.488, 0.958)	0.900 (0.628, 1.29)
	p-value		0.008*	0.027*	0.569
2009	WP$^{\alpha}$ (95% CI)	23.5 (19.2, 27.8)	16.0 (11.6, 20.4)	20.2 (16.7, 23.7)	24.8 (20.5, 29.2)
	OR (95% CI)	0.256 (0.196, 0.334)	0.628 (0.419, 0.939)	0.817 (0.591, 1.13)	1.08 (0.771, 1.51)
	p-value		0.024*	0.221	0.663
2010	WP$^{\alpha}$ (95% CI)	24.5 (20.3, 28.6)	15.8 (11.4, 20.1)	20.7 (17.5, 23.9)	19.9 (16.3, 23.5)
	OR (95% CI)	0.292 (0.227, 0.376)	0.567 (0.382, 0.843)	0.801 (0.595, 1.08)	0.756 (0.548, 1.04)
	p-value		0.005*	0.146	0.087
2011	WP$^{\alpha}$ (95% CI)	21.2 (17.5, 24.8)	16.4 (12.4, 20.4)	22.7 (19.6, 25.7)	21.8 (18.4, 25.3)
	OR (95% CI)	0.249 (0.197, 0.314)	0.735 (0.512, 1.06)	1.10 (0.829, 1.45)	1.04 (0.771, 1.39)
	p-value		0.097	0.519	0.812
2012	WP$^{\alpha}$ (95% CI)	22.5 (18.7, 26.4)	15.2 (11.4, 19.1)	18.0 (15.1, 19.1)	19.3 (16.0, 22.5)
	OR (95% CI)	0.270 (0.212, 0.343)	0.621 (0.428, 0.901)	0.758 (0.564, 1.02)	0.824 (0.607, 1.12)
	p-value		0.012*	0.065	0.215

2013	WP[α] (95% CI)	20.9 (16.3, 25.5)	18.3 (13.6, 23.0)	18.2 (15.4, 21.1)	19.8 (16.6, 22.9)
	OR (95% CI)	0.253 (0.193, 0.332)	0.849 (0.558, 1.29)	0.850 (0.609, 1.19)	0.937 (0.667, 1.32)
	p-value		0.445	0.338	0.708
2014	WP[α] (95% CI)	23.8 (18.9, 28.8)	18.9 (13.9, 23.9)	18.7 (15.2, 22.2)	18.9 (15.4, 22.3)
	OR (95% CI)	0.289 (0.217, 0.386)	0.747 (0.489, 1.42)	0.739 (0.518, 1.05)	0.741 (0.521, 1.05)
	p-value		0.178	0.095	0.096
2015	WP[α] (95% CI)	24.6 (20.0, 29.1)	19.2 (14.3, 24.0)	22.1 (19.0, 25.3)	20.7 (17.1, 24.3)
	OR (95% CI)	0.284 (0.218, 0.370)	0.745 (0.501, 1.11)	0.882 (0.650, 1.20)	0.801 (0.577, 1.11)
	p-value		0.146	0.421	0.186
2016	WP[α] (95% CI)	21.3 (17.0, 25.5)	17.9 (13.3, 22.5)	20.6 (17.1, 24.1)	21.7 (17.3, 21)
	OR (95% CI)	0.239 (0.181, 0.316)	0.825 (0.551, 1.24)	0.975 (0.699, 1.36)	1.03 (0.716, 1.48)
	p-value		0.351	0.883	0.878
2017	WP[α] (95% CI)	22.3 (18.3, 26.4)	18.7 (13.9, 23.4)	16.9 (14.1, 19.8)	20.5 (15.8, 25.1)
	OR (95% CI)	0.279 (0.540, 1.17)	0.796 (0.540, 1.17)	0.708 (0.520, 0.965)	0.892 (0.617, 1.29)
	p-value		0.251	0.029*	0.542
2018	WP[α] (95% CI)	21.1 (16.9, 25.4)	17.1 (12.1, 22.6)	21.9 (18.4, 25.4)	21.5 (17.3, 25.6)
	OR (95% CI)	0.246 (0.185, 0.328)	0.770 (0.496, 1.19)	1.05 (0.755, 1.46)	1.01 (0.708, 1.45)
	p-value		0.243	0.776	0.947

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table V: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 35 to 39 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	23.0 (19.6, 26.3)	19.9 (16.5, 23.4)	22.8 (20.1, 25.5)	19.0 (15.7, 22.3)
	OR (95% CI)	0.293 (0.238, 0.362)	0.836 (0.626, 1.12)	0.991 (0.775, 1.27)	0.786 (0.590, 1.05)
	p-value		0.225	0.942	0.101
2003	WP[α] (95% CI)	27.7 (23.9, 31.5)	25.0 (21.2, 28.9)	22.9 (20.1, 25.8)	23.6 (20.0, 27.1)
	OR (95% CI)	0.389 (0.315, 0.482)	0.870 (0.657, 1.15)	0.777 (0.605, 0.996)	0.805 (0.611, 1.06)
	p-value		0.331	0.047*	0.122
2005	WP[α] (95% CI)	25.9 (22.5, 29.4)	17.6 (14.0, 21.2)	19.2 (16.5, 21.8)	19.7 (16.2, 23.3)
	OR (95% CI)	0.350 (0.286, 0.429)	0.611 (0.449, 0.831)	0.677 (0.528, 0.867)	0.702 (0.525, 0.937)
	p-value		0.002*	0.002*	0.017*
2006	WP[α] (95% CI)	22.6 (18.2, 27.1)	20.5 (15.9, 25.1)	19.3 (16.1, 22.5)	19.8 (15.9, 23.8)
	OR (95% CI)	0.287 (0.218, 0.379)	0.882 (0.604, 1.29)	0.818 (0.591, 1.13)	0.846 (0.593, 1.21)
	p-value		0.518	0.226	0.355
2007	WP[α] (95% CI)	21.7 (17.5, 26.0)	17.3 (12.8, 21.7)	16.7 (13.7, 19.8)	23.6 (19.0, 28.1)
	OR (95% CI)	0.269 (0.204, 0.354)	0.747 (0.501, 1.12)	0.721 (0.516, 1.01)	1.10 (0.772, 1.57)
	p-value		0.154	0.055	0.595
2008	WP[α] (95% CI)	22.1 (17.6, 26.6)	24.2 (18.5, 29.9)	22.1 (18.6, 25.7)	21.8 (17.6, 26.1)
	OR (95% CI)	0.284 (0.213, 0.377)	1.13 (0.750, 1.69)	1.00 (0.719, 1.40)	0.986 (0.687, 1.42)
	p-value		0.567	0.983	0.941
2009	WP[α] (95% CI)	26.1 (21.2, 31.0)	21.6 (16.3, 26.8)	27.6 (23.7, 31.6)	16.7 (13.1, 20.2)
	OR (95% CI)	0.360 (0.272, 0.477)	0.780 (0.523, 1.16)	1.08 (0.783, 1.49)	0.567 (0.356, 0.813)
	p-value		0.224	0.637	0.002*
2010	WP[α] (95% CI)	30.0 (25.3, 34.7)	25.1 (19.8, 30.4)	21.8 (18.7, 24.8)	17.4 (13.7, 21.1)
	OR (95% CI)	0.403 (0.316, 0.515)	0.778 (0.543, 1.12)	0.651 (0.488, 0.867)	0.492 (0.349, 0.692)
	p-value		0.172	0.003*	< 0.001*
2011	WP[α] (95% CI)	26.9 (22.8, 31.0)	19.4 (15.0, 23.8)	25.4 (22.1, 28.7)	21.5 (18.1, 24.9)
	OR (95% CI)	0.351 (0.278, 0.443)	0.654 (0.460, 0.929)	0.928 (0.706, 1.22)	0.745 (0.557, 0.997)
	p-value		0.018*	0.589	0.048*
2012	WP[α] (95% CI)	23.9 (19.7, 28.2)	16.7 (12.5, 20.9)	23.6 (20.3, 27.0)	20.9 (17.3, 24.4)
	OR (95% CI)	0.311 (0.241, 0.401)	0.636 (0.434, 0.932)	0.982 (0.730, 1.32)	0.837 (0.610 1.15)
	p-value		0.020*	0.906	0.271

2013	WP[α] (95% CI)	23.8 (19.5, 28.2)	23.2 (17.9, 28.5)	20.3 (17.2, 23.4)	19.8 (16.5, 23.2)
	OR (95% CI)	0.298 (0.228, 0.389)	0.968 (0.659, 1.42)	0.819 (0.602, 1.11)	0.793 (0.576, 1.09)
	p-value		0.867	0.205	0.155
2014	WP[α] (95% CI)	27.6 (22.9, 32.3)	23.1 (17.3, 29.0)	21.6 (18.3, 24.8)	23.1 (19.3, 26.8)
	OR (95% CI)	0.360 (0.277, 0.468)	0.789 (0.528, 1.18)	0.722 (0.532, 0.980)	0.787 (0.574, 1.08)
	p-value		0.249	0.037	0.138
2015	WP[α] (95% CI)	24.8 (20.2, 29.3)	22.3 (17.2, 27.4)	24.6 (21.2, 28.1)	21.4 (17.4, 25.5)
	OR (95% CI)	0.293 (0.225, 0.382)	0.873 (0.595, 1.28)	1.00 (0.738, 1.36)	0.820 (0.583, 1.16)
	p-value		0.487	0.992	0.257
2016	WP[α] (95% CI)	28.5 (23.7, 33.3)	22.6 (16.8, 28.4)	22.0 (18.5, 25.44)	20.7 (16.9, 24.6)
	OR (95% CI)	0.359 (0.274, 0.470)	0.725 (0.483, 1.09)	0.700 (0.513, 0.956)	0.646 (0.464, 0.900)
	p-value		0.120	0.025*	0.010*
2017	WP[α] (95% CI)	24.6 (20.4, 28.9)	19.6 (14.0, 25.1)	25.1 (21.4, 28.8)	18.4 (14.7, 22.1)
	OR (95% CI)	0.353 (0.272, 0.458)	0.743 (0.488, 1.13)	1.03 (0.759, 1.39)	0.693 (0.495, 0.970)
	p-value		0.166	0.861	0.033*
2018	WP[α] (95% CI)	26.6 (21.7, 31.5)	18.1 (13.2, 23.0)	22.5 (19.1, 26.0)	25.4 (20.7, 30.2)
	OR (95% CI)	0.332 (0.252, 0.438)	0.613 (0.403, 0.930)	0.798 (0.579, 1.10)	0.940 (0.658, 1.34)
	p-value		0.021*	0.170	0.733

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table VI: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 40 to 44 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	29.2 (25.4, 32.9)	22.0 (18.4, 25.7)	28.8 (25.7, 31.9)	29.7 (25.7, 33.7)
	OR (95% CI)	0.399 (0.326, 0.488)	0.687 (0.520, 0.907)	0.980 (0.774, 1.24)	1.02 (0.784, 1.33)
	p-value		0.008*	0.870	0.880
2003	WP[α] (95% CI)	29.4 (25.8, 33.0)	29.4 (25.1, 33.8)	29.3 (26.3, 32.4)	25.6 (21.9, 29.3)
	OR (95% CI)	0.433 (0.357, 0.525)	0.998 (0.761, 1.31)	0.994 (0.791, 1.25)	0.826 (0.637, 1.07)
	p-value		0.989	0.955	0.148
2005	WP[α] (95% CI)	32.5 (28.7, 36.3)	24.7 (20.7, 28.7)	28.1 (25.0, 31.2)	25.3 (21.6, 29.1)
	OR (95% CI)	0.477 (0.394, 0.577)	0.682 (0.518, 0.898)	0.810 (0.643, 1.02)	0.704 (0.542, 0.915)
	p-value		0.006*	0.073	0.009*
2006	WP[α] (95% CI)	29.4 (24.5, 34.2)	22.2 (17.5, 26.9)	25.2 (21.8, 28.5)	22.7 (18.4, 26.9)
	OR (95% CI)	0.406 (0.314, 0.525)	0.688 (0.480, 0.987)	0.811 (0.604, 1.09)	0.709 (0.506, 0.993)
	p-value		0.042*	0.163	0.046*
2007	WP[α] (95% CI)	27.7 (23.1, 32.4)	24.7 (19.5, 29.8)	22.4 (18.8, 26.0)	24.4 (19.8, 28.9)
	OR (95% CI)	0.373 (0.289, 0.481)	0.854 (0.594, 1.23)	0.751 (0.550, 1.03)	0.839 (0.597, 1.18)
	p-value		0.394	0.072	0.309
2008	WP[α] (95% CI)	30.9 (26.0, 35.8)	28.5 (21.9, 35.0)	30.8 (26.6, 35.0)	24.2 (19.2, 29.2)
	OR (95% CI)	0.472 (0.366, 0.611)	0.890 (0.599, 1.32)	0.996 (0.737, 1.35)	0.715 (0.512, 1.02)
	p-value		0.566	0.980	0.065
2009	WP[α] (95% CI)	31.4 (26.5, 36.2)	24.2 (19.2, 29.2)	31.8 (27.7, 36.0)	23.7 (19.4, 28.0)
	OR (95% CI)	0.465 (0.361, 0.599)	0.696 (0.489, 0.992)	1.02 (0.762, 1.38)	0.681 (0.490, 0.945)
	p-value		0.045*	0.875	0.022*
2010	WP[α] (95% CI)	26.0 (21.7, 30.3)	25.7 (20.6, 30.9)	32.2 (28.4, 36.0)	29.2 (24.6, 36.0)
	OR (95% CI)	0.344 (0.268, 0.442)	0.985 (0.693, 1.40)	1.35 (1.02, 1.79)	1.17 (0.855, 1.60)
	p-value		0.934	0.039*	0.327
2011	WP[α] (95% CI)	35.8 (31.3, 40.3)	23.0 (18.5, 27.6)	29.9 (26.5, 33.2)	27.5 (23.6, 31.5)
	OR (95% CI)	0.531 (0.427, 0.660)	0.538 (0.390, 0.742)	0.765 (0.594, 0.984)	0.681 (0.516, 0.899)
	p-value		< 0.001*	0.037*	0.007*
2012	WP[α] (95% CI)	22.3 (18.2, 28.3)	18.8 (14.3, 23.4)	23.2 (20.0, 26.3)	24.5 (20.5, 28.4)
	OR (95% CI)	0.284 (0.555, 1.18)	0.810 (0.555, 1.18)	1.05 (0.786, 1.41)	1.13 (0.826, 1.55)
	p-value		0.273	0.728	0.440

2013	WP[α] (95% CI)	29.2 (24.8, 33.5)	25.6 (19.9, 31.2)	24.1 (21.0, 27.2)	28.6 (24.5, 32.7)
	OR (95% CI)	0.433 (0.341, 0.549)	0.832 (0.579, 1.20)	0.768 (0.587, 1.00)	0.972 (0.727, 1.30)
	p-value		0.320	0.054	0.850
2014	WP[α] (95% CI)	29.1 (24.3, 34.0)	28.0 (22.5, 33.5)	27.3 (24.0, 30.6)	25.9 (21.8, 30.0)
	OR (95% CI)	0.389 (0.301, 0.502)	0.952 (0.664, 1.36)	0.918 (0.690, 1.22)	0.854 (0.622, 1.17)
	p-value		0.786	0.555	0.330
2015	WP[α] (95% CI)	30.5 (25.4, 35.6)	31.4 (25.2, 37.5)	25.7 (22.2, 29.2)	25.9 (21.6, 30.1)
	OR (95% CI)	0.407 (0.311, 0.532)	1.06 (0.726, 1.53)	0.792 (0.585, 1.07)	0.801 (0.577, 1.11)
	p-value		0.778	0.132	0.183
2016	WP[α] (95% CI)	31.0 (26.1, 35.8)	26.3 (20.2, 32.4)	26.9 (22.9, 30.9)	25.0 (20.0, 29.9)
	OR (95% CI)	0.422 (0.325, 0.549)	0.792 (0.537, 1.17)	0.820 (0.606, 1.11)	0.742 (0.524, 1.05)
	p-value		0.241	0.202	0.095
2017	WP[α] (95% CI)	35.2 (29.9, 40.6)	28.0 (21.3, 34.7)	29.8 (25.8, 33.8)	27.3 (22.5, 32.1)
	OR (95% CI)	0.532 (0.411, 0.689)	0.719 (0.479, 1.08)	0.781 (0.578, 1.05)	0.690 (0.492, 0.966)
	p-value		0.112	0.107	0.031*
2018	WP[α] (95% CI)	30.3 (25.3, 35.3)	24.2 (18.8, 29.6)	29.2 (25.0, 33.4)	27.0 (22.4, 32.6)
	OR (95% CI)	0.403 (0.307, 0.529)	0.744 (0.510, 1.09)	0.959 (0.700, 1.31)	0.849 (0.609, 1.18)
	p-value		0.125	0.792	0.334

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table VII: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 45 to 49 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP$^{\alpha}$ (95% CI)	33.8 (30.0, 37.7)	30.3 (25.9, 34.6)	29.5 (26.4, 32.7)	32.7 (28.3, 37.0)
	OR (95% CI)	0.600 (0.497, 0.725)	0.843 (0.642, 1.11)	0.825 (0.656, 1.04)	0.946 (0.727, 1.23)
	p-value		0.216	0.102	0.683
2003	WP$^{\alpha}$ (95% CI)	36.3 (32.1, 40.5)	32.3 (27.8, 36.8)	33.8 (30.5, 37.2)	33.8 (29.4, 38.2)
	OR (95% CI)	0.614 (0.503, 0.749)	0.834 (0.633, 1.10)	0.890 (0.703, 1.13)	0.893 (0.684, 1.17)
	p-value		0.198	0.334	0.404
2005	WP$^{\alpha}$ (95% CI)	37.3 (33.1, 41.5)	31.5 (27.0, 35.9)	34.2 (30.9, 37.4)	31.3 (27.3, 35.3)
	OR (95% CI)	0.627 (0.515, 0.764)	0.768 (0.583, 1.01)	0.873 (0.693, 1.10)	0.765 (0.591, 0.990)
	p-value		0.060	0.247	0.042*
2006	WP$^{\alpha}$ (95% CI)	36.3 (31.5, 41.2)	27.9 (22.7, 33.1)	30.9 (27.2, 34.6)	33.0 (27.9, 38.1)
	OR (95% CI)	0.570 (0.454, 0.716)	0.678 (0.486, 0.945)	0.783 (0.597, 1.03)	0.863 (0.631, 1.18)
	p-value		0.022*	0.078	0.354
2007	WP$^{\alpha}$ (95% CI)	31.4 (26.3, 36.5)	31.4 (25.8, 37.1)	29.2 (25.5, 32.9)	34.6 (29.3, 39.9)
	OR (95% CI)	0.516 (0.398, 0.669)	0.990 (0.695,1.41)	0.896 (0.667, 1.21)	1.16 (0.827, 1.62)
	p-value		0.955	0.471	0.393
2008	WP$^{\alpha}$ (95% CI)	32.3 (27.0, 37.5)	34.2 (28.5, 39.9)	31.9 (27.8, 35.9)	29.8 (25.0, 34.6)
	OR (95% CI)	0.495 (0.384, 0.638)	1.09 (0.771, 1.55)	0.985 (0.727, 1.33)	0.897 (0.643, 1.25)
	p-value		0.618	0.921	0.521
2009	WP$^{\alpha}$ (95% CI)	34.4 (29.5, 39.3)	32.2 (26.5, 37.8)	35.2 (31.2, 39.1)	31.8 (26.6, 37.0)
	OR (95% CI)	0.502 (0.394, 0.638)	0.913 (0.651, 1.28)	1.04 (0.788, 1.37)	0.891 (0.644, 1.23)
	p-value		0.595	0.786	0.488
2010	WP$^{\alpha}$ (95% CI)	37.7 (32.5, 42.9)	34.1 (28.5, 39.7)	35.8 (32.0, 39.5)	35.3 (30.6, 39.9)
	OR (95% CI)	0.624 (0.491, 0.792)	0.854 (0.611, 1.19)	0.917 (0.697, 1.21)	0.900 (0.666, 1.22)
	p-value		0.356	0.540	0.491
2011	WP$^{\alpha}$ (95% CI)	35.3 (31.0, 39.5)	32.7 (27.6, 37.9)	38.6 (34.9, 42.6)	36.7 (32.4, 41.0)
	OR (95% CI)	0.655 (0.536, 0.801)	0.890 (0.661, 1.20)	1.16 (0.911, 1.48)	1.06 (0.817, 1.38)
	p-value		0.445	0.228	0.649
2012	WP$^{\alpha}$ (95% CI)	36.0 (31.1, 40.9)	30.0 (25.1, 34.9)	30.0 (26.5, 33.4)	32.7 (28.2, 37.1)
	OR (95% CI)	0.586 (0.465, 0.738)	0.756 (0.551, 1.04)	0.759 (0.580, 0.993)	0.863 (0.643, 1.16)
	p-value		0.084	0.044*	0.324

2013	WP[α] (95% CI)	33.2 (28.5, 37.9)	26.7 (21.6, 31.8)	32.0 (28.3, 35.7)	29.1 (24.9, 33.3)
	OR (95% CI)	0.556 (0.441, 0.702)	0.732 (0.522, 1.03)	0.940 (0.716, 1.23)	0.817 (0.609, 1.10)
	p-value		0.070	0.658	0.177
2014	WP[α] (95% CI)	38.8 (33.5, 44.1)	28.8 (23.2, 34.5)	36.6 (32.8, 40.5)	29.4 (25.0, 33.7)
	OR (95% CI)	0.678 (0.531, 0.915)	0.642 (0.450, 0.915)	0.915 (0.693, 1.21)	0.655 (0.482, 0.890)
	p-value		0.014*	0.530	0.007*
2015	WP[α] (95% CI)	37.6 (32.4, 42.7)	32.0 (26.2, 37.9)	31.6 (27.5, 35.6)	34.0 (29.4, 38.7)
	OR (95% CI)	0.622 (0.487, 0.795)	0.783 (0.552, 1.11)	0.766 (0.573, 1.02)	0.857 (0.632, 1.16)
	p-value		0.169	0.072	0.319
2016	WP[α] (95% CI)	37.9 (32.8, 43.0)	30.5 (25.0, 36.0)	33.1 (29.2, 37.1)	33.9 (28.9, 39.0)
	OR (95% CI)	0.687 (0.540, 0.873)	0.718 (0.512, 1.07)	0.827 (0.626, 1.09)	0.849 (0.621, 1.16)
	p-value		0.055	0.181	0.304
2017	WP[α] (95% CI)	38.3 (33.1, 43.5)	31.5 (24.9, 38.1)	32.8 (28.7, 36.9)	36.1 (30.7, 41.5)
	OR (95% CI)	0.691 (0.538, 0.887)	0.736 (0.505, 1.07)	0.767 (0.575, 1.02)	0.902 (0.653, 1.25)
	p-value		0.112	0.072	0.532
2018	WP[α] (95% CI)	39.8 (34.3, 45.2)	29.9 (23.8, 36.1)	30.9 (26.8, 35.1)	33.1 (27.8, 38.4)
	OR (95% CI)	0.658 (0.511, 0.846)	0.647 (0.447, 0.937)	0.678 (0.503, 0.915)	0.748 (0.538, 1.04)
	p-value		0.021*	0.011*	0.086

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table VIII Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 50 to 54 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	Northeast	South	West
2002	WP[α] (95% CI)	38.1 (33.8, 42.3)	34.7 (29.8, 39.5)	41.2 (37.5, 44.8)	33.3 (28.6, 38.0)
	OR (95% CI)	0.684 (0.560, 0.836)	0.865 (0.653, 1.15)	1.13 (0.896, 1.44)	0.803 (0.606, 1.06)
	p-value		0.314	0.293	0.125
2003	WP[α] (95% CI)	44.8 (40.3, 49.3)	32.6 (28.1, 37.1)	39.1 (35.6, 42.7)	36.9 (32.2, 41.7)
	OR (95% CI)	0.988 (0.808, 1.21)	0.583 (0.442, 0.768)	0.782 (0.617, 0.992)	0.701 (0.533, 0.922)
	p-value		< 0.001*	0.043*	0.011*
2005	WP[α] (95% CI)	43.4 (39.1, 47.6)	33.5 (28.7, 38.4)	37.0 (33.6, 40.5)	38.2 (33.9, 42.5)
	OR (95% CI)	0.889 (0.735, 1.07)	0.665 (0.504, 0.878)	0.763 (0.608, 0.958)	0.814 (0.634, 1.05)
	p-value		0.004*	0.020*	0.107
2006	WP[α] (95% CI)	40.5 (35.4, 45.5)	38.5 (32.4, 44.5)	36.2 (32.1, 40.3)	37.0 (31.7, 42.4)
	OR (95% CI)	0.776 (0.617, 0.976)	0.923 (0.663, 1.28)	0.843 (0.640, 1.11)	0.876 (0.642, 1.19)
	p-value		0.634	0.224	0.401
2007	WP[α] (95% CI)	37.9 (32.3, 43.6)	27.4 (22.3, 32.5)	35.9 (31.7, 40.0)	37.8 (32.7, 42.9)
	OR (95% CI)	0.664 (0.517, 0.853)	0.616 (0.443, 0.877)	0.917 (0.678, 1.24)	0.992 (0.717, 1.37)
	p-value		0.007*	0.575	0.961
2008	WP[α] (95% CI)	45.1 (39.6, 50.5)	35.6 (29.4, 41.7)	42.0 (37.6, 46.4)	37.8 (32.4, 43.2)
	OR (95% CI)	0.894 (0.700, 1.14)	0.663 (0.469, 0.938)	0.879 (0.662, 1.17)	0.743 (0.541, 1.02)
	p-value		0.020*	0.373	0.067
2009	WP[α] (95% CI)	47.9 (43.0, 52.9)	41.6 (34.8, 48.4)	39.7 (32.0, 43.8)	37.3 (32.0, 42.6)
	OR (95% CI)	0.987 (0.791, 1.23)	0.771 (0.546, 1.09)	0.716 (0.551, 0.931)	0.646 (0.477, 0.873)
	p-value		0.141	0.013*	0.005*
2010	WP[α] (95% CI)	51.5 (46.5, 56.4)	32.6 (27.3, 37.8)	43.7 (39.8, 47.6)	41.0 (35.9, 46.1)
	OR (95% CI)	1.22 (0.978, 1.52)	0.453 (0.331, 0.619)	0.732 (0.567, 0.945)	0.656 (0.490, 0.877)
	p-value		< 0.001*	0.017*	0.005*
2011	WP[α] (95% CI)	45.9 (41.3, 50.5)	36.5 (31.2, 41.9)	40.8 (37.1, 44.4)	43.0 (38.5, 47.5)
	OR (95% CI)	0.860 (0.702, 1.05)	0.678 (0.504, 0.913)	0.811 (0.639, 1.03)	0.888 (0.684, 1.15)
	p-value		0.010*	0.086	0.370
2012	WP[α] (95% CI)	38.0 (33.3, 42.7)	34.2 (29.1, 39.3)	37.9 (34.2, 41.6)	38.8 (34.2, 43.3)
	OR (95% CI)	0.747 (0.604, 0.924)	0.847 (0.629, 1.14)	0.995 (0.773, 1.28)	1.04 (0.789, 1.37)
	p-value		0.277	0.970	0.776

2013	WP[α] (95% CI)	44.0 (38.8, 49.3)	38.3 (32.8, 43.7)	38.6 (35.0, 42.3)	37.3 (32.8, 41.8)
	OR (95% CI)	0.946 (0.753, 1.19)	0.777 (0.568, 1.06)	0.796 (0.613, 1.03)	0.761 (0.572, 1.01)
	p-value		0.115	0.087	0.061
2014	WP[α] (95% CI)	39.0 (34.3, 43.6)	39.1 (33.1, 45.2)	41.1 (36.5, 45.8)	37.2 (32.4, 42.0)
	OR (95% CI)	0.766 (0.611, 0.961)	1.01 (0.729, 1.39)	1.07 (0.810, 1.42)	0.912 (0.685, 1.21)
	p-value		0.972	0.619	0.526
2015	WP[α] (95% CI)	42.8 (37.5, 48.0)	37.8 (32.2, 43.4)	40.0 (36.1, 43.8)	39.7 (34.7, 44.6)
	OR (95% CI)	0.768 (0.608, 0.971)	0.808 (0.585, 1.11)	0.892 (0.681, 1.17)	0.880 (0.653, 1.19)
	p-value		0.193	0.403	0.402
2016	WP[α] (95% CI)	49.9 (44.9, 54.8)	35.2 (29.5, 41.0)	43.5 (39.7, 47.3)	37.3 (32.3, 42.3)
	OR (95% CI)	1.19 (0.953, 1.48)	0.544 (0.394, 0.752)	0.779 (0.605, 1.00)	0.601 (0.448, 0.806)
	p-value		< 0.001*	0.053	< 0.001*
2017	WP[α] (95% CI)	47.5 (42.2, 52.7)	40.9 (34.4, 47.5)	42.7 (38.4, 47.0)	36.4 (31.1, 41.8)
	OR (95% CI)	1.06 (0.838, 1.34)	0.747 (0.529, 1.06)	0.813 (0.617, 1.07)	0.645 (0.472, 0.883)
	p-value		0.098	0.144	0.006*
2018	WP[α] (95% CI)	39.8 (34.4, 45.2)	41.8 (35.5, 48.2)	42.2 (38.0, 46.5)	36.4 (31.0, 41.7)
	OR (95% CI)	0.764 (0.596, 0.951)	1.06 (0.752, 1.50)	1.10 (0.826, 1.46)	0.846 (0.613, 1.17)
	p-value		0.728	0.514	0.310

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table IX: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 55 to 59 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP$^{\alpha}$ (95% CI)	45.8 (40.8, 50.8)	40.4 (35.1, 45.7)	42.7 (38.8, 46.6)	33.5 (28.8, 38.2)
	OR (95% CI)	1.04 (0.835, 1.29)	0.790 (0.586, 1.07)	0.870 (0.672, 1.13)	0.606 (0.452, 0.812)
	p-value		0.124	0.289	< 0.001*
2003	WP$^{\alpha}$ (95% CI)	50.8 (46.2, 55.4)	40.6 (35.3, 46.0)	46.5 (42.6, 50.3)	42.6 (37.3, 47.8)
	OR (95% CI)	1.40 (1.13, 1.72)	0.627 (0.468, 0.840)	0.822 (0.644, 1.05)	0.690 (0.519, 0.919)
	p-value		0.002*	0.116	0.011*
2005	WP$^{\alpha}$ (95% CI)	46.7 (42.3, 51.2)	40.7 (35.6, 45.8)	43.5 (39.8, 47.3)	43.3 (38.5, 48.2)
	OR (95% CI)	1.01 (0.826, 1.22)	0.793 (0.599, 1.05)	0.885 (0.699, 1.12)	0.886 (0.677, 1.16)
	p-value		0.104	0.308	0.376
2006	WP$^{\alpha}$ (95% CI)	45.4 (39.7, 51.1)	35.6 (29.6, 41.6)	40.5 (36.3, 44.7)	40.1 (34.7, 45.4)
	OR (95% CI)	1.05 (0.820, 1.35)	0.640 (0.452, 0.907)	0.794 (0.595, 1.06)	0.780 (0.582, 1.10)
	p-value		0.012*	0.116	0.169
2007	WP$^{\alpha}$ (95% CI)	38.5 (33.0, 44.0)	37.7 (30.6, 44.9)	39.0 (34.4, 43.5)	42.2 (36.3, 48.1)
	OR (95% CI)	0.833 (0.639, 1.09)	0.970 (0.656, 1.44)	1.01 (0.743, 1.39)	1.16 (0.825, 1.63)
	p-value		0.880	0.929	0.391
2008	WP$^{\alpha}$ (95% CI)	44.4 (38.7, 50.2)	35.7 (29.3, 42.1)	40.8 (36.4, 45.2)	38.7 (33.3, 44.1)
	OR (95% CI)	0.933 (0.724, 1.20)	0.678 (0.470, 0.977)	0.855 (0.635, 1.15)	0.790 (0.569, 1.10)
	p-value		0.037*	0.304	0.160
2009	WP$^{\alpha}$ (95% CI)	53.0 (47.7, 58.3)	42.8 (36.7, 48.9)	43.9 (39.6, 48.3)	42.0 (36.7, 47.3)
	OR (95% CI)	1.38 (1.09, 1.73)	0.659 (0.475, 0.913)	0.703 (0.533, 0.926)	0.635 (0.468, 0.860)
	p-value		0.012*	0.012*	0.003*
2010	WP$^{\alpha}$ (95% CI)	57.9 (52.8, 63.0)	44.5 (38.1, 50.8)	47.5 (43.5, 51.5)	44.6 (39.3, 49.8)
	OR (95% CI)	1.61 (1.27, 2.03)	0.575 (0.411, 0.803)	0.648 (0.497, 0.845)	0.568 (0.421, 0.767)
	p-value		0.001*	0.001*	< 0.001*
2011	WP$^{\alpha}$ (95% CI)	49.2 (44.1, 54.2)	38.4 (32.9, 43.8)	48.7 (44.9, 52.5)	40.4 (35.9, 44.9)
	OR (95% CI)	1.11 (0.883, 1.39)	0.641 (0.471, 0.871)	0.985 (0.764, 1.27)	0.697 (0.529, 0.918)
	p-value		0.005*	0.905	0.040*
2012	WP$^{\alpha}$ (95% CI)	44.3 (39.3, 49.2)	37.5 (32.1, 43.0)	44.3 (40.6, 48.0)	44.4 (39.7, 49.0)
	OR (95% CI)	0.888 (0.716, 1.10)	0.780 (0.574, 1.06)	1.01 (0.790, 1.30)	1.02 (0.778, 1.35)
	p-value		0.111	0.913	0.866

2013	WP[α] (95% CI)	49.6 (44.7, 54.6)	40.7 (35.1, 46.2)	45.1 (41.3, 48.9)	47.1 (42.5, 51.7)
	OR (95% CI)	1.14 (0.921, 1.42)	0.687 (0.507, 0.931)	0.820 (0.639, 1.05)	0.892 (0.679, 1.17)
	p-value		0.016*	0.120	0.410
2014	WP[α] (95% CI)	44.8 (40.0, 49.5)	41.4 (35.8, 47.0)	39.5 (35.9, 43.1)	42.3 (37.6, 47.1)
	OR (95% CI)	0.926 (0.748, 1.15)	0.859 (0.636, 1.16)	0.767 (0.636, 1.16)	0.898 (0.682, 1.18)
	p-value		0.332	0.069	0.439
2015	WP[α] (95% CI)	49.9 (44.5, 55.3)	41.6 (35.5, 47.6)	46.5 (42.6, 50.5)	44.9 (40.0, 49.7)
	OR (95% CI)	1.16 (0.916, 1.47)	0.708 (0.509, 0.985)	0.868 (0.662, 1.14)	0.816 (0.608, 1.09)
	p-value		0.040*	0.302	0.174
2016	WP[α] (95% CI)	47.1 (42.4, 51.7)	40.5 (34.8, 46.2)	45.3 (41.4, 49.2)	48.8 (43.4, 54.2)
	OR (95% CI)	0.980 (0.795, 1.21)	0.770 (0.569, 1.04)	0.936 (0.732, 1.20)	1.07 (0.803, 1.43)
	p-value		0.091	0.596	0.643
2017	WP[α] (95% CI)	50.6 (45.6, 55.5)	44.7 (38.1, 51.3)	43.6 (39.6, 47.7)	44.3 (38.8, 49.8)
	OR (95% CI)	1.23 (0.983, 1.53)	0.788 (0.566, 1.10)	0.747 (0.577, 0.967)	0.786 (0.583, 1.06)
	p-value		0.159	0.027*	0.114
2018	WP[α] (95% CI)	48.7 (43.8, 53.7)	40.0 (33.7, 46.2)	45.8 (41.7, 49.8)	43.9 (38.6, 49.1)
	OR (95% CI)	1.03 (0.825, 1.29)	0.692 (0.499, 0.960)	0.875 (0.676, 1.13)	0.822 (0.613, 1.10)
	p-value		0.028	0.311	0.190

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table X: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 60 to 64 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP$^{\alpha}$ (95% CI)	45.9 (40.4, 51.4)	48.2 (42.2, 54.2)	40.5 (36.4, 44.7)	44.1 (37.9, 50.4)
	OR (95% CI)	0.992 (0.775, 1.27)	1.09 (0.785, 1.51)	0.798 (0.602, 1.06)	0.936 (0.668, 1.31)
	p-value		0.606	0.117	0.703
2003	WP$^{\alpha}$ (95% CI)	49.3 (43.9, 54.7)	37.5 (31.6, 43.5)	47.8 (43.6, 52.0)	47.7 (41.7, 53.6)
	OR (95% CI)	1.21 (0.954, 1.53)	0.612 (0.437, 0.858)	0.951 (0.723, 1.25)	0.935 (0.676, 1.29)
	p-value		0.005*	0.720	0.682
2005	WP$^{\alpha}$ (95% CI)	52.5 (47.6, 57.4)	47.1 (40.9, 53.3)	46.8 (42.6, 50.9)	46.5 (41.2, 51.8)
	OR (95% CI)	1.39 (1.12, 1.72)	0.819 (0.595, 1.13)	0.796 (0.614, 1.03)	0.797 (0.595, 1.07)
	p-value		0.222	0.084	0.129
2006	WP$^{\alpha}$ (95% CI)	52.9 (46.9, 59.0)	43.8 (36.0, 51.6)	46.3 (41.4, 51.2)	42.9 (36.8, 49.0)
	OR (95% CI)	1.33 (1.01, 1.75)	0.686 (0.458, 1.03)	0.747 (0.546, 1.02)	0.658 (0.465, 0.933)
	p-value		0.068	0.069	0.019*
2007	WP$^{\alpha}$ (95% CI)	42.5 (36.6. 48.5)	36.9 (30.4, 43.4)	44.5 (39.8, 49.3)	41.8 (35.8, 47.7)
	OR (95% CI)	0.907 (0.687, 1.20)	0.787 (0.542, 1.14)	1.09 (0.798, 1.50)	0.975 (0.689, 1.38)
	p-value		0.208	0.579	0.889
2008	WP$^{\alpha}$ (95% CI)	49.0 (43.2, 54.8)	44.7 (37.8, 51.5)	46.9 (42.1, 51.8)	46.4 (40.0, 52.7)
	OR (95% CI)	1.27 (0.984, 1.64)	0.828 (0.575, 1.19)	0.920 (0.679, 1.25)	0.910 (0.641, 1.29)
	p-value		0.311	0.592	0.600
2009	WP$^{\alpha}$ (95% CI)	51.3 (46.0, 56.6)	45.4 (39.1, 51.7)	50.6 (46.0, 55.1)	49.3 (43.7, 55.0)
	OR (95% CI)	1.32 (1.04, 1.67)	0.795 (0.570, 1.11)	0.973 (0.737, 1.29)	0.939 (0.685, 1.29)
	p-value		0.178	0.850	0.695
2010	WP$^{\alpha}$ (95% CI)	50.5 (45.1, 55.9)	40.6 (34.8, 46.5)	48.8 (44.8, 52.9)	40.7 (35.6, 45.9)
	OR (95% CI)	1.30 (1.03, 1.66)	0.651 (0.471, 0.902)	0.940 (0.715, 1.24)	0.659 (0.485, 0.895)
	p-value		0.010*	0.658	0.008*
2011	WP$^{\alpha}$ (95% CI)	51.1 (46.2, 56.0)	38.3 (32.9, 46.7)	54.9 (51.2, 58.5)	48.6 (44.0, 53.2)
	OR (95% CI)	1.24 (0.996, 1.53)	0.591 (0.437, 0.800)	1.16 (0.908, 1.49)	0.891 (0.679, 1.17)
	p-value		< 0.001*	0.232	0.403
2012	WP$^{\alpha}$ (95% CI)	52.8 (47.8, 59.8)	42.7 (37.2, 48.2)	45.9 (42.2, 49.6)	46.3 (41.5, 51.1)
	OR (95% CI)	1.32 (1.07, 1.65)	0.661 (0.489, 0.893)	0.747 (0.582, 0.960)	0.774 (0.587, 1.02)
	p-value		0.007*	0.023*	0.070

2013	WP[α] (95% CI)	51.3 (45.9, 56.6)	41.5 (35.5, 47.5)	49.0 (45.1, 52.8)	49.0 (44.2, 53.9)
	OR (95% CI)	1.33 (1.06, 1.69)	0.669 (0.481, 0.930)	0.885 (0.679, 1.15)	0.904 (0.677, 1.21)
	p-value		0.017*	0.363	0.492
2014	WP[α] (95% CI)	55.6 (50.7, 60.5)	41.9 (35.6, 48.2)	44.7 (40.7, 48.7)	48.6 (43.8, 53.4)
	OR (95% CI)	1.47 (1.18, 1.84)	0.569 (0.409, 0.790)	0.650 (0.502, 0.841)	0.756 (0.572, 1.00)
	p-value		< 0.001*	0.001*	0.050
2015	WP[α] (95% CI)	48.2 (42.8, 53.6)	45.1 (38.6, 51.6)	46.4 (42.2, 50.5)	48.5 (43.7, 53.4)
	OR (95% CI)	1.04 (0.827, 1.31)	0.899 (0.642, 1.26)	0.925 (0.705, 1.21)	1.03 (0.773, 1.38)
	p-value		0.732	0.537	0.834
2016	WP[α] (95% CI)	56.6 (52.0, 61.2)	48.6 (43.1, 54.1)	52.2 (48.1, 56.4)	48.4 (43.3, 53.6)
	OR (95% CI)	1.50 (1.22, 1.84)	0.719 (0.539, 0.959)	0.836 (0.652, 1.07)	0.712 (0.539, 0.942)
	p-value		0.025*	0.157	0.017*
2017	WP[α] (95% CI)	50.8 (46.0, 55.6)	47.5 (41.4, 53.5)	46.7 (42.7, 50.6)	50.8 (45.5, 56.1)
	OR (95% CI)	1.28 (1.03, 1.59)	0.877 (0.643, 1.20)	0.833 (0.650, 1.07)	0.989 (0.742, 1.32)
	p-value		0.407	0.151	0.940
2018	WP[α] (95% CI)	51.2 (46.4, 56.1)	45.7 (40.0, 51.5)	48.6 (44.6, 52.5)	47.9 (42.5, 53.2)
	OR (95% CI)	1.11 (0.896, 1.38)	0.801 (0.592, 1.08)	0.897 (0.698, 1.15)	0.870 (0.651, 1.16)
	p-value		0.150	0.394	0.347

[α] WP: Weighted prevalence

* Significant at P < 0.05

Table XI: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 65 to 69 years, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	47.8 (42.1, 53.6)	40.7 (34.3, 47.1)	44.4 (39.8, 49.0)	40.4 (33.7, 47.1)
	OR (95% CI)	1.09 (0.846, 1.40)	0.755 (0.529, 1.08)	0.873 (0.649, 1.75)	0.755 (0.525, 1.09)
	p-value		0.121	0.369	0.130
2003	WP[α] (95% CI)	54.3 (48.5, 60.1)	41.1 (34.7, 47.5)	47.4 (42.9, 51.9)	43.6 (37.1, 50.1)
	OR (95% CI)	1.57 (1.21, 2.03)	0.591 (0.414, 0.844)	0.746 (0.555, 1.00)	0.646 (0.453, 0.922)
	p-value		0.004*	0.053	0.016*
2005	WP[α] (95% CI)	51.1 (45.6, 56.5)	45.8 (39.5, 52.1)	48.6 (44.0, 53.1)	42.7 (36.4, 49.1)
	OR (95% CI)	1.18 (0.930, 1.49)	0.814 (0.583, 1.14)	0.912 (0.687, 1.21)	0.721 (0.514, 1.01)
	p-value		0.228	0.525	0.059
2006	WP[α] (95% CI)	48.3 (41.7, 54.9)	41.0 (33.5, 48.5)	47.1 (42.1, 52.1)	41.7 (34.9, 48.4)
	OR (95% CI)	1.19 (0.885, 1.60)	0.706 (0.468, 1.07)	0.935 (0.668, 1.31)	0.739 (0.501, 1.09)
	p-value		0.099	0.694	0.126
2007	WP[α] (95% CI)	43.7 (37.0, 50.5)	38.1 (31.1, 45.1)	40.8 (35.9, 45.7)	36.6 (30.3, 42.8)
	OR (95% CI)	0.970 (0.715, 1.32)	0.781 (0.518, 1.18)	0.869 (0.613, 1.23)	0.748, (0.506, 1.11)
	p-value		0.237	0.429	0.145
2008	WP[α] (95% CI)	51.8 (44.8, 58.8)	42.4 (34.9, 50.0)	49.4 (44.4, 54.4)	45.5 (39.2, 51.8)
	OR (95% CI)	1.36 (1.00, 1.86)	0.663 (0.435, 1.01)	0.901 (0.638, 1.27)	0.776 (0.531, 1.13)
	p-value		0.056	0.555	0.190
2009	WP[α] (95% CI)	49.2 (42.7, 55.8)	42.8 (35.8, 49.8)	48.7 (43.9, 53.5)	51.4 (45.1, 57.7)
	OR (95% CI)	1.22 (0.915, 1.64)	0.753 (0.510, 1.11)	0.944 (0.680, 1.31)	1.06 (0.736, 1.54)
	p-value		0.154	0.731	0.743
2010	WP[α] (95% CI)	56.7 (50.6, 62.8)	44.5 (37.3, 51.6)	48.5 (43.8, 53.1)	49.5 (43.6, 55.3)
	OR (95% CI)	1.56 (1.19, 2.06)	0.620 (0.421, 0.915)	0.728 (0.531, 0.997)	0.760 (0.538, 1.07)
	p-value		0.016*	0.048*	0.119
2011	WP[α] (95% CI)	50.8 (45.4, 56.1)	49.2 (43.3, 55.1)	50.7 (46.4, 54.9)	45.1 (40.0, 50.2)
	OR (95% CI)	1.27 (1.01, 1.61)	0.949 (0.688, 1.31)	0.997 (0.757, 1.31)	0.791 (0.586, 1.07)
	p-value		0.751	0.980	0.127
2012	WP[α] (95% CI)	51.7 (46.1, 57.4)	36.7 (30.5, 43.0)	50.1 (45.9, 54.2)	42.0 (36.9, 47.0)
	OR (95% CI)	1.27 (0.994, 1.62)	0.538 (0.377, 0.767)	0.945 (0.713, 1.25)	0.674 (0.496, 0.916)
	p-value		< 0.001*	0.694	0.012*

2013	WP[α] (95% CI)	47.3 (41.9, 52.8)	43.8 (37.3, 50.2)	49.2 (45.1, 53.2)	52.3 (47.5, 57.2)
	OR (95% CI)	1.03 (0.815, 1.31)	0.852 (0.605, 1.20)	1.07 (0.817, 1.41)	1.21 (0.904, 1.63)
	p-value		0.358	0.613	0.199
2014	WP[α] (95% CI)	51.7 (46.4, 56.9)	43.3 (37.2, 49.4)	49.4 (45.4, 53.5)	49.0 (43.8, 54.2)
	OR (95% CI)	1.23 (0.981, 1.54)	0.721 (0.521, 0.999)	0.928 (0.712, 1.21)	0.897 (0.667, 1.21)
	p-value		0.049*	0.583	0.474
2015	WP[α] (95% CI)	58.0 (52.5, 63.6)	47.3 (40.9, 53.8)	51.9 (47.8, 53.8)	49.6 (44.4, 54.9)
	OR (95% CI)	1.55 (1.20, 1.99)	0.659 (0.465, 0.934)	0.778 (0.586, 1.03)	0.716 (0.524, 0.977)
	p-value		0.019*	0.081	0.035*
2016	WP[α] (95% CI)	53.4 (48.6, 58.1)	45.6 (40.3, 50.9)	48.6 (44.8, 52.4)	48.1 (42.9, 53.3)
	OR (95% CI)	1.31 (1.06, 1.62)	0.737 (0.553, 0.982)	0.818 (0.641, 1.04)	0.801 (0.604, 1.06)
	p-value		0.037*	0.106	0.125
2017	WP[α] (95% CI)	51.7 (47.0, 56.5)	49.5 (43.2, 55.8)	47.1 (43.1, 51.1)	47.7 (42.6, 52.9)
	OR (95% CI)	1.36 (1.10, 1.68)	0.886 (0.646, 1.22)	0.809 (0.629, 1.04)	0.851 (0.642, 1.13)
	p-value		0.453	0.100	0.262
2018	WP[α] (95% CI)	55.4 (50.5, 60.2)	50.2 (44.4, 56.1)	50.1 (46.3, 53.8)	49.9 (44.8, 55.0)
	OR (95% CI)	1.30 (1.05, 1.62)	0.810 (0.597, 1.10)	0.808 (0.630, 1.04)	0.802 (0.603, 1.07)
	p-value		0.175	0.094	0.128

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table XII: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value], aged 70 years and above, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP$^{\alpha}$ (95% CI)	52.4 (49.0, 55.7)	47.4 (43.6, 51.2)	48.2 (45.3, 51.0)	45.4 (41.5, 49.3)
	OR (95% CI)	1.23 (1.06, 1.41)	0.820 (0.670, 1.00)	0.848 (0.711, 1.01)	0.760 (0.618, 0.935)
	p-value		0.055	0.066	0.009*
2003	WP$^{\alpha}$ (95% CI)	56.6 (53.1, 60.1)	49.5 (45.7, 53.2)	51.4 (48.6, 54.2)	51.1 (47.1, 55.1)
	OR (95% CI)	1.51 (1.29, 1.76)	0.757 (0.614, 0.934)	0.822 (0.684, 0.988)	0.814 (0.657, 1.01)
	p-value		0.009*	0.037*	0.061
2005	WP$^{\alpha}$ (95% CI)	55.6 (52.3, 59.0)	48.8 (45.1, 52.5)	53.0 (50.3, 55.8)	49.9 (46.0, 53.8)
	OR (95% CI)	1.46 (1.26, 1.68)	0.761 (0.622, 0.931)	0.897 (0.753, 1.07)	0.795 (0.646, 0.978)
	p-value		0.008*	0.223	0.030*
2006	WP$^{\alpha}$ (95% CI)	54.8 (50.5, 59.1)	47.8 (43.1, 52.6)	48.4 (45.0, 51.8)	45.8 (41.5, 50.2)
	OR (95% CI)	1.37 (1.13, 1.65)	0.754 (0.583, 0.976)	0.777 (0.623, 0.970)	0.703 (0.550, 0.899)
	p-value		0.032*	0.026*	0.005*
2007	WP$^{\alpha}$ (95% CI)	46.5 (42.5, 50.5)	43.5 (38.9. 48.2)	47.2 (43.7, 50.6)	43.9 (39.5, 48.2)
	OR (95% CI)	0.969 (0.815, 1.15)	0.884 (0.689, 1.13)	1.02 (0.826, 1.26)	0.899 (0.708, 1.14)
	p-value		0.331	0.851	0.380
2008	WP$^{\alpha}$ (95% CI)	48.4 (44.1, 52.7)	45.2 (40.4, 50.1)	49.2 (45.8, 52.6)	44.5 (40.1, 48.9)
	OR (95% CI)	1.08 (0.897, 1.29)	0.886 (0.682, 1.15)	1.04 (0.836, 1.30)	0.864 (0.673, 1.11)
	p-value		0.367	0.714	0.250
2009	WP$^{\alpha}$ (95% CI)	56.7 (52.8, 60.6)	44.4 (39.7, 49.0)	53.2 (49.9, 56.5)	49.0 (44.6, 53.3)
	OR (95% CI)	1.58 (1.33, 1.87)	0.603 (0.471, 0.772)	0.865 (0.704, 1.06)	0.740 (0.584, 0.940)
	p-value		< 0.001*	0.170	0.013*
2010	WP$^{\alpha}$ (95% CI)	51.5 (47.7, 55.3)	45.1 (40.8, 49.3)	50.5 (47.3, 53.7)	49.9 (45.9, 53.9)
	OR (95% CI)	1.23 (1.05, 1.44)	0.769 (0.610, 0.969)	0.966 (0.793, 1.18)	0.932 (0.748, 1.16)
	p-value		0.026*	0.733	0.530
2011	WP$^{\alpha}$ (95% CI)	53.8 (50.3, 57.3)	49.3 (45.3, 53.2)	55.6 (52.8, 58.4)	53.5 (50.0, 56.9)
	OR (95% CI)	1.32 (1.13, 1.54)	0.834 (0.675, 1.03)	1.07 (0.890, 1.28)	0.983 (0.806, 1.20)
	p-value		0.091	0.488	0.865
2012	WP$^{\alpha}$ (95% CI)	46.6 (43.0, 50.3)	45.4 (41.1, 49.6)	45.7 (42.9, 48.6)	45.7 (42.1, 49.4)
	OR (95% CI)	0.995 (0.851, 1.16)	0.940 (0.749, 1.18)	0.968 (0.802, 1.17)	0.969 (0.786, 1.19)
	p-value		0.593	0.729	0.767

2013	WP[α] (95% CI)	53.3 (49.6, 56.9)	48.0 (43.8, 52.1)	51.7 (48.8, 54.6)	53.4 (49.7, 57.0)
	OR (95% CI)	1.32 (1.13, 1.55)	0.818 (0.655, 1.02)	0.942 (0.780, 1.14)	1.00 (0.812, 1.23)
	p-value		0.077	0.540	0.991
2014	WP[α] (95% CI)	54.6 (51.0, 58.3)	46.0 (41.8, 50.2)	51.6 (48.7, 54.4)	49.5 (45.9, 53.1)
	OR (95% CI)	1.36 (1.16, 1.59)	1.715 (0.572, 0.894)	0.887 (0.736, 1.07)	0.836 (0.680, 1.03)
	p-value		0.003*	0.208	0.090
2015	WP[α] (95% CI)	56.1 (52.5, 59.8)	47.9 (43.7, 52.1)	53.1 (50.3, 56.0)	52.3 (48.5, 56.0)
	OR (95% CI)	1.58 (0.134, 1.86)	0.714 (0.568, 0.897)	0.887 (0.734, 0.568)	0.860 (0.694, 1.07)
	p-value		0.004*	0.217	0.168
2016	WP[α] (95% CI)	53.1 (49.8, 56.3)	46.2 (42.2, 50.2)	53.7 (50.9, 56.4)	51.2 (47.7, 54.7)
	OR (95% CI)	1.32 (1.15, 1.53)	0.759 (0.616, 0.932)	1.03 (0.867, 1.23)	0.932 (0.767, 1.13)
	p-value		0.009*	0.730	0.477
2017	WP[α] (95% CI)	58.6 (55.4, 61.8)	54.7 (50.7, 58.7)	51.3 (48.5, 54.1)	53.6 (50.0, 57.2)
	OR (95% CI)	1.62 (1.40, 1.87)	0.843 (0.684, 1.04)	0.741 (0.624, 0.881)	0.816 (0.669, 0.995)
	p-value		0.110	< 0.001*	0.044*
2018	WP[α] (95% CI)	58.0 (54.7, 61.3)	54.8 (50.9, 58.7)	53.7 (51.0, 56.3)	55.9 (52.4, 59.5)
	OR (95% CI)	1.50 (1.30, 1.74)	0.878 (0.712, 1.08)	0.841 (0.707, 1.00)	0.918 (0.753, 1.12)
	p-value		0.220	0.052	0.398

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table XIII: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in male US residents, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	30.1 (28.3, 31.9)	26.5 (24.5, 28.5)	27.6 (26.1, 29.0)	26.4 (24.5, 28.2)
	OR (95% CI)	0.203 (0.167, 0.247)	0.793 (0.692, 0.909)	0.867 (0.773, 0.972)	0.817 (0.715, 0.934)
	p-value		< 0.001*	0.015*	0.003*
2003	WP[α] (95% CI)	33.0 (31.1, 34.9)	28.5 (26.4, 30.5)	27.7 (26.3, 29.1)	26.1 (24.3, 27.9)
	OR (95% CI)	0.232 (0.193, 0.278)	0.760 (0.663, 0.871)	0.757 (0.676, 0.847)	0.730 (0.642, 0.830)
	p-value		< 0.001*	< 0.001*	< 0.001*
2005	WP[α] (95% CI)	32.5 (30.7, 34.3)	29.3 (27.1, 31.4)	27.1 (25.7, 28.6)	26.9 (25.1, 28.7)
	OR (95% CI)	0.185 (0.150, 0.227)	0.759 (0.660, 0.872)	0.754 (0.673, 0.844)	0.743 (0.653, 0.846)
	p-value		< 0.001*	< 0.001*	< 0.001*
2006	WP[α] (95% CI)	33.0 (30.8, 35.2)	24.9 (22.4, 27.4)	26.7 (25.1, 28.3)	26.2 (24.1, 28.2)
	OR (95% CI)	0.159 (0.127, 0.200)	0.639 (0.539, 0.757)	0.727 (0.636, 0.829)	0.704 (0.606, 0.817)
	p-value		< 0.001*	< 0.001*	< 0.001*
2007	WP[α] (95% CI)	27.9 (25.6, 30.2)	23.9 (21.5, 26.3)	23.2 (21.6, 24.8)	26.5 (24.4, 28.6)
	OR (95% CI)	0.121 (0.093, 0.156)	0.788 (0.660, 0.941)	0.786 (0.680, 0910)	0.956 (0.814, 1.12)
	p-value		0.008*	0.001*	0.588
2008	WP[α] (95% CI)	32.0 (29.6, 34.3)	28.0 (25.3, 30.8)	28.1 (26.3, 29.9)	28.2 (26.0, 30.3)
	OR (95% CI)	0.210 (0.163, 0.270)	0.787 (0.658, 0.941)	0.814 (0.706, 0.940)	0.827 (0.707, 0.967)
	p-value		0.009*	0.005*	0.017*
2009	WP[α] (95% CI)	34.5 (32.3, 36.7)	27.7 (25.1, 30.3)	31.2 (29.4, 32.9)	30.4 (28.2, 32.6)
	OR (95% CI)	0.221 (0.176, 0.277)	0.670 (0.594, 0.825)	0.863 (0.758, 0.982)	0.841 (0.726, 0.973)
	p-value		< 0.001*	0.026*	0.020*
2010	WP[α] (95% CI)	35.6 (33.4, 37.8)	30.4 (27.9, 32.9)	30.9 (29.3, 32.6)	28.6 (26.6, 30.5)
	OR (95% CI)	0.220 (0.177, 0.272)	0.759 (0.649, 0.888)	0.800 (0.706, 0.908)	0.756 (0.658, 0.868)
	p-value		< 0.001*	< 0.001*	< 0.001*
2011	WP[α] (95% CI)	34.9 (32.9, 36.8)	27.4 (25.2, 29.5)	32.9 (31.4, 34.5)	30.7 (29.0, 32.4)
	OR (95% CI)	0.198 (0.165, 0.238)	0.644 (0.560, 0.740)	0.893 (0.798, 0.999)	0.843 (0.747, 0.952)
	p-value	< 0.001*	0.048*	0.006*	0.016*
2012	WP[α] (95% CI)	30.5 (28.5, 32.5)	23.9 (21.8, 26.0)	28.7 (27.2, 30.2)	29.4 (27.6, 31.1)
	OR (95% CI)	0.168 (0.137, 0.207)	0.669 (0.574, 0.780)	0.886 (0.783, 1.00)	0.938 (0.823, 1.07)
	p-value		< 0.001*	0.054	0.335

2013	WP[α] (95% CI)	31.8 (29.7, 33.8)	27.3 (25.0, 29.5)	29.5 (28.0, 31.1)	28.8 (27.1, 30.6)
	OR (95% CI)	0.151 (0.121, 0.189)	0.736 (0.632, 0.857)	0.860 (0.759, 0.975)	0.889 (0.779, 1.01)
	p-value		< 0.001*	0.018*	0.080
2014	WP[α] (95% CI)	34.8 (32.6, 36.9)	28.9 (26.5, 31.4)	30.6 (28.9, 32.2)	29.2 (27.4, 31.0)
	OR (95% CI)	0.215 (0.174, 0.265)	0.714 (0.610, 0.836)	0.800 (0.704, 0.908)	0.776 (0.680, 0.886)
	p-value		< 0.001*	< 0.001*	< 0.001*
2015	WP[α] (95% CI)	34.4 (32.2, 36.6)	31.5 (28.9, 34.0)	31.6 (30.0, 33.3)	31.0 (29.0, 32.9)
	OR (95% CI)	0.182 (0.146, 0.227)	0.805 (0.688, 0.943)	0.839 (0.741, 0.951)	0.855 (0.746, 0.980)
	p-value		0.007*	0.006*	0.024*
2016	WP[α] (95% CI)	35.2 (33.2, 37.2)	28.4 (26.1, 30.7)	31.1 (29.5, 32.7)	30.8 (28.8, 32.8)
	OR (95% CI)	0.176 (0.142, 0.218)	0.685 (0.591, 0.795)	0.811 (0.718, 0.915)	0.847 (0.741, 0.968)
	p-value		< 0.001*	< 0.001*	0.015*
2017	WP[α] (95% CI)	35.8 (33.8, 37.8)	30.7 (28.1, 33.3)	29.2 (27.6, 30.9)	30.3 (28.3, 32.4)
	OR (95% CI)	0.178 (0.143, 0.222)	0.750 (0.612, 0.876)	0.735 (0.651, 0.830)	0.780 (0.681, 0.894)
	p-value		< 0.001*	< 0.001*	0.002*
2018	WP[α] (95% CI)	36.2 (34.1, 38.3)	31.2 (28.7, 33.7)	33.3 (31.5, 35.0)	32.7 (30.5, 34.9)
	OR (95% CI)	0.203 (0.160, 0.256)	0.732 (0.629, 0.583)	0.857 (0.757, 0.971)	0.881 (0.766, 1.01)
	p-value		< 0.001*	0.015*	0.076

[α] WP: Weighted prevalence

* Significant at P < 0.05

Table XIV: Joint symptoms trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in female US residents, according to the National Health Interview Survey (NHIS) from 2002 until 2018 (except 2004)

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
2002	WP[α] (95% CI)	33.7 (32.1, 35.3)	29.6 (27.8, 31.4)	30.9 (29.6, 32.2)	30.2 (28.5, 32.0)
	OR (95% CI)	0.176 (0.149, 0.209)	0.766 (0.682, 0.860)	0.853 (0.771, 0.943)	0.850 (0.756, 0.955)
	p-value		< 0.001*	0.002*	0.006*
2003	WP[α] (95% CI)	38.1 (36.3, 39.8)	31.8 (30.0, 33.6)	34.5 (33.1, 35.8)	32.7 (30.9, 34.4)
	OR (95% CI)	0.187 (0.157, 0.224)	0.694 (0.616, 0.781)	0.829 (0.749, 0.916)	0.797 (0.710, 0.895)
	p-value		< 0.001*	< 0.001*	< 0.001*
2005	WP[α] (95% CI)	37.2 (35.5, 38.8)	31.0 (29.1, 32.8)	32.9 (31.6, 34.2)	31.5 (29.8, 33.2)
	OR (95% CI)	0.210 (0.176, 0.252)	0.697 (0.620, 0.785)	0.810 (0.734, 0.895)	0.773 (0.689, 0.867)
	p-value		< 0.001*	< 0.001*	< 0.001*
2006	WP[α] (95% CI)	35.4 (33.3, 37.5)	31.0 (28.8, 33.2)	29.8 (28.3, 31.3)	31.0 (29.0, 33.0)
	OR (95% CI)	0.169 (0.137, 0.210)	0.796 (0.688, 0.920)	0.775 (0.685, 0.876)	0.821 (0.715, 0.944)
	p-value		0.002*	< 0.001*	0.005*
2007	WP[α] (95% CI)	30.4 (28.5, 32.4)	29.2 (26.9, 31.4)	29.7 (28.2, 31.3)	30.2 (28.2, 32.3)
	OR (95% CI)	0.118 (0.093, 0.150)	0.886 (0.761, 1.03)	0.974 (0.853, 1.10)	0.992 (0.861,1.14)
	p-value		0.120	0.680	0.911
2008	WP[α] (95% CI)	35.6 (33.5, 37.7)	31.7 (29.4, 34.1)	34.4 (32.8, 36.1)	30.6 (28.6, 32.7)
	OR (95% CI)	0.210 (0.169, 0.261)	0.757 (0.652, 0.878)	0.947 (0.837, 1.07)	0.802 (0.697, 0.924)
	p-value		< 0.001*	0.389	0.002*
2009	WP[α] (95% CI)	38.8 (36.8, 40.8)	32.7 (30.4, 35.0)	34.8 (33.2, 36.4)	31.8 (29.8, 33.9)
	OR (95% CI)	0.190 (0.154, 0.234)	0.702 (0.608, 0.811)	0.828 (0.735, 0.932)	0.717 (0.627, 0.821)
	p-value		< 0.001*	0.002*	< 0.001*
2010	WP[α] (95% CI)	38.5 (36.5, 40.4)	31.1 (28.9, 33.3)	36.2 (34.7, 37.7)	33.0 (31.2, 34.9)
	OR (95% CI)	0.208 (0.170, 0.255)	0.633 (0.550, 0.727)	0.888 (0.795, 0.993)	0.768 (0.677, 0.871)
	p-value		< 0.001*	0.037*	< 0.001*
2011	WP[α] (95% CI)	36.0 (34.3, 37.8)	32.1 (30.0, 34.1)	37.6 (36.2, 39.0)	33.4 (31.8, 35.1)
	OR (95% CI)	0.152 (0.126, 0.184)	0.775 (0.682, 0.880)	1.06 (0.959, 1.18)	0.880 (0.785, 0.986)
	p-value		< 0.001*	0.240	0.028*
2012	WP[α] (95% CI)	34.6 (32.8, 36.4)	30.4 (28.4, 32.4)	32.3 (31.0, 33.7)	31.5 (29.7, 33.2)
	OR (95% CI)	0.174 (0.144, 0.211)	0.782 (0.686, 0.892)	0.884 (0.794, 0.984)	0.887 (0.757, 1.24)
	p-value		< 0.001*	0.025*	0.051

2013	WP[α] (95% CI)	35.9 (33.9, 37.8)	33.1 (30.9, 35.3)	34.5 (33.1, 35.9)	34.8 (33.1, 36.5)
	OR (95% CI)	0.180 (0.146, 0.221)	0.805 (0.699, 0.927)	0.911 (0.816, 1.02)	0.961 (0.852, 1.08)
	p-value		0.003*	0.102	0.518
2014	WP[α] (95% CI)	37.4 (35.3, 39.6)	34.8 (32.5, 37.1)	33.6 (32.2, 35.0)	32.8 (31.1, 34.6)
	OR (95% CI)	0.178 (0.145, 0.219)	0.810 (0.705, 0.931)	0.833 (0.747, 0.929)	0.835 (0.739, 0.944)
	p-value		0.003*	0.001*	0.004*
2015	WP[α] (95% CI)	38.3 (36.2, 40.4)	34.2 (31.8, 36.5)	35.3 (33.9, 36.8)	33.9 (32.1, 35.7)
	OR (95% CI)	0.183 (0.146, 0.230)	0.792 (0.685, 0.915)	0.873 (0.779, 0.980)	0.686 (0.766, 0.984)
	p-value		0.002*	0.021*	0.027*
2016	WP[α] (95% CI)	38.7 (36.8, 40.6)	34.2 (31.9, 36.5)	36.8 (35.3, 38.4)	33.6 (31.7, 35.5)
	OR (95% CI)	0.194 (0.160, 0.236)	0.769 (0.671, 0.882)	0.918 (0.824, 1.02)	0.825 (0.729, 0.934)
	p-value		< 0.001*	0.122	0.002*
2017	WP[α] (95% CI)	40.1 (38.1, 42.0)	36.6 (34.2, 39.1)	36.6 (35.0, 38.1)	35.7 (33.6, 37.8)
	OR (95% CI)	0.218 (0.176, 0.270)	0.816 (0.710, 0.939)	0.832 (0.744, 0.930)	0.834 (0.734, 0.947)
	p-value		0.004*	0.001*	0.005*
2018	WP[α] (95% CI)	37.5 (35.4, 39.5)	34.1 (31.7, 36.4)	34.8 (33.2, 36.4)	34.2 (32.2, 36.3)
	OR (95% CI)	0.166 (0.129, 0.214)	0.772 (0.670, 0.889)	0.845 (0.751, 0.951)	0.847 (0.741, 0.969)
	p-value		< 0.001*	0.005*	0.015*

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

APPENDIX M

Geospatial trends: region-specific trends of low back pain (NHIS)

Table I: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in the overall US population, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	28.6 (27.5, 29.7)	27.1 (25.9, 28.2)	27.4 (26.6, 28.3)	29.7 (28.5, 30.9)
	OR (95% CI)	0.288 (0.260, 0.319)	0.916 (0.846, 0.992)	0.942 (0.879, 1.01)	1.06 (0.979, 1.14)
	p-value		0.031*	0.086	0.153
1998	WP[α] (95% CI)	28.5 (27.4, 29.7)	27.8 (26.5, 29.0)	27.6 (26.7, 28.5)	28.1 (2.9, 29.3)
	OR (95% CI)	0.273 (0.244, 0.305)	0.951 (0.874, 1.03)	0.955 (0.887, 1.03)	0.985 (0.907, 1.07)
	p-value		0.243	0.212	0.717
1999	WP[α] (95% CI)	27.1 (25.9, 28.2)	27.1 (25.8, 28.4)	25.3 (24.4, 26.2)	27.6 (26.3, 28.9)
	OR (95% CI)	0.265 (0.236, 0.297)	0.981 (0.897, 1.07)	0.907 (0.841, 0.979)	1.02 (0.938, 1.11)
	p-value		0.675	0.012*	0.612
2000	WP[α] (95% CI)	28.1 (27.0, 29.2)	26.1 (24.8, 27.4)	26.5 (25.6, 27.5)	28.7 (27.4, 29.9)
	OR (95% CI)	0.278 (0.248, 0.311)	0.890 (0.816, 0.971)	0.918 (0.852, 0.989)	1.03)
	p-value		0.009*	0.024*	0.539
2001	WP[α] (95% CI)	32.4 (31.2, 33.6)	30.9 (29.6, 32.2)	29.4 (28.5, 30.3)	32.8 (31.5, 34.1)
	OR (95% CI)	0.370 (0.334, 0.409)	0.923 (0.849, 1.00)	0.868 (0.808, 0.931)	1.02 (0.941, 1.10)
	p-value		0.056	< 0.001*	0.644
2002	WP[α] (95% CI)	27.5 (26.3, 28.7)	27.6 (26.3, 29.0)	24.5 (23.6, 25.4)	27.7 (26.5, 29.0)
	OR (95% CI)	0.278 (0.249, 0.311)	0.990 (0.906, 1.08)	0.851 (0.788, 0.919)	1.01 (0.926, 1.10)
	p-value		0.824	< 0.001*	0.820
2003	WP[α] (95% CI)	29.1 (27.9, 30.2)	27.6 (26.2, 28.9)	25.3 (24.4, 26.3)	29.4 (28.1, 30.6)
	OR (95% CI)	0.263 (0.235, 0.294)	0.917 (0.838, 1.00)	0.823 (0.763, 0.888)	1.03 (0.944, 1.12)
	p-value		0.057	< 0.001*	0.562
2005	WP[α] (95% CI)	29.7 (28.5, 30.9)	28.7 (27.3, 30.1)	27.5 (26.5, 28.4)	28.8 (27.5, 30.0)
	OR (95% CI)	0.273 (0.243, 0.306)	0.925 (0.846, 1.01)	0.896 (0.832, 0.964)	0.957 (0.881, 1.04)
	p-value		0.083	0.003*	0.308
2006	WP[α] (95% CI)	29.3 (27.8, 30.7)	28.7 (27.0, 30.4)	26.0 (24.9, 27.1)	27.6 (26.2, 29.0)
	OR (95% CI)	0.249 (0.217, 0.285)	0.964 (0.865, 1.07)	0.850 (0.776, 0.931)	0.921 (0.833, 1.02)
	p-value		0.510	< 0.001*	0.107
2007	WP[α] (95% CI)	26.1 (24.6, 27.5)	25.9 (24.3, 27.5)	24.1 (23.0, 25.1)	27.5 (26.0, 28.9)
	OR (95% CI)	0.218 (0.190, 0.254)	0.980 (0.875, 1.10)	0.900 (0.819, 0.990)	1.08 (0.975, 1.20)
	p-value		0.729	0.029*	0.137

2008	WP[α] (95% CI)	27.5 (26.1, 29.0)	27.9 (26.1, 29.7)	27.0 (25.9, 28.2)	27.6 (26.1, 29.1)
	OR (95% CI)	0.264 (0.228, 0.305)	0.998 (0.900, 1.12)	0.972 (0.884, 1.07)	1.01 (0.906, 1.12)
	p-value		0.973	0.560	0.911
2009	WP[α] (95% CI)	29.7 (28.3, 31.1)	28.3 (26.6, 29.9)	28.4 (27.3, 29.5)	27.7 (26.3, 29.1)
	OR (95% CI)	0.233 (0.203, 0.268)	0.916 (0.823, 1.02)	0.943 (0.864, 1.03)	0.913 (0.828, 1.01)
	p-value		0.106	0.195	0.068
2010	WP[α] (95% CI)	28.5 (27.2, 29.8)	28.6 (27.0, 30.3)	28.7 (27.7, 29.8)	29.5 (28.2, 30.8)
	OR (95% CI)	0.237 (0.208, 0.270)	0.989 (0.891, 1.10)	1.01 (0.927, 1.10)	1.06 (0.968, 1.16)
	p-value		0.834	0.857	0.209
2011	WP[α] (95% CI)	28.4 (27.2, 29.7)	27.9 (26.4, 29.4)	30.0 (29.0, 31.0)	28.6 (27.5, 29.8)
	OR (95% CI)	0.215 (0.190, 0.243)	0.950 (0.864, 1.05)	1.07 (0.991, 1.16)	1.02 (0.936, 1.11)
	p-value		0.292	0.084	0.689
2012	WP[α] (95% CI)	28.3 (26.9, 29.6)	26.5 (25.1, 28.0)	28.3 (27.3, 29.3)	28.6 (27.4, 29.8)
	OR (95% CI)	0.240 (0.211, 0.273)	0.899 (0.813, 0.993)	0.996 (0.917, 1.08)	1.02 (0.930, 1.11)
	p-value		0.036	0.919	0.715
2013	WP[α] (95% CI)	30.0 (28.6, 31.4)	27.8 (26.2, 29.4)	28.9 (27.9, 29.9)	29.3 (28.1, 30.5)
	OR (95% CI)	0.232 (0.202, 0.267)	0.867 (0.781, 0.962)	0.929 (0.854, 1.01)	0.966 (0.883, 1.06)
	p-value		0.007*	0.085	0.448
2014	WP[α] (95% CI)	30.5 (28.9, 32.0)	26.8 (28.9, 32.0)	27.9 (26.9, 28.9)	29.5 (28.2, 30.7)
	OR (95% CI)	0.278 (0.231, 0.334)	0.813 (0.728, 0.908)	0.879 (0.801, 0.965)	0.962 (0.872, 1.06)
	p-value		< 0.001*	0.007*	0.438
2015	WP[α] (95% CI)	29.6 (28.1, 31.0)	30.3 (28.6, 32.0)	29.6 (28.5, 30.6)	30.2 (28.9, 31.5)
	OR (95% CI)	0.192 (0.165, 0.223)	1.01 (0.906, 1.12)	0.990 (0.906, 1.12)	1.04 (0.948, 1.14)
	p-value		0.900	0.811	0.395
2016	WP[α] (95% CI)	29.7 (28.4, 31.0)	27.6 (26.0, 29.2)	29.1 (28.0, 30.2)	29.4 (28.0, 30.8)
	OR (95% CI)	0.231 (0.201, 0.266)	0.882 (0.797, 0.977)	0.963 (0.887, 1.05)	0.999 (0.911, 1.10)
	p-value		0.016*	0.372	0.988
2017	WP[α] (95% CI)	28.5 (27.2, 29.8)	28.4 (26.7, 30.1)	28.8 (27.7, 29.9)	28.8 (27.4, 30.2)
	OR (95% CI)	0.201 (0.174, 0.233)	0.979 (0.880, 1.09)	1.01 (0.932, 1.10)	1.02 (0.929, 1.12)
	p-value		0.704	0.754	0.673
2018	WP[α] (95% CI)	29.8 (28.4, 31.2)	29.1 (27.4, 30.7)	29.5 (28.4, 30.6)	31.0 (29.5, 32.4)
	OR (95% CI)	0.198 (0.169, 0.232)	0.926 (0.833, 1.03)	0.970 (0.889, 1.06)	1.06 (0.965, 1.17)
	p-value		0.151	0.486	0.216

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table II: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 18 to 24 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year		Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	22.4 (19.2, 25.5)	21.3 (17.6, 24.9)	20.8 (18.2, 23.3)	23.9 (20.2, 27.6)
	OR (95% CI)	0.334 (0.276, 0.405)	0.944 (0.711, 1.25)	0.926 (0.728, 1.18)	1.10 (0.834, 1.45)
	p-value		0.693	0.530	0.506
1998	WP[α] (95% CI)	22.6 (19.2, 26.0)	21.0 (16.7, 25.3)	20.7 (18.0, 23.5)	19.2 (15.9, 22.5)
	OR (95% CI)	0.328 (0.265, 0.407)	0.914 (0.661, 1.26)	0.898 (0.694, 1.16)	0.814 (0.610, 1.09)
	p-value		0.584	0.412	0.165
1999	WP[α] (95% CI)	23.7 (20.2, 27.1)	19.6 (15.5, 23.8)	18.6 (16.1, 21.2)	19.5 (15.9, 23.0)
	OR (95% CI)	0.359 (0.292, 0.441)	0.785 (0.566, 1.09)	0.735 (0.570, 1.09)	0.783 (0.580, 1.06)
	p-value		0.149	0.018*	0.108
2000	WP[α] (95% CI)	24.6 (21.1, 28.1)	18.3 (14.6, 22.1)	17.9 (15.4, 20.5)	23.9 (20.2, 27.5)
	OR (95% CI)	0.384 (0.311, 0.474)	0.688 (0.503, 0.942)	0.669 (0.517, 0.866)	0.967 (0.733, 1.27)
	p-value		0.020*	0.002*	0.810
2001	WP[α] (95% CI)	27.6 (24.1, 31.2)	27.3 (22.9, 31.7)	23.8 (21.1, 26.5)	25.8 (22.1, 29.5)
	OR (95% CI)	0.430 (0.355, 0.522)	0.981 (0.738, 1.30)	0.826 (0.655, 1.04)	0.923 (0.710, 1.20)
	p-value		0.895	0.109	0.548
2002	WP[α] (95% CI)	24.9 (21.5, 28.4)	17.6 (14.0, 21.1)	17.4 (14.9, 19.9)	24.7 (20.9, 28.5)
	OR (95% CI)	0.401 (0.330, 0.488)	0.640 (0.470, 0.871)	0.641 (0.497, 0.827)	0.985 (0.748, 1.30)
	p-value		0.005*	< 0.001*	0.916
2003	WP[α] (95% CI)	22.1 (18.8, 25.4)	18.3 (14.4, 22.3)	15.0 (12.6, 17.3)	25.3 (21.7, 29.0)
	OR (95% CI)	0.338 (0.275, 0.416)	0.785 (0.567, 1.09)	0.621 (0.475, 0.811)	1.20 (0.914, 1.58)
	p-value		0.147	< 0.001*	0.189
2005	WP[α] (95% CI)	22.9 (19.5, 26.2)	18.7 (14.3, 23.1)	18.3 (15.7, 20.8)	22.4 (18.4, 26.4)
	OR (95% CI)	0.365 (0.296, 0.450)	0.769 (0.454, 1.09)	0.763 (0.589, 0.987)	0.989 (0.730, 1.34)
	p-value		0.136	0.040*	0.942
2006	WP[α] (95% CI)	22.4 (18.4, 26.4)	18.4 (13.3, 23.5)	16.3 (13.5, 19.1)	18.7 (15.0, 22.5)
	OR (95% CI)	0.346 (0.270, 0.444)	0.677 (0.512, 1.18)	0.677 (0.499, 0.919)	0.806 (0.576, 1.13)
	p-value		0.239	0.012*	0.209
2007	WP[α] (95% CI)	17.9 (14.3, 21.6)	22.4 (16.7, 28.1)	15.4 (12.6, 18.2)	18.0 (13.9, 22.1)
	OR (95% CI)	0.263 (0.201, 0.345)	1.37 (0.906, 2.06)	0.847 (0.608, 1.18)	1.02 (0.704, 1.49)
	p-value		0.137	0.324	0.900

2008	WP[α] (95% CI)	24.4 (20.0, 28.9)	14.9 (10.1, 19.8)	20.6 (17.1, 24.0)	20.8 (16.2, 25.3)
	OR (95% CI)	0.414 (0.317, 0.539)	0.557 (0.355, 0.874)	0.797 (0.578, 1.10)	0.824 (0.571, 1.19)
	p-value		0.011*	0.166	0.300
2009	WP[α] (95% CI)	19.6 (15.7, 23.5)	14.0 (9.6, 18.4)	18.8 (15.8, 21.8)	18.0 (14.3, 21.7)
	OR (95% CI)	0.271 (0.206, 0.359)	0.672 (0.432, 1.05)	0.948 (0.689, 1.30)	0.905 (0.636, 1.29)
	p-value		0.079	0.744	0.581
2010	WP[α] (95% CI)	19.3 (15.7, 22.8)	23.1 (17.1, 29.2)	18.3 (15.5, 21.1)	18.8 (15.3, 22.2)
	OR (95% CI)	0.290 (0.227, 0.370)	1.25 (0.836, 1.88)	0.943 (0.702, 1.27)	0.984 (0.712, 1.36)
	p-value		0.274	0.699	0.921
2011	WP[α] (95% CI)	17.8 (14.5, 21.1)	14.8 (10.2, 19.5)	18.1 (15.5, 20.7)	20.1 (16.8, 23.3)
	OR (95% CI)	0.279 (0.218, 0.359)	0.786 (0.510, 1.21)	1.01 (0.757, 1.34)	1.16 (0.860, 1.57)
	p-value		0.276	0.966	0.329
2012	WP[α] (95% CI)	22.8 (18.8, 26.8)	14.6 (10.6, 18.6)	18.5 (15.6, 21.4)	19.7 (16.5, 22.9)
	OR (95% CI)	0.379 (0.297, 0.484)	0.578 (0.390, 0.857)	0.766 (0.567, 1.03)	0.832 (0.612, 1.13)
	p-value		0.006*	0.082	0.241
2013	WP[α] (95% CI)	20.3 (16.0, 24.7)	19.9 (14.9, 24.9)	15.2 (12.5, 17.9)	18.4 (15.1, 21.7)
	OR (95% CI)	0.337 (0.255, 0.447)	0.955 (0.631, 1.45)	0.687 (0.487, 0.969)	0.915 (0.645, 1.30)
	p-value		0.829	0.033*	0.618
2014	WP[α] (95% CI)	28.2 (21.0, 35.5)	13.7 (9.6, 17.7)	17.7 (14.6, 20.7)	20.5 (16.9, 24.1)
	OR (95% CI)	0.504 (0.336, 0.758)	0.414 (0.245, 0.671)	0.535 (0.355, 0.806)	0.665 (0.441, 1.00)
	p-value		< 0.001*	0.003*	0.050
2015	WP[α] (95% CI)	17.1 (13.2, 21.0)	14.9 (9.8, 20.0)	13.8 (11.1, 16.5)	19.7 (15.9, 23.6)
	OR (95% CI)	0.246 (0.181, 0.332)	0.851 (0.520, 1.39)	0.765 (0.535, 1.09)	1.20 (0.829, 1.73)
	p-value		0.519	0.141	0.339
2016	WP[α] (95% CI)	20.1 (16.2, 23.9)	13.5 (9.5, 17.6)	15.1 (12.1, 18.1)	23.8 (19.3, 28.3)
	OR (95% CI)	0.308 (0.267, 0.401)	0.623 (0.406, 0.956)	0.717 (0.512, 1.00)	1.24 (0.880, 1.75)
	p-value		0.030*	0.053	0.219
2017	WP[α] (95% CI)	18.5 (14.6, 22.3)	16.4 (11.2, 21.5)	16.1 (13.0, 19.2)	16.9 (13.1, 20.6)
	OR (95% CI)	0.299 (0.225, 0.396)	0.822 (0.518, 1.31)	0.859 (0.610, 1.21)	0.878 (0.606, 1.27)
	p-value		0.407	0.382	0.492
2018	WP[α] (95% CI)	18.8 (14.7, 23.0)	14.2 (9.1, 19.3)	14.1 (10.9, 17.3)	18.5 (14.3, 22.7)
	OR (95% CI)	0.319 (0.235, 0.432)	0.702 (0.427, 1.15)	0.743 (0.509, 1.09)	1.01 (0.687, 1.50)
	p-value		0.163	0.125	0.941

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table III: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 25 to 29 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	27.5 (24.0, 31.0)	24.1 (20.2, 28.0)	23.4 (20.7, 26.0)	25.6 (22.2, 28.9)
	OR (95% CI)	0.439 (0.364, 0.529)	0.828 (0.628, 1.09)	0.801 (0.637, 1.01)	0.901 (0.702, 1.16)
	p-value		0.181	0.059	0.414
1998	WP[α] (95% CI)	27.7 (24.2, 31.3)	26.5 (22.2, 30.8)	23.6 (20.7, 26.5)	24.3 (20.9, 27.8)
	OR (95% CI)	0.420 (0.346, 0.510)	0.935 (0.705, 1.24)	0.810 (0.637, 1.03)	0.843 (0.650, 1.09)
	p-value		0.639	0.087	0.200
1999	WP[α] (95% CI)	25.2 (21.4, 29.0)	26.2 (21.0, 31.3)	21.5 (18.6, 24.3)	24.7 (20.8, 28.5)
	OR (95% CI)	0.390 (0.314, 0.485)	1.06 (0.759, 1.48)	0.815 (0.627, 1.06)	0.976 (0.731, 1.30)
	p-value		0.735	0.129	0.870
2000	WP[α] (95% CI)	24.3 (20.6, 28.0)	20.2 (16.5, 23.9)	22.1 (19.1, 25.0)	26.5 (22.5, 30.5)
	OR (95% CI)	0.350 (0.283, 0.433)	0.787 (0.580, 1.07)	0.880 (0.675, 1.15)	1.13 (0.847, 1.51)
	p-value		0.124	0.345	0.406
2001	WP[α] (95% CI)	27.5 (23.8, 31.3)	25.2 (20.8, 29.7)	24.2 (21.4, 27.1)	27.5 (23.7, 31.2)
	OR (95% CI)	0.455 (0.373, 0.556)	0.880 (0.651, 1.19)	0.829 (0.649, 1.06)	0.992 (0.760, 1.30)
	p-value		0.403	0.133	0.954
2002	WP[α] (95% CI)	24.3 (20.4, 28.2)	22.6 (17.9, 27.2)	19.9 (16.9, 22.9)	23.0 (19.2, 26.9)
	OR (95% CI)	0.354 (0.281, 0.445)	0.911 (0.648, 1.28)	0.772 (0.581, 1.03)	0.937 (0.692, 1.27)
	p-value		0.590	0.076	0.674
2003	WP[α] (95% CI)	27.2 (23.2, 31.1)	26.6 (21.1, 32.1)	20.5 (17.5, 23.4)	25.1 (21.3, 28.9)
	OR (95% CI)	0.414 (0.332, 0.516)	0.979 (0.690, 1.39)	0.687 (0.524, 0.902)	0.905 (0.679, 1.20)
	p-value		0.903	0.007*	0.492
2005	WP[α] (95% CI)	25.6 (21.5, 29.6)	23.1 (18.2, 28.0)	21.2 (18.4, 24.1)	25.8 (21.8, 29.8)
	OR (95% CI)	0.432 (0.344, 0.542)	0.825 (0.583, 1.17)	0.764 (0.581, 1.00)	0.995 (0.738, 1.34)
	p-value		0.280	0.054	0.974
2006	WP[α] (95% CI)	30.4 (25.1, 35.7)	22.4 (17.2, 27.6)	22.9 (19.3, 26.6)	22.0 (17.9, 26.1)
	OR (95% CI)	0.546 (0.419, 0.711)	0.631 (0.427, 0.932)	0.660 (0.476, 0.914)	0.635 (0.449, 0.898)
	p-value		0.021*	0.012*	0.010*
2007	WP[α] (95% CI)	21.0 (16.5, 25.5)	22.4 (16.7, 28.1)	22.9 (19.2, 26.6)	20.0 (15.9, 24.1)
	OR (95% CI)	0.304 (0.227, 0.408)	1.07 (0.701, 1.64)	1.11 (0.792, 1.56)	0.934 (0.643, 1.36)
	p-value		0.745	0.540	0.721

2008	WP[α] (95% CI)	25.5 (20.3, 30.7)	28.1 (21.7, 34.5)	21.5 (18.0, 24.9)	20.5 (16.2, 24.7)
	OR (95% CI)	0.394 (0.294, 0.529)	1.12 (0.737, 1.70)	0.793 (0.565, 1.11)	0.739 (0.507, 1.08)
	p-value		0.597	0.181	0.115
2009	WP[α] (95% CI)	25.1 (20.7, 29.5)	23.0 (17.2, 28.8)	25.2 (21.3, 29.1)	21.2 (17.0, 25.3)
	OR (95% CI)	0.428 (0.333, 0.551)	0.876 (0.584, 1.31)	0.993 (0.728, 1.36)	0.808 (0.574, 1.14)
	p-value		0.521	0.967	0.219
2010	WP[α] (95% CI)	23.6 (19.5, 27.6)	26.1 (20.3, 31.9)	25.8 (22.4, 29.2)	24.2 (20.3, 28.2)
	OR (95% CI)	0.335 (0.262, 0.428)	1.16 (0.795, 1.68)	1.13 (0.847, 1.50)	1.05 (0.770, 1.43)
	p-value		0.448	0.412	0.762
2011	WP[α] (95% CI)	26.4 (22.4, 30.3)	20.4 (15.7, 25.9)	22.0 (19.0, 25.1)	20.2 (17.0, 23.5)
	OR (95% CI)	0.391 (0.312, 0.489)	0.719 (0.502, 1.03)	0.787 (0.599, 1.03)	0.711 (0.533, 0.948)
	p-value		0.071	0.085	0.020*
2012	WP[α] (95% CI)	24.4 (19.9, 28.8)	23.4 (18.4, 28.4)	24.0 (20.4, 27.6)	26.1 (22.2, 30.0)
	OR (95% CI)	0.351 (0.273, 0.451)	0.946 (0.655, 1.37)	0.978 (0.716, 1.33)	1.09 (0.796, 1.50)
	p-value		0.767	0.887	0.587
2013	WP[α] (95% CI)	27.4 (22.5, 32.2)	19.0 (14.1, 23.8)	21.3 (20.4, 27.5)	24.0 (20.4, 27.5)
	OR (95% CI)	0.402 (0.310, 0.521)	0.618 (0.416, 0.920)	0.715 (0.526, 0.973)	0.835 (0.611, 1.14)
	p-value		0.018*	0.033*	0.257
2014	WP[α] (95% CI)	24.7 (20.2, 29.2)	20.7 (15.5, 25.8)	19.9 (17.0, 22.7)	23.5 (19.7, 27.2)
	OR (95% CI)	0.372 (0.287, 0.482)	0.787 (0.529, 1.17)	0.761 (0.564, 1.03)	0.939 (0.684, 1.29)
	p-value		0.236	0.074	0.697
2015	WP[α] (95% CI)	24.7 (19.9, 29.4)	19.7 (14.8, 24.6)	26.5 (22.9, 30.1)	26.4 (22.1, 30.8)
	OR (95% CI)	0.341 (0.259, 0.448)	0.746 (0.498, 1.12)	1.09 (0.799, 1.50)	1.09 (0.780, 1.53)
	p-value		0.154	0.574	0.607
2016	WP[α] (95% CI)	26.4 (21.8, 31.0)	21.2 (15.2, 27.2)	24.6 (20.8, 28.4)	21.3 (17.2, 25.5)
	OR (95% CI)	0.385 (0.297, 0.500)	0.757 (0.492, 1.16)	0.910 (0.665, 1.25)	0.758 (0.538, 1.07)
	p-value		0.206	0.556	0.113
2017	WP[α] (95% CI)	24.9 (20.6, 29.1)	22.1 (15.9, 28.3)	25.5 (21.5, 29.5)	23.7 (19.2, 28.1)
	OR (95% CI)	0.415 (0.321, 0.538)	0.828 (0.539, 1.27)	1.00 (0.734, 1.37)	0.941 (0.672, 1.32)
	p-value		0.388	0.984	0.723
2018	WP[α] (95% CI)	27.5 (22.3, 32.7)	24.2 (18.0, 26.4)	22.5 (18.7, 31.7)	26.2 (20.7, 31.7)
	OR (95% CI)	0.372 (0.280, 0.495)	0.844 (0.551, 1.29)	0.768 (0.546, 1.08)	0.936 (0.636, 1.38)
	p-value		0.436	0.129	0.737

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table IV: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 30 to 34 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	28.0 (24.7, 31.2)	25.3 (22.0, 28.7)	26.0 (23.3, 28.7)	25.2 (22.0, 28.4)
	OR (95% CI)	0.381 (0.319, 0.454)	0.873 (0.688, 1.11)	0.904 (0.731, 1.12)	0.869 (0.688, 1.10)
	p-value		0.265	0.352	0.236
1998	WP[α] (95% CI)	25.4 (22.0, 28.8)	23.6 (20.1, 27.2)	28.3 (25.3, 31.3)	27.1 (23.4, 30.8)
	OR (95% CI)	0.361 (0.296, 0.440)	0.899 (0.689, 1.17)	1.15 (0.913, 1.45)	1.09 (0.839, 1.41)
	p-value		0.434	0.232	0.527
1999	WP[α] (95% CI)	26.2 (22.6, 29.8)	21.7 (17.9, 25.5)	22.1 (19.3, 24.9)	29.4 (25.2, 33.5)
	OR (95% CI)	0.368 (0.302, 0.450)	0.777 (0.582, 1.04)	0.797 (0.624, 1.02)	1.17 (0.890, 1.53)
	p-value		0.088	0.070	0.264
2000	WP[α] (95% CI)	25.8 (22.3, 29.2)	25.0 (21.1, 29.0)	22.5 (19.8, 25.3)	23.4 (19.7, 27.0)
	OR (95% CI)	0.371 (0.305, 0.451)	0.962 (0.728, 1.27)	0.837 (0.659, 1.06)	0.880 (0.671, 1.16)
	p-value		0.783	0.146	0.359
2001	WP[α] (95% CI)	27.9 (24.3, 31.4)	27.6 (23.5, 31.6)	24.2 (21.5, 26.9)	33.5 (29.7, 37.3)
	OR (95% CI)	0.426 (0.353, 0.514)	0.974 (0.744, 1.27)	0.828 (0.657, 1.04)	1.31 (1.02, 1.67)
	p-value		0.845	0.105	0.033*
2002	WP[α] (95% CI)	26.6 (23.1, 30.2)	26.3 (22.2, 30.4)	21.3 (18.5, 24.0)	23.3 (19.8, 26.7)
	OR (95% CI)	0.382 (0.313, 0.497)	0.983 (0.743, 1.30)	0.743 (0.581, 0.950)	0.833 (0.639, 1.09)
	p-value		0.905	0.018*	0.179
2003	WP[α] (95% CI)	24.0 (20.3, 27.7)	24.4 (20.2, 28.5)	21.6 (18.9, 24.4)	23.5 (20.2, 26.9)
	OR (95% CI)	0.347 (0.279, 0.432)	1.01 (0.748, 1.38)	0.875 (0.676, 1.13)	0.977 (0.742, 1.29)
	p-value		0.925	0.313	0.870
2005	WP[α] (95% CI)	23.9 (20.2, 27.5)	25.5 (20.7, 26.3)	23.5 (20.7, 26.3)	25.5 (21.8, 29.2)
	OR (95% CI)	0.350 (0.282, 0.433)	1.08 (0.788, 1.48)	0.975 (0.7556, 1.26)	1.09 (0.822, 1.44)
	p-value		0.628	0.848	0.558
2006	WP[α] (95% CI)	27.5 (22.3, 32.6)	27.6 (22.2, 33.0)	22.5 (19.0, 25.9)	23.4 (19.2, 27.7)
	OR (95% CI)	0.378 (0.284, 0.504)	1.00 (0.691, 1.46)	0.765 (0.553, 1.06)	0.809 (0.569, 1.15)
	p-value		0.979	0.107	0.237
2007	WP[α] (95% CI)	25.1 (20.3, 29.9)	22.2 (16.8, 27.6)	22.6 (19.3, 25.9)	25.1 (20.6, 29.7)
	OR (95% CI)	0.344 (0.259, 0.456)	0.849 (0.568, 1.27)	0.869 (0.633, 1.19)	1.01 (0.709, 1.43)
	p-value		0.426	0.385	0.975

2008	WP[α] (95% CI)	24.9 (20.4, 29.4)	21.5 (15.8, 27.3)	24.1 (20.5, 27.7)	28.2 (23.6, 32.9)
	OR (95% CI)	0.375 (0.289, 0.487)	0.826 (0.546, 1.25)	0.956 (0.699, 1.31)	1.20 (0.862, 1.68)
	p-value		0.368	0.775	0.277
2009	WP[α] (95% CI)	27.3 (22.9, 31.6)	23.5 (18.3, 28.8)	24.8 (21.2, 28.5)	25.2 (20.9, 29.5)
	OR (95% CI)	0.407 (0.321, 0.516)	0.816 (0.565, 1.18)	0.882 (0.658, 1.18)	0.898 (0.654, 1.23)
	p-value		0.275	0.403	0.504
2010	WP[α] (95% CI)	26.1 (21.8, 30.3)	24.4 (19.1, 29.8)	25.0 (21.6, 28.3)	26.2 (22.3, 30.2)
	OR (95% CI)	0.374 (0.294, 0.477)	0.924 (0.644, 1.32)	0.948 (0.715, 1.26)	1.02 (0.753, 1.37)
	p-value		0.666	0.712	0.918
2011	WP[α] (95% CI)	27.4 (23.4, 31.5)	23.7 (19.0, 28.4)	26.9 (23.6, 30.2)	26.8 (23.1, 30.4)
	OR (95% CI)	0.416 (0.334, 0.517)	0.813 (0.584, 1.13)	0.969 (0.746, 1.26)	0.974 (0.739, 1.28)
	p-value		0.220	0.811	0.850
2012	WP[α] (95% CI)	22.9 (19.0, 26.8)	19.9 (15.5, 24.3)	23.9 (20.8, 26.9)	23.7 (20.2, 27.1)
	OR (95% CI)	0.328 (0.257, 0.420)	0.831 (0.583, 1.19)	1.05 (0.793, 1.38)	1.04 (0.776, 1.39)
	p-value		0.307	0.741	0.793
2013	WP[α] (95% CI)	25.3 (21.2, 29.3)	18.9 (14.5, 23.3)	27.9 (24.6, 31.2)	25.9 (22.3, 29.6)
	OR (95% CI)	0.409 (0.325, 0.514)	0.692 (0.482, 0.992)	1.12 (0.852, 1.46)	1.02 (0.767, 1.36)
	p-value		0.045*	0.424	0.879
2014	WP[α] (95% CI)	27.1 (22.3, 31.8)	25.5 (19.8, 31.1)	21.8 (18.3, 25.3)	25.9 (22.3, 29.6)
	OR (95% CI)	0.446 (0.342, 0.582)	0.914 (0.620, 1.35)	0.739 (0.535, 1.02)	0.947 (0.695, 1.29)
	p-value		0.650	0.066	0.732
2015	WP[α] (95% CI)	27.2 (22.4, 32.0)	30.6 (24.6, 36.6)	24.2 (21.0, 27.4)	27.0 (23.0, 30.9)
	OR (95% CI)	0.424 (0.325, 0.553)	1.15 (0.794, 1.68)	0.846 (0.628, 1.14)	0.988 (0.721, 1.35)
	p-value		0.453	0.273	0.941
2016	WP[α] (95% CI)	25.0 (20.5, 29.5)	24.6 (19.2, 30.0)	27.1 (23.2, 30.9)	22.1 (18.3, 26.0)
	OR (95% CI)	0.395 (0.305, 0.513)	0.945 (0.645, 1.39)	1.09 (0.798, 1.48)	0.848 (0.610, 1.18)
	p-value		0.773	0.601	0.328
2017	WP[α] (95% CI)	23.4 (19.3, 27.4)	27.8 (22.3, 33.3)	24.7 (21.3, 28.1)	26.4 (21.8, 31.0)
	OR (95% CI)	0.344 (0.270, 0.440)	1.28 (0.893, 1.83)	1.08 (0.804, 1.45)	1.20 (0.865, 1.67)
	p-value		0.180	0.613	0.275
2018	WP[α] (95% CI)	25.5 (20.9, 30.2)	19.6 (14.4, 24.8)	25.8 (22.1, 29.6)	32.3 (27.4, 37.2)
	OR (95% CI)	0.379 (0.291, 0.494)	0.712 (0.473, 1.07)	1.01 (0.741, 1.38)	1.40 (1.01, 1.95)
	p-value		0.104	0.938	0.045*

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table V: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 35 to 39 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	29.9 (26.8, 33.0)	28.3 (24.8, 31.7)	27.2 (24.6, 29.7)	30.3 (26.9, 33.7)
	OR (95% CI)	0.425 (0.361, 0.499)	0.923 (0.737, 1.16)	0.895 (0.720, 1.06)	1.02 (0.820, 1.27)
	p-value		0.487	0.179	0.865
1998	WP[α] (95% CI)	26.4 (23.2, 29.7)	27.7 (24.0, 31.3)	27.5 (24.7, 30.3)	29.1 (25.5, 32.7)
	OR (95% CI)	0.358 (0.299, 0.429)	1.07 (0.832, 1.36)	1.06 (0.849, 1.31)	1.14 (0.896, 1.45)
	p-value		0.616	0.624	0.284
1999	WP[α] (95% CI)	23.4 (20.3, 26.6)	30.3 (26.2, 34.4)	25.3 (22.5, 28.0)	24.5 (21.0, 28.0)
	OR (95% CI)	0.314 (0.259, 0.381)	1.42 (1.09, 1.84)	1.11 (0.881, 1.39)	1.06 (0.817, 1.37)
	p-value		0.008*	0.382	0.670
2000	WP[α] (95% CI)	29.3 (25.8, 32.8)	23.5 (19.9, 27.1)	28.0 (25.1, 30.8)	27.0 (23.4, 30.7)
	OR (95% CI)	0.414 (0.344, 0.499)	0.740 (0.549, 0.962)	0.937 (0.751, 1.17)	0.893 (0.695, 1.15)
	p-value		0.024*	0.563	0.379
2001	WP[α] (95% CI)	33.8 (30.2, 37.4)	34.4 (30.3, 38.5)	29.3 (26.6, 34.1)	30.4 (26.6, 34.1)
	OR (95% CI)	0.529 (0.445, 0630)	1.03 (0.807, 1.31)	0.813 (0.656, 1.01)	0.861 (0.677, 1.09)
	p-value		0.815	0.059	0.222
2002	WP[α] (95% CI)	25.1 (21.6, 28.6)	25.5 (21.6, 29.3)	23.9 (21.2, 26.7)	29.6 (25.6, 33.7)
	OR (95% CI)	0.352 (0.287, 0.430)	1.02 (0.771, 1.34)	0.938 (0.738, 1.19)	1.26 (0.961, 1.64)
	p-value		0.908	0.598	0.096
2003	WP[α] (95% CI)	30.3 (26.4, 34.1)	27.6 (23.6, 31.7)	25.0 (22.0, 28.0)	30.3 (26.4, 34.3)
	OR (95% CI)	0.434 (0.353, 0.533)	0.880 (0.669, 1.16)	0.768 (0.603, 0.977)	1.00 (0.772, 1.30)
	p-value		0.358	0.032*	0.981
2005	WP[α] (95% CI)	30.8 (27.1, 34.5)	27.9 (23.7, 32.2)	25.1 (22.0, 28.3)	28.9 (24.8, 33.0)
	OR (95% CI)	0.433 (0.357, 0.526)	0.874 (0.664, 1.15)	0.754 (0.593, 0.960)	0.913 (0.701, 1.19)
	p-value		0.336	0.022*	0.498
2006	WP[α] (95% CI)	24.1 (19.5, 28.7)	27.0 (22.0, 32.1)	23.0 (19.3, 26.7)	25.8 (21.4, 30.1)
	OR (95% CI)	0.306 (0.231, 0.404)	1.17 (0.816, 1.67)	0.943 (0.680, 1.31)	1.09 (0.780, 1.54)
	p-value		0.398	0.723	0.600
2007	WP[α] (95% CI)	28.4 (23.7, 33.2)	22.9 (17.7, 28.0)	18.2 (15.3, 21.1)	30.3 (25.5, 35.1)
	OR (95% CI)	0.421 (0.328, 0.542)	0.753 (0.517, 1.10)	0.561 (0.412, 0.762)	1.11 (0.797, 1.54)
	p-value		0.139	< 0.001*	0.543

2008	WP[α] (95% CI)	25.7 (20.9, 30.6)	29.0 (23.1, 34.8)	26.3 (23.1, 34.8)	26.9 (22.3, 31.6)
	OR (95% CI)	0.364 (0.276, 0.480)	1.17 (0.798, 1.72)	1.03 (0.751, 1.42)	1.06 (0.751, 1.50)
	p-value		0.422	0.871	0.737
2009	WP[α] (95% CI)	27.4 (22.5, 32.2)	27.5 (22.0, 33.0)	28.2 (24.4, 32.1)	25.9 (21.4, 30.5)
	OR (95% CI)	0.454 (0.347, 0.592)	1.03 (0.711, 1.49)	1.06 (0.778, 1.44)	0.962 (0.685, 1.35)
	p-value		0.882	0.716	0.821
2010	WP[α] (95% CI)	33.2 (28.4, 38.0)	25.4 (20.2, 30.5)	28.6 (25.2, 32.0)	26.5 (22.3, 30.6)
	OR (95% CI)	0.566 (0.446, 0.718)	0.691 (0.488, 0.978)	0.802 (0.609, 1.06)	0.727 (0.535, 0.987)
	p-value		0.037*	0.115	0.041*
2011	WP[α] (95% CI)	27.7 (23.7, 31.8)	25.1 (20.4, 29.9)	28.3 (24.8, 31.7)	25.4 (21.8, 29.0)
	OR (95% CI)	0.398 (0.319, 0.496)	0.876 (0.634, 1.21)	1.03 (0.789, 1.34)	0.887 (0.672, 1.17)
	p-value		0.421	0.836	0.397
2012	WP[α] (95% CI)	28.8 (24.3, 33.3)	26.9 (21.7, 32.1)	27.0 (23.6, 30.3)	28.3 (24.4, 32.3)
	OR (95% CI)	0.430 (0.339, 0.546)	0.911 (0.646, 1.29)	0.917 (0.695, 1.21)	0.981 (0.731, 1.32)
	p-value		0.596	0.541	0.897
2013	WP[α] (95% CI)	27.1 (22.0, 32.2)	28.9 (22.9, 35.0)	26.0 (22.5, 29.5)	26.0 (22.3, 29.6)
	OR (95% CI)	0.387 (0.291, 0.517)	1.09 (0.738, 1.62)	0.942 (0.686, 1.29)	0.940 (0.682, 1.30)
	p-value		0.656	0.709	0.704
2014	WP[α] (95% CI)	28.4 (23.7, 33.1)	27.0 (21.4, 32.5)	28.5 (24.7, 32.2)	27.3 (23.3, 31.2)
	OR (95% CI)	0.422 (0.327, 0.544)	0.932 (0.678, 1.34)	1.00 (0.745, 1.35)	0.944 (0.696, 1.28)
	p-value		0.707	0.991	0.713
2015	WP[α] (95% CI)	27.6 (22.9, 32.4)	26.7 (21.2, 32.2)	26.5 (22.9, 30.1)	28.0 (23.7, 32.2)
	OR (95% CI)	0.377 (0.292, 0.488)	0.954 (0.658, 1.38)	0.945 (0.699, 1.28)	1.02 (0.739, 1.40)
	p-value		0.802	0.716	0.922
2016	WP[α] (95% CI)	32.5 (27.7, 37.3)	30.2 (23.8, 36.6)	23.5 (20.1, 27.0)	27.5 (22.9, 32.0)
	OR (95% CI)	0.519 (0.407, 0.662)	0.904 (0.621, 1.31)	0.642 (0.478, 0.860)	0.793 (0.578, 1.09)
	p-value		0.596	0.003*	0.152
2017	WP[α] (95% CI)	28.3 (23.9, 32.8)	25.5 (19.2, 31.9)	25.9 (22.2, 29.6)	26.7 (22.1, 31.2)
	OR (95% CI)	0.400 (0.311, 0.514)	0.866 (0.580, 1.29)	0.886 (0.661, 1.19)	0.920 (0.669, 1.27)
	p-value		0.481	0.416	0.610
2018	WP[α] (95% CI)	33.2 (27.7, 38.7)	25.6 (19.9, 31.3)	27.4 (23.7, 31.3)	29.2 (24.4, 34.0)
	OR (95% CI)	0.519 (0.400, 0.675)	0.689 (0.467, 1.02)	0.762 (0.557, 1.04)	0.829 (0.589, 1.17)
	p-value		0.061	0.090	0.282

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table VI: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 40 to 44 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	30.3 (27.0, 33.6)	28.1 (24.5, 31.6)	28.3 (25.4, 31.0)	29.8 (26.1, 33.5)
	OR (95% CI)	0.452 (0.381, 0.538)	0.897 (0.710, 1.14)	0.906 (0.736, 1.12)	0.977 (0.771, 1.24)
	p-value		0.367	0.353	0.845
1998	WP[α] (95% CI)	29.4 (25.9, 32.9)	24.7 (21.0, 28.5)	25.3 (22.5, 28.1)	26.9 (23.2, 30.6)
	OR (95% CI)	0.424 (0.352, 0.511)	0.791 (0.607, 1.03)	0.815 (0.650, 1.02)	0.885 (0.687, 11.14)
	p-value		0.081	0.076	0.344
1999	WP[α] (95% CI)	27.1 (23.5, 30.7)	30.2 (25.9, 34.5)	21.9 (19.2, 24.5)	31.3 (27.4, 35.1)
	OR (95% CI)	0.384 (0.314, 0.468)	1.16 (0.885, 1.52)	0.752 (0.592, 0.954)	1.22 (0.948, 1.58)
	p-value		0.280	0.019*	0.122
2000	WP[α] (95% CI)	24.6 (21.3, 28.0)	28.0 (24.0, 32.0)	29.4 (26.4, 32.0)	31.1 (27.0, 35.2)
	OR (95% CI)	0.321 (0.263, 0.393)	1.19 (0.911, 0.156)	1.27 (1.01, 1.61)	1.38 (1.06, 1.79)
	p-value				
2001	WP[α] (95% CI)	31.8 (28.2, 35.4)	31.3 (27.5, 35.1)	30.2 (27.3, 33.1)	32.7 (28.8, 36.5)
	OR (95% CI)	0.476 (0.397, 0.571)	0.976 (0.765, 1.25)	0.926 (0.747, 1.15)	1.04 (0.817, 1.32)
	p-value		0.845	0.482	0.755
2002	WP[α] (95% CI)	26.6 (22.9, 30.2)	30.0 (25.9, 34.2)	23.9 (21.1, 26.6)	28.5 (24.7, 32.4)
	OR (95% CI)	0.366 (0.298, 0.449)	1.19 (0.906, 1.56)	0.867 (0.681, 1.10)	1.11 (0.848, 1.44)
	p-value		0.213	0.245	0.457
2003	WP[α] (95% CI)	29.6 (26.0, 33.2)	29.2 (24.9, 33.5)	25.8 (22.7, 28.8)	27.5 (23.8, 31.3)
	OR (95% CI)	0.463 (0.381, 0.561)	0.976 (0.743, 1.28)	0.820 (0.648, 1.04)	0.903 (0.700, 1.17)
	p-value		0.859	0.097	0.434
2005	WP[α] (95% CI)	33.2 (29.4, 37.0)	31.9 (27.6, 36.3)	28.5 (25.4, 31.6)	27.8 (24.1, 31.6)
	OR (95% CI)	0.494 (0.408, 0.598)	0.944 (0.726, 1.23)	0.804 (0.639, 1.01)	0.776 (0.601, 1.00)
	p-value		0.671	0.063	0.052
2006	WP[α] (95% CI)	30.3 (25.4, 35.2)	30.5 (25.1, 35.8)	27.2 (23.8, 30.6)	28.2 (23.7, 32.6)
	OR (95% CI)	0.449 (0.350, 0.575)	1.00 (0.712, 1.42)	0.855 (0.641, 1.14)	0.897 (0.651, 1.23)
	p-value		0.980	0.287	0.504
2007	WP[α] (95% CI)	24.3 (19.5, 29.1)	28.0 (22.5, 33.5)	22.3 (18.9, 25.7)	30.3 (25.5, 35.1)
	OR (95% CI)	0.311 (0.239, 0.406)	1.21 (0.832, 1.77)	0.893 (0.644, 1.24)	1.35 (0.959, 1.91)
	p-value		0.315	0.498	0.085

2008	WP[α] (95% CI)	31.6 (26.6, 36.6)	30.2 (23.6, 36.9)	26.5 (22.5, 30.6)	28.2 (23.1, 33.3)
	OR (95% CI)	0.466 (0.360, 0.602)	0.937 (0.634, 1.38)	0.781 (0.573, 1.06)	0.850 (0.604, 1.19)
	p-value		0.743	0.118	0.349
2009	WP[α] (95% CI)	28.6 (23.7, 33.4)	34.0 (28.6, 39.5)	30.6 (26.4, 34.8)	28.5 (23.8, 33.8)
	OR (95% CI)	0.389 (0.301, 0.504)	1.29 (0.920, 1.81)	1.10 (0.811, 1.50)	0.995 (0.715, 1.39)
	p-value		0.139	0.536	0.976
2010	WP[α] (95% CI)	27.8 (23.3, 32.2)	27.0 (21.8, 32.2)	34.8 (31.0, 38.7)	28.0 (23.6, 32.3)
	OR (95% CI)	0.381 (0.299, 0.485)	0.963 (0.682, 1.36)	1.39 (1.05, 1.84)	1.01 (0.741, 1.38)
	p-value		0.832	0.022*	0.945
2011	WP[α] (95% CI)	29.9 (25.6, 34.1)	32.1 (26.9, 37.2)	33.5 (30.1, 37.0)	30.3 (26.3, 34.4)
	OR (95% CI)	0.414 (0.330, 0.519)	1.11 (0.812, 1.52)	1.18 (0.918, 1.53)	1.02 (0.773, 1.35)
	p-value		0.516	0.194	0.879
2012	WP[α] (95% CI)	30.8 (26.2, 35.3)	27.7 (22.5, 32.9)	27.8 (24.5, 31.1)	27.1 (23.1, 31.0)
	OR (95% CI)	0.436 (0.343, 0.554)	0.931 (0.656, 1.32)	0.807 (0.615, 1.06)	1.19 (0.894, 1.60)
	p-value		0.687	0.123	0.230
2013	WP[α] (95% CI)	29.6 (25.1, 34.0)	28.1 (22.6, 33.7)	25.3 (22.2, 28.5)	33.4 (29.1, 37.7)
	OR (95% CI)	0.436 (0.343, 0.554)	0.931 (0.656, 1.32)	0.807 (0.615, 1.06)	1.19 (0.894, 1.60)
	p-value		0.687	0.123	0.230
2014	WP[α] (95% CI)	30.0 (25.0, 34.9)	24.2 (19.2, 29.2)	29.5 (25.9, 33.1)	27.9 (23.9, 31.9)
	OR (95% CI)	0.433 (0.335, 0.560)	0.744 (0.519, 1.07)	0.977 (0.730, 1.31)	0.903 (0.662, 1.23)
	p-value		0.109	0.877	0.517
2015	WP[α] (95% CI)	32.8 (27.7, 37.9)	24.4 (19.0, 29.7)	26.3 (22.9, 29.8)	28.7 (24.2, 33.1)
	OR (95% CI)	0.543 (0.421, 0.701)	0.647 (0.446, 0.937)	0.724 (0.540, 0.971)	0.815 (0.592, 1.12)
	p-value		0.022*	0.031*	0.211
2016	WP[α] (95% CI)	31.9 (27.1, 36.7)	28.8 (22.6, 35.0)	32.0 (27.6, 36.3)	29.6 (24.4, 34.8)
	OR (95% CI)	0.438 (0.340, 0.563)	0.856 (0.589, 1.24)	1.00 (0.745, 1.35)	0.897 (0.642, 1.25)
	p-value		0.417	0.988	0.526
2017	WP[α] (95% CI)	33.2 (27.9, 38.4)	25.8 (19.1, 32.4)	28.9 (24.9, 32.9)	27.8 (22.8, 32.9)
	OR (95% CI)	0.568 (0.438, 0.738)	0.683 (0.448, 1.04)	0.813 (0.598, 1.11)	0.779 (0.551, 1.10)
	p-value		0.076	0.187	0.157
2018	WP[α] (95% CI)	29.3 (24.4, 34.2)	26.4 (20.9, 31.9)	28.3 (24.2, 32.4)	31.8 (26.8, 36.8)
	OR (95% CI)	0.398 (0.305, 0.520)	0.872 (0.601, 1.26)	0.959 (0.702, 1.31)	1.12 (0.808, 1.57)
	p-value		0.470	0.795	0.486

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table VII: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 45 to 49 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	29.8 (26.2, 33.4)	28.6 (24.7, 32.6)	28.2 (25.1, 31.2)	34.1 (30.1, 38.1)
	OR (95% CI)	0.465 (0.386, 0.561)	0.943 (0.727, 1.22)	0.923 (0.734, 1.16)	1.22 (0.952, 1.47)
	p-value		0.662	0.495	0.116
1998	WP[α] (95% CI)	31.8 (27.9, 35.7)	29.3 (25.3, 33.3)	28.3 (25.2, 31.3)	29.1 (24.9, 33.3)
	OR (95% CI)	0.475 (0.388, 0.580)	0.890 (0.683, 1.16)	0.847 (0.670, 1.07)	0.881 (0.672, 1.16)
	p-value		0.385	0.167	0.362
1999	WP[α] (95% CI)	28.9 (24.9, 32.9)	30.7 (26.1, 35.3)	29.8 (26.5, 33.1)	30.1 (26.0, 34.2)
	OR (95% CI)	0.418 (0.337, 0.519)	1.09 (0.816, 1.46)	1.04 (0.810, 1.34)	1.06 (0.800, 1.39)
	p-value		0.555	0.750	0.700
2000	WP[α] (95% CI)	30.4 (26.7, 34.1)	30.0 (25.5, 34.5)	29.7 (26.5, 32.9)	28.5 (24.5, 32.5)
	OR (95% CI)	0.465 (0.383, 0.564)	0.982 (0.744, 1.30)	0.967 (0.765, 1.22)	0.914 (0.702, 1.19)
	p-value		0.900	0.777	0.506
2001	WP[α] (95% CI)	33.9 (29.9, 37.8)	34.9 (30.4, 39.5)	32.4 (29.2, 35.6)	35.3 (31.3, 39.3)
	OR (95% CI)	0.482 (0.397, 0.584)	1.05 (0.804, 1.37)	0.939 (0.747, 1.18)	1.07 (0.832, 1.37)
	p-value		0.718	0.592	0.609
2002	WP[α] (95% CI)	27.5 (23.8, 31.2)	33.4 (28.7, 38.0)	26.5 (23.5, 29.5)	29.5 (25.1, 33.8)
	OR (95% CI)	0.390 (0.319, 0.477)	1.32 (0.996, 1.74)	0.949 (0.746, 1.21)	1.10 (0.832, 1.45)
	p-value		0.053	0.674	0.507
2003	WP[α] (95% CI)	30.2 (26.3, 34.1)	30.7 (26.3, 35.1)	26.1 (23.1, 29.1)	32.5 (28.1, 36.8)
	OR (95% CI)	0.465 (0.379, 0.570)	1.02 (0.773, 1.35)	0.810 (0.635, 1.03)	1.11 (0.845, 1.46)
	p-value		0.874	0.091	0.454
2005	WP[α] (95% CI)	30.5 (26.5, 34.4)	28.4 (24.1, 32.8)	27.7 (24.6, 30.7)	30.9 (27.0, 34.8)
	OR (95% CI)	0.428 (0.350, 0.523)	0.909 (0.684, 1.21)	0.873 (0.687, 1.11)	1.02 (0.786, 1.33)
	p-value		0.509	0.269	0.876
2006	WP[α] (95% CI)	28.7 (24.2, 33.2)	29.5 (24.3, 34.7)	28.8 (25.3, 32.4)	27.2 (25.3, 32.4)
	OR (95% CI)	0.434 (0.341, 0.551)	1.04 (0.741, 1.45)	1.02 (0.767, 1.35)	0.937 (0.680, 1.29)
	p-value		0.836	0.910	0.689
2007	WP[α] (95% CI)	29.9 (24.9, 34.9)	26.1 (21.2, 31.1)	28.5 (24.8, 32.2)	29.1 (24.4, 33.9)
	OR (95% CI)	0.470 (0.362, 0.610)	0.821 (0.578, 1.17)	0.929 (0.688, 1.26)	0.965 (0.692, 1.34)
	p-value		0.272	0.633	0.832

2008	WP[α] (95% CI)	27.4 (22.5, 32.3)	28.2 (23.0, 33.4)	25.5 (21.8, 29.2)	28.4 (23.7, 33.2)
	OR (95% CI)	0.409 (0.315, 0.530)	1.04 (0.730, 1.49)	0.912 (0.665, 1.25)	1.07 (0.760, 1.50)
	p-value		0.816	0.565	0.707
2009	WP[α] (95% CI)	33.4 (28.6, 38.3)	30.7 (25.3, 36.0)	32.2 (28.3, 36.1)	33.5 (28.2, 38.8)
	OR (95% CI)	0.529 (0.416, 0.672)	0.873 (0.626, 1.22)	0.940 (0.709, 1.25)	1.00 (0.725, 1.38)
	p-value		0.422	0.666	0.999
2010	WP[α] (95% CI)	29.2 (24.6, 33.9)	28.2 (22.8, 33.6)	30.4 (26.8, 34.0)	33.0 (28.5, 37.4)
	OR (95% CI)	0.451 (0.353, 0.577)	0.949 (0.670, 1.34)	1.05 (0.792, 1.39)	1.19 (0.876, 1.61)
	p-value		0.768	0.737	0.269
2011	WP[α] (95% CI)	32.0 (27.8, 36.1)	31.5 (26.5, 36.4)	33.1 (29.7, 36.6)	31.5 (27.3, 35.6)
	OR (95% CI)	0.525 (0.427, 0.645)	0.975 (0.723, 1.31)	1.06 (0.826, 1.35)	0.974 (0.743, 1.28)
	p-value		0.869	0.657	0.848
2012	WP[α] (95% CI)	32.3 (27.6, 37.1)	30.9 (25.9, 35.9)	33.8 (30.1, 37.5)	34.2 (29.8, 38.7)
	OR (95% CI)	0.527 (0.418, 0.666)	0.926 (0.673, 1.28)	1.07 (0.811, 1.40)	1.09 (0.812, 1.47)
	p-value		0.639	0.650	0.564
2013	WP[α] (95% CI)	34.0 (29.2, 38.9)	30.2 (24.6, 35.8)	33.2 (29.5, 36.9)	28.9 (24.7, 33.1)
	OR (95% CI)	0.523 (0.414, 0.661)	0.839 (0.596, 1.18)	0.961 (0.731, 1.26)	0.787 (0.585, 1.06)
	p-value		0.317	0.777	0.113
2014	WP[α] (95% CI)	32.8 (27.7, 37.9)	33.5 (27.5, 39.4)	31.5 (27.8, 35.3)	31.9 (27.3, 36.5)
	OR (95% CI)	0.451 (0.349, 0.583)	1.02 (0.722, 1.45)	0.940 (0.705, 1.25)	0.962 (0.703, 1.32)
	p-value		0.892	0.675	0.806
2015	WP[α] (95% CI)	32.1 (27.0, 37.2)	31.3 (25.5, 37.1)	35.5 (31.4, 39.7)	33.7 (29.1, 38.4)
	OR (95% CI)	0.506 (0.392, 0.653)	0.963 (0.672, 1.38)	1.16 (0.865, 1.57)	1.08 (0.786, 1.47)
	p-value		0.837	0.317	0.650
2016	WP[α] (95% CI)	31.8 (26.9, 36.7)	31.6 (26.0, 37.2)	28.5 (24.8, 32.1)	32.3 (27.6, 37.0)
	OR (95% CI)	0.489 (0.382, 0.626)	0.989 (0.702, 1.39)	0.859 (0.644, 1.15)	1.03 (0.751, 1.40)
	p-value		0.950	0.303	0.874
2017	WP[α] (95% CI)	27.5 (22.8, 32.2)	28.8 (22.7, 34.8)	32.8 (28.7, 36.8)	34.5 (29.1, 39.8)
	OR (95% CI)	0.409 (0.314, 0.533)	1.06 (0.727, 1.55)	1.26 (0.937, 1.70)	1.38 (0.987, 1.93)
	p-value		0.759	0.125	0.059
2018	WP[α] (95% CI)	33.9 (28.6, 39.2)	25.5 (19.8, 31.1)	32.3 (28.1, 36.5)	29.9 (24.9, 35.0)
	OR (95% CI)	0.504 (0.389, 0.653)	0.665 (0.455, 0.972)	0.928 (0.588, 1.17)	0.828 (0.588, 1.17)
	p-value		0.035*	0.633	0.279

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table VIII: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 50 to 54 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	35.7 (31.3, 40.1)	34.2 (29.5, 38.9)	31.2 (27.9, 34.6)	31.8 (27.4, 36.2)
	OR (95% CI)	0.597 (0.484, 0.736)	0.930 (0.701, 1.23)	0.815 (0.637, 1.04)	0.842 (0.637, 1.11)
	p-value		0.615	0.105	0.227
1998	WP[α] (95% CI)	34.5 (30.2, 38.7)	29.6 (25.0, 34.1)	31.2 (27.9, 34.6)	34.6 (29.9, 39.3)
	OR (95% CI)	0.591 (0.482, 0.726)	0.787 (0.589, 1.05)	0.856 (0.669, 1.10)	0.996 (0.753, 1.32)
	p-value		0.106	0.217	0.978
1999	WP[α] (95% CI)	31.3 (27.1, 35.5)	31.5 (27.0, 36.1)	30.6 (27.1, 34.1)	30.7 (25.9, 35.5)
	OR (95% CI)	0.517 (0.418, 0.639)	1.01 (0.756, 1.35)	0.974 (0.753, 1.26)	0.792 (0.720, 1.31)
	p-value		0.950	0.842	0.856
2000	WP[α] (95% CI)	29.4 (25.5, 33.4)	29.2 (24.6, 33.8)	28.0 (24.8, 31.3)	30.3 (25.9, 34.7)
	OR (95% CI)	0.471 (0.382, 0.580)	0.988 (0.738, 1.32)	0.927 (0.723, 1.19)	1.05 (0.794, 1.40)
	p-value		0.937	0.549	0.722
2001	WP[α] (95% CI)	36.2 (32.2, 40.2)	34.9 (30.3, 39.4)	33.8 (30.6, 37.1)	37.9 (33.2, 42.6)
	OR (95% CI)	0.628 (0.518, 0.762)	0.939 (0.719, 1.23)	0.900 (0.717, 1.13)	1.08 (0.827, 1.40)
	p-value		0.643	0.363	0.581
2002	WP[α] (95% CI)	28.0 (24.2, 31.9)	28.2 (23.5, 32.9)	31.0 (27.5, 34.5)	31.6 (26.7, 36.5)
	OR (95% CI)	0.438 (0.354, 0.542)	1.01 (0.750, 1.37)	1.15 (0.895, 1.48)	1.17 (0.870, 1.58)
	p-value		0.936	0.275	0.297
2003	WP[α] (95% CI)	30.8 (26.7, 34.9)	30.1 (25.6, 34.6)	29.4 (26.1, 32.7)	37.0 (32.1, 41.9)
	OR (95% CI)	0.451 (0.366, 0.556)	0.967 (0.725, 1.29)	0.933 (0.727, 1.20)	1.32 (0.992, 1.75)
	p-value		0.819	0.587	0.057
2005	WP[α] (95% CI)	31.7 (27.8, 35.6)	33.1 (28.1, 38.0)	30.7 (27.4, 34.0)	30.8 (26.7, 34.9)
	OR (95% CI)	0.502 (0.412, 0.613)	1.07 (0.806, 1.43)	0.955 (0.753, 1.21)	0.968 (0.744, 1.26)
	p-value		0.624	0.708	0.810
2006	WP[α] (95% CI)	33.2 (28.4, 38.1)	28.0 (22.7, 33.2)	31.4 (27.4, 35.9)	33.2 (27.9, 38.5)
	OR (95% CI)	0.506 (0.397, 0.644)	0.781 (0.556, 1.10)	0.919 (0.689, 1.23)	0.999 (0.723, 1.38)
	p-value		0.154	0.565	0.994
2007	WP[α] (95% CI)	25.6 (20.9, 30.3)	26.4 (21.4, 31.5)	26.5 (22.6, 30.4)	31.2 (26.4, 36.0)
	OR (95% CI)	0.350 (0.267, 0.458)	1.05 (0.731, 1.50)	1.05 (0.764, 1.44)	1.32 (0.946, 1.84)
	p-value		0.805	0.768	0.102

2008	WP[α] (95% CI)	30.8 (25.8, 35.8)	30.7 (24.9, 36.5)	32.9 (28.7, 37.1)	30.9 (25.9, 35.9)
	OR (95% CI)	0.428 (0.329, 0.556)	1.00 (0.699, 1.44)	1.10 (0.815, 1.49)	1.01 (0.722, 1.40)
	p-value		0.990	0.525	0.972
2009	WP[α] (95% CI)	33.4 (28.8, 38.0)	33.0 (26.7, 39.3)	29.6 (25.9, 33.3)	30.6 (25.7, 35.6)
	OR (95% CI)	0.484 (0.385, 0.609)	0.985 (0.691, 1.40)	0.838 (0.637, 1.10)	0.881 (0.645, 1.20)
	p-value		0.932	0.206	0.425
2010	WP[α] (95% CI)	32.8 (28.2, 37.4)	31.5 (26.2, 36.7)	31.9 (28.2, 35.6)	33.4 (28.6, 38.1)
	OR (95% CI)	0.522 (0.417, 0.655)	0.941 (0.682, 1.30)	0.962 (0.735, 1.26)	1.03 (0.762, 1.39)
	p-value		0.712	0.779	0.856
2011	WP[α] (95% CI)	29.9 (25.8, 34.1)	34.0 (28.7, 39.2)	31.4 (28.0, 34.8)	34.9 (30.6, 39.3)
	OR (95% CI)	0.412 (0.331, 0.512)	1.20 (0.885, 1.63)	1.07 (0.832, 1.38)	1.25 (0.954, 1.65)
	p-value		0.239	0.593	0.105
2012	WP[α] (95% CI)	31.3 (26.6, 36.1)	26.9 (22.3, 31.6)	30.2 (26.9, 33.6)	32.4 (28.0, 36.8)
	OR (95% CI)	0.463 (0.369, 0.581)	0.808 (0.5844, 1.12)	0.949 (0.722, 1.25)	1.05 (0.780, 1.42)
	p-value		0.198	0.709	0.739
2013	WP[α] (95% CI)	38.5 (33.2, 43.7)	31.9 (26.7, 37.2)	31.5 (28.0, 35.1)	32.0 (27.7, 36.2)
	OR (95% CI)	0.680 (0.534, 0.864)	0.746 (0.537, 1.04)	0.736 (0.559, 0.969)	0.754 (0.560, 1.01)
	p-value		0.081	0.029*	0.061
2014	WP[α] (95% CI)	32.4 (27.9, 36.9)	27.7 (22.3, 33.1)	28.5 (25.0, 32.0)	31.3 (26.8, 35.8)
	OR (95% CI)	0.528 (0.419, 0.665)	0.799 (0.562, 1.12)	0.824 (0.631, 1.08)	0.944 (0.704, 1.27)
	p-value		0.196	0.154	0.701
2015	WP[α] (95% CI)	32.6 (27.5, 37.6)	36.2 (30.6, 41.9)	35.8 (32.0, 39.6)	37.7 (32.8, 42.7)
	OR (95% CI)	0.474 (0.371, 0.606)	1.18 (0.843, 1.65)	1.15 (0.869, 1.53)	1.25 (0.917, 1.71)
	p-value		0.336	0.322	0.156
2016	WP[α] (95% CI)	33.3 (28.6, 37.9)	31.2 (25.3, 37.0)	35.1 (31.4, 38.8)	32.9 (28.1, 37.8)
	OR (95% CI)	0.545 (0.432, 0.686)	0.909 (0.643, 1.28)	1.09 (0.834, 1.42)	0.990 (0.731, 1.34)
	p-value		0.588	0.532	0.948
2017	WP[α] (95% CI)	32.9 (27.9, 37.9)	31.3 (25.4, 37.3)	32.8 (28.8, 36.7)	31.9 (26.5, 37.2)
	OR (95% CI)	0.512 (0.398, 0.657)	0.926 (0.646, 1.32)	0.992 (0.742, 1.33)	0.959 (0.686, 1.34)
	p-value		0.664	0.956	0.809
2018	WP[α] (95% CI)	29.7 (24.7, 34.6)	29.8 (24.0, 35.7)	32.0 (27.9, 36.0)	33.1 (28.0, 38.2)
	OR (95% CI)	0.477 (0.367, 0.620)	0.990 (0.688, 1.43)	1.11 (0.822, 1.50)	1.15 (0.829, 1.61)
	p-value		0.958	0.498	0.395

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table IX: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 55 to 59 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	29.4 (25.0, 33.8)	31.5 (26.5, 36.4)	32.4 (28.6, 36.2)	33.3 (28.2, 38.4)
	OR (95% CI)	0.402 (0.318, 0.507)	1.11 (0.809, 1.52)	1.15 (0.876, 1.52)	1.20 (0.877, 1.64)
	p-value		0.524	0.308	0.254
1998	WP[α] (95% CI)	28.4 (23.8, 33.0)	37.4 (31.8, 43.1)	30.7 (27.0, 34.4)	34.2 (28.8, 39.6)
	OR (95% CI)	0.453 (0.357, 0.576)	1.50 (1.07, 2.09)	1.11 (0.830, 1.47)	1.32 (0.947, 1.84)
	p-value		0.017*	0.490	0.101
1999	WP[α] (95% CI)	31.0 (26.3, 35.7)	29.2 (24.3, 34.2)	29.4 (25.8, 33.1)	31.6 (26.5, 36.7)
	OR (95% CI)	0.505 (0.398, 0.641)	0.916 (0.663, 1.26)	0.926 (0.699, 1.22)	1.03 (0.746, 1.42)
	p-value		0.593	0.589	0.863
2000	WP[α] (95% CI)	34.4 (29.5, 39.3)	26.5 (21.7, 31.2)	31.4 (27.7, 35.0)	34.7 (29.5, 39.8)
	OR (95% CI)	0.567 (0.447, 0.718)	0.684 (0.493, 0.949)	0.874 (0.622, 1.15)	1.01 (0.740, 1.39)
	p-value		0.023*	0.338	0.939
2001	WP[α] (95% CI)	36.3 (31.5, 41.1)	33.3 (28.3, 38.4)	37.0 (33.2, 40.7)	34.2 (29.2, 39.3)
	OR (95% CI)	0.608 (0.485, 0.764)	0.873 (0.641, 1.19)	1.03 (0.791, 1.34)	0.909 (0.670, 1.23)
	p-value		0.388	0.838	0.538
2002	WP[α] (95% CI)	32.4 (27.7, 37.1)	34.6 (29.5, 39.8)	30.1 (26.4, 33.7)	31.7 (27.0, 36.5)
	OR (95% CI)	0.556 (0.442, 0.701)	1.10 (0.801, 1.50)	0.889 (0.674, 1.17)	0.987 (0.724, 1.34)
	p-value		0.566	0.405	0.933
2003	WP[α] (95% CI)	36.7 (32.2, 41.2)	36.4 (31.2, 41.7)	36.1 (32.4, 39.8)	32.7 (27.8, 37.6)
	OR (95% CI)	0.665 (0.538, 0.822)	0.966 (0.718, 1.30)	0.965 (0.750, 1.24)	0.823
	p-value		0.820	0.780	0.198
2005	WP[α] (95% CI)	25.6 (21.9, 29.4)	37.2 (32.1, 42.3)	32.4 (28.8, 35.9)	31.2 (26.7, 35.8)
	OR (95% CI)	0.382 (0.307, 0.474)	1.74 (1.30, 2.34)	1.39 (1.08, 1.80)	1.33 (0.999, 1.78)
	p-value		< 0.001*	0.011*	0.051
2006	WP[α] (95% CI)	35.8 (30.3, 41.4)	32.5 (26.6, 38.5)	27.2 (23.5, 30.9)	34.2 (26.9, 39.4)
	OR (95% CI)	0.647 (0.496, 0.844)	0.845 (0.587, 1.22)	0.655 (0.483, 0.889)	0.928 (0.665, 1.30)
	p-value		0.366	0.007*	0.661
2007	WP[α] (95% CI)	27.0 (22.2, 31.8)	28.5 (22.4, 34.6)	29.3 (25.1, 33.5)	34.3 (28.7, 40.0)
	OR (95% CI)	0.384 (0.294, 0.503)	1.08 (0.735, 1.59)	1.12 (0.815, 1.54)	1.41 (0.995, 2.01)
	p-value		0.693	0.486	0.054

2008	WP[α] (95% CI)	26.9 (21.8, 31.9)	26.9 (20.9, 33.0)	28.8 (24.8, 32.8)	30.4 (25.3, 35.4)
	OR (95% CI)	0.400 (0.306, 0.524)	0.991 (0.665, 1.48)	1.10 (0.793, 1.52)	1.19 (0.835, 1.69)
	p-value		0.965	0.577	0.337
2009	WP[α] (95% CI)	38.7 (33.4, 43.9)	34.8 (28.8, 40.9)	31.2 (27.2, 35.2)	31.1 (26.2, 36.0)
	OR (95% CI)	0.708 (0.557, 0.899)	0.487 (0.599, 1.20)	0.726 (0.543, 0.971)	0.712 (0.516, 0.981)
	p-value		0.346	0.031*	0.038*
2010	WP[α] (95% CI)	35.4 (30.4, 40.4)	32.9 (27.0, 38.9)	34.7 (30.9, 38.9)	37.5 (27.0, 38.9)
	OR (95% CI)	0.589 (0.464, 0.748)	0.891 (0.629, 1.26)	0.965 (0.733, 1.48)	1.08 (0.793, 1.48)
	p-value		0.516	0.801	0.615
2011	WP[α] (95% CI)	34.3 (29.7, 38.9)	31.2 (26.0, 36.4)	39.2 (35.5, 42.8)	33.6 (29.3, 38.0)
	OR (95% CI)	0.524 (0.418, 0.657)	0.867 (0.630, 1.19)	1.23 (0.953, 1.59)	0.969 (0.731, 1.29)
	p-value		0.379	0.111	0.829
2012	WP[α] (95% CI)	27.2 (22.9, 31.5)	33.7 (28.3, 38.7)	34.3 (28.3, 38.7)	31.9 (27.6, 36.2)
	OR (95% CI)	0.386 (0.306, 0.486)	1.36 (0.948, 1.87)	1.40 (1.07, 1.83)	1.26 (0.938, 1.69)
	p-value		0.062	0.014*	0.125
2013	WP[α] (95% CI)	36.6 (31.8, 41.4)	31.6 (26.3, 36.9)	38.8 (35.2, 42.5)	36.3 (31.8, 40.8)
	OR (95% CI)	0.545 (0.436, 0.683)	0.803 (0.854, 1.10)	1.11 (0.855, 1.43)	0.992 (0.747, 1.32)
	p-value		0.177	0.444	0.954
2014	WP[α] (95% CI)	31.6 (27.1, 36.0)	34.4 (29.1, 39.7)	32.4 (28.9, 35.8)	39.1 (34.4, 43.9)
	OR (95% CI)	0.488 (0.389, 0.612)	1.13 (0.825, 1.54)	1.03 (0.796, 1.34)	1.39 (1.04, 1.85)
	p-value		0.450	0.812	0.024*
2015	WP[α] (95% CI)	35.8 (30.5, 41.1)	39.0 (33.0, 45.0)	33.9 (30.2, 37.6)	34.5 (29.9, 39.1)
	OR (95% CI)	0.577 (0.449, 0.741)	1.14 (0.812, 1.61)	0.919 (0.692, 1.22)	0.944 (0.694, 1.28)
	p-value		0.444	0.558	0.714
2016	WP[α] (95% CI)	31.2 (27.0, 35.5)	29.3 (24.1, 34.4)	34.8 (31.1, 38.4)	35.2 (30.2, 40.2)
	OR (95% CI)	0.432 (0.347, 0.538)	0.907 (0.660, 1.25)	1.17 (0.906, 1.51)	1.20 (0.890, 1.60)
	p-value		0.548	0.230	0.236
2017	WP[α] (95% CI)	32.0 (27.5, 36.5)	33.8 (27.5, 40.1)	34.3 (30.5, 38.1)	31.6 (26.5, 36.6)
	OR (95% CI)	0.516 (0.409, 0.651)	1.09 (0.764, 1.54)	1.10 (0.844, 1.44)	0.988 (0.723, 1.35)
	p-value		0.647	0.472	0.938
2018	WP[α] (95% CI)	31.3 (26.8, 35.8)	34.5 (28.5, 40.4)	34.7 (27.4, 37.0)	32.2 (27.4, 37.0)
	OR (95% CI)	0.486 (0.385, 0.614)	1.15 (0.820, 1.61)	1.16 (0.880, 1.52)	1.04 (0.770, 1.41)
	p-value		0.423	0.299	0.785

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table X: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 60 to 64 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	28.9 (24.4, 33.3)	26.4 (21.3, 31.5)	32.1 (28.2, 36.0)	36.0 (30.2, 41.8)
	OR (95% CI)	0.438 (0.346, 0.555)	0.891 (0.634, 1.25)	1.16 (0.879, 1.54)	1.37 (0.988, 1.91)
	p-value		0.504	0.290	0.059
1998	WP[α] (95% CI)	29.7 (24.9, 34.5)	28.5 (23.3, 33.7)	33.3 (29.2, 37.5)	32.4 (26.7, 38.0)
	OR (95% CI)	0.439 (0.342, 0.564)	0.943 (0.669, 1.33)	1.18 (0.878, 1.59)	1.14 (0.804, 1.60)
	p-value		0.738	0.270	0.470
1999	WP[α] (95% CI)	30.6 (25.7, 35.6)	22.0 (17.4, 26.7)	28.7 (24.8, 32.6)	29.9 (24.3, 35.5)
	OR (95% CI)	0.470 (0.365, 0.605)	0.636 (0.445, 0.909)	0.912 (0.674, 1.23)	0.969 (0.680, 1.38)
	p-value		0.013*	0.549	0.860
2000	WP[α] (95% CI)	31.3 (26.5, 36.2)	34.1 (28.3, 40.0)	31.7 (27.6, 35.8)	33.3 (27.7, 38.8)
	OR (95% CI)	0.519 (0.405, 0.664)	1.14 (0.807, 1.61)	1.01 (0.755, 1.36)	1.10 (0.782, 1.54)
	p-value		0.458	0.931	0.594
2001	WP[α] (95% CI)	37.8 (32.7, 43.0)	34.0 (28.1, 40.0)	37.0 (32.8, 41.2)	40.0 (34.3, 45.8)
	OR (95% CI)	0.628 (0.496, 0.797)	0.851 (0.603, 1.20)	0.966 (0.728, 1.28)	1.10 (0.798, 1.52)
	p-value		0.356	0.809	0.553
2002	WP[α] (95% CI)	29.0 (24.1, 34.0)	33.1 (27.4, 38.9)	26.6 (22.8, 30.3)	31.8 (25.6, 37.9)
	OR (95% CI)	0.442 (0.340, 0.575)	1.21 (0.848, 1.72)	0.882 (0.649, 1.20)	1.14 (0.789, 1.65)
	p-value		0.297	0.426	0.483
2003	WP[α] (95% CI)	34.3 (29.2, 39.4)	27.5 (22.2, 32.8)	29.6 (25.7, 33.5)	31.1 (25.6, 36.5)
	OR (95% CI)	0.582 (0.455, 0.744)	0.725 (0.510, 1.03)	0.810 (0.604, 1.09)	0.863 (0.614, 1.21)
	p-value		0.072	0.158	0.400
2005	WP[α] (95% CI)	40.3 (35.5, 45.2)	33.6 (27.7, 39.5)	36.3 (32.2, 40.4)	32.4 (27.4, 37.5)
	OR (95% CI)	0.382 (0.307, 0.474)	0.758 (0.543, 1.06)	0.846 (0.646, 1.11)	0.717 (0.527, 0.977)
	p-value		0.103	0.227	0.035*
2006	WP[α] (95% CI)	32.7 (26.9, 38.5)	43.2 (35.4, 51.1)	31.6 (27.2, 36.1)	30.7 (25.2, 36.3)
	OR (95% CI)	0.550 (0.409, 0.739)	1.56 (1.03, 2.38)	0.935 (0.671, 1.30)	0.904 (0.624, 1.31)
	p-value		0.038*	0.694	0.594
2007	WP[α] (95% CI)	28.6 (22.6, 34.7)	27.5 (21.8, 33.2)	29.7 (25.4, 34.0)	33.6 (27.9, 39.4)
	OR (95% CI)	0.475 (0.343, 0.658)	0.945 (0.628, 1.42)	1.06 (0.741, 1.51)	1.27 (0.862, 1.88)
	p-value		0.787	0.757	0.225

2008	WP[α] (95% CI)	34.3 (28.7, 39.8)	33.5 (27.0, 39.9)	29.1 (24.7, 33.4)	30.0 (24.3, 35.6)
	OR (95% CI)	0.583 (0.446, 0.761)	0.961 (0.657, 1.41)	0.786 (0.567, 1.09)	0.825 (0.573, 1.19)
	p-value		0.839	0.147	0.300
2009	WP[α] (95% CI)	30.8 (25.9, 35.7)	30.9 (25.1, 36.8)	35.8 (34.5, 40.0)	34.0 (28.7, 39.4)
	OR (95% CI)	0.485 (0.376, 0.625)	1.01 (0.708, 1.45)	1.25 (0.933, 1.68)	1.17 (0.840, 1.62)
	p-value		0.947	0.134	0.357
2010	WP[α] (95% CI)	29.5 (24.6, 34.5)	32.5 (26.8, 38.2)	32.2 (28.4, 36.1)	35.0 (30.1, 40.0)
	OR (95% CI)	0.422 (0.327, 0.545)	1.15 (0.806, 1.63)	1.13 (0.844, 1.52)	1.29 (0.931, 1.77)
	p-value		0.448	0.402	0.127
2011	WP[α] (95% CI)	31.9 (27.4, 36.4)	29.7 (24.6, 34.7)	36.6 (33.0, 40.1)	33.7 (29.3, 38.1)
	OR (95% CI)	0.478 (0.381, 0.600)	0.900 (0.653, 1.29)	1.23 (0.950, 1.59)	1.08 (0.813, 1.44)
	p-value		0.517	0.117	0.583
2012	WP[α] (95% CI)	34.4 (29.6, 39.2)	32.6 (27.5, 37.7)	33.6 (30.1, 37.1)	36.4 (31.7, 41.1)
	OR (95% CI)	0.590 (0.469, 0.743)	0.918 (0.670, 1.26)	0.954 (0.732, 1.24)	1.10 (0.818, 1.47)
	p-value		0.595	0.726	0.539
2013	WP[α] (95% CI)	34.6 (29.6, 39.7)	32.2 (26.5, 37.9)	33.8 (30.2, 37.4)	32.6 (28.1, 37.1)
	OR (95% CI)	0.570 (0.448, 0.726)	0.893 (0.633, 1.26)	0.956 (0.726, 1.26)	0.909 (0.671, 1.23)
	p-value		0.519	0.748	0.539
2014	WP[α] (95% CI)	30.6 (26.0, 35.2)	32.4 (26.6, 38.2)	34.0 (30.3, 37.8)	33.9 (29.4, 38.4)
	OR (95% CI)	0.447 (0.354, 0.565)	1.09 (0.772, 1.53)	1.17 (0.892, 1.54)	1.16 (0.866, 1.56)
	p-value		0.633	0.254	0.317
2015	WP[α] (95% CI)	34.1 (29.1, 39.1)	40.3 (33.9, 46.7)	37.7 (33.7, 41.8)	35.6 (31.0, 40.3)
	OR (95% CI)	0.526 (0.414, 0.669)	1.31 (0.926, 1.85)	1.17 (0.883, 1.55)	1.07 (0.793, 1.45)
	p-value		0.128	0.274	0.648
2016	WP[α] (95% CI)	37.4 (32.8, 42.0)	35.8 (30.6, 41.0)	35.0 (31.2, 38.9)	35.2 (30.5, 40.0)
	OR (95% CI)	0.568 (0.456, 0.706)	0.935 (0.692, 1.26)	0.904 (0.696, 1.17)	0.914 (0.686, 1.22)
	p-value		0.663	0.448	0.539
2017	WP[α] (95% CI)	31.5 (27.1, 36.0)	36.2 (30.3, 42.2)	32.8 (29.0, 36.6)	35.0 (30.0, 40.0)
	OR (95% CI)	0.486 (0.386, 0.612)	1.24 (0.888, 1.72)	1.06 (0.807, 1.38)	1.16 (0.861, 1.57)
	p-value		0.210	0.695	0.323
2018	WP[α] (95% CI)	32.6 (28.2, 37.1)	38.5 (32.9, 44.0)	35.6 (34.3, 44.9)	39.6 (34.3, 44.9)
	OR (95% CI)	0.513 (0.410, 0.642)	1.29 (0.946, 1.76)	1.14(0.876, 1.48)	1.35 (1.00, 1.82)
	p-value		0.107	0.332	0.050*

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table XI: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 65 to 69 years, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	26.9 (22.5, 31.2)	24.3 (19.8, 28.8)	32.8 (29.0, 36.6)	36.8 (29.6, 44.0)
	OR (95% CI)	0.935 (0.309, 0.504)	0.864 (0.620, 1.20)	1.32 (0.996, 1.75)	1.56 (1.07, 2.28)
	p-value		0.388	0.054	0.020*
1998	WP[α] (95% CI)	28.8 (24.0, 33.5)	36.4 (30.6, 42.3)	30.1 (26.2, 33.9)	30.8 (24.8, 36.7)
	OR (95% CI)	0.432 (0.336, 0.557)	1.40 (0.989, 1.97)	1.07 (0.793, 1.43)	1.09 (0.731, 1.57)
	p-value		0.058	0.674	0.626
1999	WP[α] (95% CI)	31.5 (26.1, 37.0)	26.4 (21.1, 31.8)	27.7 (23.7, 31.8)	30.1 (23.6, 36.7)
	OR (95% CI)	0.469 (0.359, 0.614)	0.779 (0.536, 1.13)	0.832 (0.603, 1.15)	0.938 (0.629, 1.40)
	p-value		0.190	0.263	0.755
2000	WP[α] (95% CI)	27.0 (22.0, 32.1)	25.5 (20.0, 31.0)	29.2 (25.1, 33.3)	33.3 (27.1, 39.5)
	OR (95% CI)	0.380 (0.290, 0.500)	0.926 (0.629, 1.36)	1.12 (0.808, 1.55)	1.35 (0.926, 1.98)
	p-value		0.697	0.500	0.118
2001	WP[α] (95% CI)	35.3 (30.0, 40.6)	29.5 (24.1, 34.9)	26.9 (22.8, 30.9)	33.6 (27.9, 39.4)
	OR (95% CI)	0.580 (0.449, 0.749)	0.766 (0.540, 1.09)	0.673 (0.657, 1.32)	0.930 (0.657, 1.32)
	p-value		0.135	0.013*	0.685
2002	WP[α] (95% CI)	29.3 (24.1, 34.6)	23.0 (17.7, 28.4)	26.0 (21.9, 30.1)	28.7 (22.8, 34.5)
	OR (95% CI)	0.504 (0.384, 0.662)	0.726 (0.489, 1.08)	0.48 (0.610, 1.18)	0.995 (0.678, 1.46)
	p-value		0.113	0.328	0.977
2003	WP[α] (95% CI)	31.9 (26.5, 37.3)	28.4 (22.6, 34.1)	29.1 (25.1, 33.1)	32.1 (26.0, 38.2)
	OR (95% CI)	0.572 (0.437, 0.749)	0.853 (0.585, 1.25)	0.866 (0.632, 1.18)	1.01 (0.695, 1.47)
	p-value		0.412	0.372	0.958
2005	WP[α] (95% CI)	34.8 (29.6, 40.0)	24.9 (19.8, 30.0)	32.8 (28.5, 37.0)	33.0 (27.0, 38.9)
	OR (95% CI)	0.601 (0.468, 0.770)	0.625 (0.436, 0.894)	0.922 (0.683, 1.25)	0.932 (0.654, 1.33)
	p-value		0.010*	0.599	0.697
2006	WP[α] (95% CI)	31.9 (25.8, 37.9)	27.5 (20.6, 34.4)	31.0 (26.2, 35.7)	30.7 (24.3, 37.0)
	OR (95% CI)	0.577 (0.424, 0.784)	0.776 (0.495, 1.22)	0.945 (0.659, 1.35)	0.919 (0.612, 1.38)
	p-value		0.269	0.757	0.683
2007	WP[α] (95% CI)	34.7 (28.2, 41.2)	34.8 (27.8, 41.7)	26.9 (22.5, 31.3)	26.9 (21.2, 32.5)
	OR (95% CI)	0.647 (0.472, 0.887)	0.994 (0.652, 1.51)	0.679 (0.471, 0.980)	0.697 (0.464, 1.05)
	p-value		0.997	0.039*	0.084

2008	WP[α] (95% CI)	28.6 (22.1, 35.1)	33.4 (26.3, 40.4)	36.7 (31.8, 41.6)	31.8 (26.0, 37.7)
	OR (95% CI)	0.495 (0.352, 0.697)	1.22 (0.780, 1.91)	1.45 (0.987, 2.11)	1.17 (0.771, 1.78)
	p-value		0.383	0.058	0.461
2009	WP[α] (95% CI)	31.2 (25.1, 37.3)	26.5 (20.4, 32.6)	31.3 (26.8, 35.8)	33.1 (27.0, 39.2)
	OR (95% CI)	0.548 (0.405, 0.743)	0.779 (0.509, 1.19)	0.973 (0.682, 1.39)	1.07 (0.715, 1.59)
	p-value		0.250	0.881	0.752
2010	WP[α] (95% CI)	31.6 (26.1, 37.2)	32.7 (25.8, 39.6)	32.7 (28.4, 37.0)	35.2 (29.6, 40.8)
	OR (95% CI)	0.546 (0.414, 0.720)	1.07 (0.713, 1.61)	1.07 (0.776, 1.47)	1.20 (0.843, 1.71)
	p-value		0.738	0.681	0.313
2011	WP[α] (95% CI)	29.5 (24.6, 34.3)	35.5 (29.9, 41.2)	34.1 (30.1, 38.1)	33.0 (28.2, 37.9)
	OR (95% CI)	0.431 (0.334, 0.556)	1.32 (0.940, 1.86)	1.24 (0.925, 1.66)	1.18 (0.858, 1.62)
	p-value		0.109	0.150	0.309
2012	WP[α] (95% CI)	28.2 (23.2, 33.1)	29.5 (23.6, 35.4)	32.6 (28.7, 36.5)	31.2 (26.4, 36.0)
	OR (95% CI)	0.469 (0.361, 0.609)	1.07 (0.792, 1.55)	1.25 (0.923, 1.70)	1.16 (0.832, 1.62)
	p-value		0.737	0.148	0.378
2013	WP[α] (95% CI)	32.2 (27.1, 37.4)	25.4 (20.1, 30.8)	38.6 (34.6, 42.5)	34.5 (29.9, 39.0)
	OR (95% CI)	0.516 (0.402, 0.663)	0.710 (0.492, 1.02)	1.32 (0.987, 1.76)	1.10 (0.806, 1.50)
	p-value		0.067	0.062	0.545
2014	WP[α] (95% CI)	33.1 (28.2, 37.9)	28.0 (22.5, 33.5)	35.2 (31.4, 34.0)	35.6 (30.8, 40.4)
	OR (95% CI)	0.562 (0.444, 0.711)	0.794 (0.559, 1.13)	1.12 (0.847, 1.47)	1.12 (0.826, 1.52)
	p-value		0.196	0.437	0.467
2015	WP[α] (95% CI)	32.7 (27.4, 38.1)	35.6 (29.5, 41.7)	31.3 (27.5, 35.1)	36.2 (31.2, 41.2)
	OR (95% CI)	0.506 (0.390, 0.657)	1.14 (0.795, 1.64)	0.936 (0.692, 1.26)	1.17 (0.843, 1.62)
	p-value		0.474	0.665	0.351
2016	WP[α] (95% CI)	31.0 (26.6, 35.3)	29.4 (24.6, 34.2)	35.2 (31.5, 38.8)	33.3 (28.4, 38.2)
	OR (95% CI)	0.465 (0.372, 0.581)	0.928 (0.682, 1.26)	1.20 (0.930, 1.56)	1.11 (0.820, 1.50)
	p-value		0.635	0.159	0.504
2017	WP[α] (95% CI)	30.5 (26.2, 34.9)	29.2 (23.7, 34.8)	35.0 (31.2, 38.8)	33.3 (28.5, 28.2)
	OR (95% CI)	0.454 (0.363, 0.568)	0.936 (0.669, 1.31)	1.22 (0.939, 1.59)	1.14 (0.845, 1.53)
	p-value		0.698	0.136	0.395
2018	WP[α] (95% CI)	36.4 (31.6, 41.1)	36.0 (30.3, 41.7)	34.0 (30.4, 37.6)	34.1 (29.2, 38.9)
	OR (95% CI)	0.581 (0.465, 0.727)	0.984 (0.714, 1.36)	0.902 (0.696, 1.17)	0.903 (0.671, 1.22)
	p-value		0.922	0.438	0.502

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table XII: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in US residents aged 70 years and above, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	29.2 (26.4, 32.0)	27.3 (24.4, 30.3)	29.1 (26.7, 31.5)	32.1 (28.8, 35.4)
	OR (95% CI)	0.464 (0.402, 0.535)	0.912 (0.746, 1.12)	0.998 (0.835, 1.19)	1.16 (0.946, 1.42)
	p-value		0.372	0.982	0.154
1998	WP[α] (95% CI)	32.7 (29.6, 35.9)	29.9 (26.6, 33.1)	32.0 (29.4, 34.6)	32.2 (28.8, 35.6)
	OR (95% CI)	0.570 (0.490, 0.663)	0.882 (0.714, 1.09)	0.976 (0.810, 1.18)	0.988 (0.799, 1.22)
	p-value		0.241	0.802	0.913
1999	WP[α] (95% CI)	27.7 (24.8, 30.6)	28.2 (24.8, 31.5)	30.0 (27.4, 32.6)	28.9 (25.6, 32.3)
	OR (95% CI)	0.447 (0.382, 0.522)	1.02 (0.817, 1.27)	1.12 (0.922, 1.35)	1.08 (0.865, 1.34)
	p-value		0.869	0.260	0.511
2000	WP[α] (95% CI)	32.3 (29.2, 35.4)	30.1 (26.8, 33.4)	28.7 (26.2, 31.3)	31.8 (28.4, 35.2)
	OR (95% CI)	0.543 (0.467, 0.631)	0.898 (0.725, 1.11)	0.842 (0.697, 1.02)	0.976 (0.790, 1.21)
	p-value		0.322	0.073	0.819
2001	WP[α] (95% CI)	34.9 (31.7, 38.2)	28.9 (25.6, 32.1)	30.9 (28.3, 33.5)	36.5 (32.8, 40.2)
	OR (95% CI)	0.603 (0.518, 0.702)	0.755 (0.610, 0.936)	0.824 (0.684, 0.993)	1.07 (0.864, 1.33)
	p-value		0.010*	0.042*	0.534
2002	WP[α] (95% CI)	32.2 (29.1, 35.3)	30.6 (27.0, 34.1)	28.3 (25.7, 30.9)	27.7 (24.3, 31.1)
	OR (95% CI)	0.526 (0.452, 0.612)	0.929 (0.745, 1.16)	0.835 (0.690, 1.01)	0.811 (0.649, 1.01)
	p-value		0.512	0.066	0.065
2003	WP[α] (95% CI)	30.6 (27.3, 33.8)	28.3 (24.9, 31.6)	28.8 (26.2, 31.4)	32.7 (29.0, 36.5)
	OR (95% CI)	0.500 (0.426, 0.587)	0.907 (0.724, 1.14)	0.934 (0.765, 1.14)	1.12 (0.892, 1.42)
	p-value		0.396	0.502	0.321
2005	WP[α] (95% CI)	34.7 (31.5, 37.9)	30.2 (26.7, 33.7)	34.8 (26.7, 33.7)	33.8 (30.1, 37.5)
	OR (95% CI)	0.594 (0.511, 0.690)	0.816 (0.656, 1.01)	1.00 (0.835, 1.21)	0.965 (0.776, 1.20)
	p-value		0.066	0.966	0.751
2006	WP[α] (95% CI)	30.5 (26.6, 34.4)	33.6 (29.1, 38.1)	31.3 (28.1, 34.4)	34.5 (30.3, 38.6)
	OR (95% CI)	0.453 (0.372, 0.552)	1.15 (0.876, 1.52)	1.04 (0.818, 1.31)	1.20 (0.926, 1.56)
	p-value		0.312	0.767	0.167
2007	WP[α] (95% CI)	31.3 (27.5, 35.0)	27.6 (23.5, 31.7)	28.8 (25.6, 31.9)	29.6 (25.6, 33.5)
	OR (95% CI)	0.857 (0.437, 0.636)	0.833 (0.636, 1.09)	0.880 (0.697, 1.11)	0.923 (0.714, 1.19)
	p-value		0.183	0.279	0.542

2008	WP[α] (95% CI)	26.3 (22.4, 30.2)	33.3 (28.7, 38.0)	31.8 (28.6, 35.0)	33.1 (28.9, 37.3)
	OR (95% CI)	0.395 (0.322, 0.484)	1.41 (1.05, 1.88)	1.32 (1.03, 1.69)	1.40 (1.06, 1.85)
	p-value		0.021*	0.031*	0.018*
2009	WP[α] (95% CI)	34.8 (31.1, 38.5)	32.0 (27.5, 36.4)	31.2 (28.1, 34.3)	31.4 (27.5, 35.3)
	OR (95% CI)	0.596 (0.501, 0.711)	0.877 (0.675, 1.14)	0.848 (0.681, 1.06)	0.865 (0.679, 1.10)
	p-value		0.328	0.141	0.244
2010	WP[α] (95% CI)	30.9 (27.4, 34.3)	31.9 (27.8, 35.9)	28.1 (25.3, 30.9)	36.3 (32.4, 40.2)
	OR (95% CI)	0.499 (0.421, 0.592)	1.05 (0.816, 1.34)	0.879 (0.711, 1.34)	1.27 (1.01, 1.60)
	p-value		0.724	0.236	0.045*
2011	WP[α] (95% CI)	32.0 (28.7, 35.2)	31.4 (27.8, 35.0)	33.2 (30.5, 35.8)	32.9 (29.7, 36.2)
	OR (95% CI)	0.540 (0.460, 0.633)	0.976 (0.779, 1.22)	1.05 (0.865, 1.27)	1.04 (0.846, 1.28)
	p-value		0.832	0.636	0.698
2012	WP[α] (95% CI)	30.4 (27.0, 33.7)	29.2 (25.4, 33.0)	30.9 (28.2, 33.5)	29.7 (26.4, 33.0)
	OR (95% CI)	0.495 (0.419, 0.585)	0.935 (0.732, 1.19)	1.03 (0.838, 1.26)	0.973 (0.777, 1.22)
	p-value		0.587	0.804	0.810
2013	WP[α] (95% CI)	31.6 (28.2, 35.1)	34.7 (30.8, 38.6)	32.2 (29.5, 34.9)	36.9 (33.4, 40.5)
	OR (95% CI)	0.506 (0.428, 0.600)	1.16 (0.918, 1.47)	1.03 (0.843, 1.26)	1.27 (1.02, 1.57)
	p-value		0.215	0.767	0.035*
2014	WP[α] (95% CI)	35.7 (32.2, 39.2)	29.4 (25.6, 33.2)	33.2 (30.4, 35.9)	34.7 (31.3, 38.1)
	OR (95% CI)	0.620 (0.527, 0.729)	0.758 (0.597, 0.961)	0.896 (0.756, 1.09)	0.980 (0.791, 1.22)
	p-value		0.022*	0.273	0.857
2015	WP[α] (95% CI)	34.1 (30.5, 37.7)	34.5 (30.5, 38.4)	36.6 (33.8, 39.4)	32.7 (29.1, 36.2)
	OR (95% CI)	0.576 (0.486, 0.682)	1.02 (0.800, 1.29)	1.12 (0.916, 1.37)	0.941 (0.749, 1.18)
	p-value		0.900	0.271	0.598
2016	WP[α] (95% CI)	31.2 (28.2, 34.3)	29.5 (25.9, 33.0)	33.2 (30.6, 35.7)	35.3 (31.8, 38.7)
	OR (95% CI)	0.523 (0.449, 0.609)	0.919 (0.735, 1.15)	1.10 (0.916, 1.32)	1.21 (0.981, 1.48)
	p-value		0.459	0.309	0.076
2017	WP[α] (95% CI)	33.3 (30.2, 36.4)	33.3 (29.6, 37.0)	32.6 (30.0, 35.1)	34.1 (30.7, 37.5)
	OR (95% CI)	0.544 (0.468, 0.632)	0.993 (0.799, 1.24)	0.967 (0.807, 1.16)	1.04 (0.843, 1.27)
	p-value		0.953	0.712	0.734
2018	WP[α] (95% CI)	35.3 (32.1, 38.5)	38.2 (34.3, 42.1)	38.7 (36.0, 41.3)	38.7 (35.2, 42.1)
	OR (95% CI)	0.600 (0.516, 0.697)	1.13 (0.913, 1.41)	1.16 (0.973, 1.39)	1.16 (0.947, 1.42)
	p-value		0.256	0.097	0.153

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table XIII: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in male US residents, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	28.0 (26.4, 29.6)	24.4 (22.6, 26.1)	25.8 (24.5, 27.2)	27.9 (26.2, 29.7)
	OR (95% CI)	0.254 (0.215, 0.299)	0.823 (0.727, 0.931)	0.901 (0.810, 1.00)	1.00 (0.889, 1.13)
	p-value		0.002*	0.053	0.970
1998	WP[α] (95% CI)	27.4 (25.7, 29.1)	25.6 (23.7, 27.4)	25.3 (23.9, 26.6)	26.5 (24.7, 28.3)
	OR (95% CI)	0.249 (0.210, 0.294)	0.901 (0.791, 1.03)	0.899 (0.804, 1.01)	0.964 (0.851, 1.09)
	p-value		0.115	0.063	0.563
1999	WP[α] (95% CI)	25.3 (23.6, 27.0)	25.4 (23.4, 27.4)	23.2 (21.8, 24.5)	25.6 (23.7, 27.4)
	OR (95% CI)	0.228 (0.190, 0.273)	0.988 (0.859, 1.14)	0.886 (0.787, 0.997)	1.01 (0.884, 1.16)
	p-value		0.862	0.044*	0.874
2000	WP[α] (95% CI)	26.0 (24.3, 27.7)	24.6 (22.6, 26.5)	25.0 (23.6, 26.4)	26.6 (24.8, 28.5)
	OR (95% CI)	0.228 (0.192, 0.271)	0.918 (0.801, 1.05)	0.943 (0.840, 1.06)	1.03 (0.908, 1.18)
	p-value		0.223	0.315	0.618
2001	WP[α] (95% CI)	32.1 (30.3, 33.8)	29.2 (27.2, 31.2)	27.2 (25.8, 28.6)	30.2 (28.4, 32.0)
	OR (95% CI)	0.344 (0.295, 0.402)	0.860 (0.757, 0.977)	0.793 (0.512, 0.883)	0.918 (0.814, 1.03)
	p-value		0.021*	< 0.001*	0.158
2002	WP[α] (95% CI)	25.5 (23.8, 27.2)	26.5 (24.5, 28.5)	22.3 (21.0, 23.6)	24.8 (22.9, 26.6)
	OR (95% CI)	0.226 (0.189, 0.271)	1.04 (0.903, 1.19)	0.835 (0.741, 0.941)	0.956 (0.836, 1.09)
	p-value		0.614	0.003*	0.508
2003	WP[α] (95% CI)	28.0 (26.3, 29.8)	24.9 (22.9, 26.9)	22.4 (21.1, 23.8)	27.1 (25.3, 29.0)
	OR (95% CI)	0.229 (0.193, 0.273)	0.847 (0.737, 0.974)	0.740 (0.659, 0.831)	0.974 (0.857, 1.11)
	p-value		0..020*	< 0.001*	0.690
2005	WP[α] (95% CI)	28.0 (26.2, 29.7)	27.5 (25.4, 29.6)	24.7 (23.3, 26.0)	26.0 (24.2, 27.8)
	OR (95% CI)	0.222 (0.185, 0.266)	0.932 (0.813, 1.07)	0.842 (0.751, 0.944)	0.898 (0.789, 1.02)
	p-value		0.309	0.003*	0.100
2006	WP[α] (95% CI)	26.9 (24.7, 29.0)	28.8 (26.2, 31.5)	23.9 (22.3, 25.5)	25.4 (23.3, 27.4)
	OR (95% CI)	0.198 (0.159, 0.246)	1.08 (0.914, 1.29)	0.852 (0.741, 0.980)	0.920 (0.790, 1.07)
	p-value		0.351	0.025*	0.287
2007	WP[α] (95% CI)	23.7 (21.7, 25.7)	23.2 (20.8, 25.6)	21.7 (20.1, 23.3)	26.6 (24.5, 28.7)
	OR (95% CI)	0.171 (0.136, 0.215)	0.967 (0.812, 1.16)	0.898 (0.776, 1.04)	1.18 (1.01, 1.38)
	p-value		0.723	0.147	0.036*

2008	WP[α] (95% CI)	25.9 (23.7, 28.1)	25.3 (22.7, 28.0)	24.5 (22.8, 26.2)	25.4 (23.3, 27.5)
	OR (95% CI)	0.201 (0.160, 0.253)	0.959 (0.800, 1.15)	0.925 (0.799, 1.07)	0.976 (0.832, 1.14)
	p-value		0.650	0.294	0.760
2009	WP[α] (95% CI)	26.9 (24.9, 28.9)	26.0 (23.5, 28.4)	26.8 (25.1, 28.5)	25.0 (23.1, 27.0)
	OR (95% CI)	0.202 (0.164, 0.248)	0.940 (0.797, 1.11)	0.998 (0.872, 1.14)	0.916 (0.791, 1.06)
	p-value		0.458	0.981	0.246
2010	WP[α] (95% CI)	26.0 (24.1, 28.0)	27.7 (25.2, 30.1)	26.5 (25.0, 28.1)	26.8 (24.9, 28.7)
	OR (95% CI)	0.185 (0.151, 0.226)	1.07 (0.914, 1.26)	1.03 (0.901, 1.17)	1.07 (0.927, 1.23)
	p-value		0.390	0.703	0.367
2011	WP[α] (95% CI)	26.0 (24.3, 27.7)	27.2 (25.0, 29.5)	28.2 (26.8, 29.7)	27.4 (25.7, 29.1)
	OR (95% CI)	0.156 (0.130, 0.188)	1.03 (0.890, 1.19)	1.10 (0.981, 1.24)	1.09 (0.963, 1.24)
	p-value		0.703	0.102	0.169
2012	WP[α] (95% CI)	26.3 (24.3, 28.3)	23.0 (20.9, 25.1)	25.8 (24.3, 27.2)	27.4 (25.7, 29.2)
	OR (95% CI)	0.182 (0.148, 0.224)	0.817 (0.697, 0.956)	0.964 (0.847, 1.10)	1.05 (0.919, 1.20)
	p-value		0.012*	0.571	0.464
2013	WP[α] (95% CI)	27.9 (25.9, 29.9)	25.9 (23.6, 28.2)	26.8 (25.3, 28.3)	27.8 (26.0, 29.5)
	OR (95% CI)	0.165 (0.131, 0.209)	0.867 (0.740, 1.02)	0.924 (0.812, 1.05)	1.01 (0.880, 1.16)
	p-value		0.079	0.226	0.904
2014	WP[α] (95% CI)	27.3 (25.3, 29.3)	25.5 (23.2, 27.8)	26.1 (24.5, 27.6)	27.3 (25.5, 29.0)
	OR (95% CI)	0.199 (0.160, 0.247)	0.887 (0.757, 1.04)	0.956 (0.813, 1.05)	1.01 (0.879, 1.15)
	p-value		0.140	0.246	0.916
2015	WP[α] (95% CI)	28.3 (26.2, 30.4)	29.8 (27.2, 32.3)	27.6 (26.0, 29.1)	28.4 (26.5, 30.3)
	OR (95% CI)	0.164 (0.130, 0.206)	1.04 (0.883, 1.22)	0.940 (0.824, 1.07)	1.00 (0.871, 1.16)
	p-value		0.656	0.351	0.958
2016	WP[α] (95% CI)	28.4 (26.5, 30.3)	27.1 (24.7, 29.5)	26.8 (25.2, 28.3)	27.6 (25.6, 29.6)
	OR (95% CI)	0.186 (0.149, 0.231)	0.906 (0.776, 1.06)	0.907 (0.801, 1.03)	0.977 (0.852, 1.12)
	p-value		0.213	0.127	0.735
2017	WP[α] (95% CI)	25.6 (23.8, 27.5)	27.8 (25.3, 30.4)	25.3 (23.7, 26.9)	27.1 (25.1, 29.1)
	OR (95% CI)	0.142 (0.113, 0.178)	1.09 (0.932, 1.29)	0.994 (0.874, 1.13)	1.08 (0.942, 1.25)
	p-value		0.271	0.925	0.262
2018	WP[α] (95% CI)	28.4 (26.4, 30.4)	26.1 (23.7, 28.5)	27.3 (25.7, 28.9)	30.0 (27.9, 32.1)
	OR (95% CI)	0.130 (0.102, 0.165)	0.845 (0.722, 0.990)	0.936 (0.822, 1.07)	1.10 (0.952, 1.27)
	p-value		0.037*	0.316	0.197

[α] WP: Weighted prevalence

* Significant at $P < 0.05$

Table XIV: Low back pain trends [prevalence (95% CI) (%), OR (95% CI) and p-value] in female US residents, according to the National Health Interview Survey (NHIS) from 1997 until 2018 (except 2004), by regional residence

Year	Statistic	Region			
		Midwest	*Northeast*	*South*	*West*
1997	WP[α] (95% CI)	29.2 (27.8, 30.6)	29.4 (27.8, 31.0)	28.9 (27.7, 30.1)	31.4 (29.7, 33.0)
	OR (95% CI)	0.323 (0.284, 0.369)	1.00 (0.903, 1.11)	0.983 (0.898, 1.08)	1.11 (1.00, 1.23)
	p-value		0.976	0.703	0.041*
1998	WP[α] (95% CI)	29.5 (28.0, 31.1)	29.7 (28.0, 31.4)	29.7 (28.4, 31.0)	29.6 (27.9, 31.3)
	OR (95% CI)	0.298 (0.256, 0.346)	0.992 (0.888, 1.11)	1.01 (0.914, 1.11)	1.01 (0.901, 1.12)
	p-value		0.888	0.901	0.911
1999	WP[α] (95% CI)	28.8 (27.2, 30.3)	28.5 (26.8, 30.3)	27.2 (26.0, 28.5)	29.5 (27.8, 31.2)
	OR (95% CI)	0.303 (0.262, 0.352)	0.972 (0.866, 1.09)	0.924 (0.837, 1.02)	1.04 (0.925, 1.16)
	p-value		0.637	0.122	0.541
2000	WP[α] (95% CI)	30.0 (28.5, 31.6)	27.4 (25.7, 29.1)	27.9 (26.7, 29.2)	30.7 (29.0, 32.4)
	OR (95% CI)	0.332 (0.286, 0.385)	0.867 (0.774, 0.970)	0.896 (0.812, 0.988)	1.03 (0.921, 1.15)
	p-value		0.013*	0.027*	0.629
2001	WP[α] (95% CI)	32.8 (31.2, 34.4)	32.4 (30.6, 34.2)	31.4 (30.1, 32.7)	35.3 (33.6, 37.1)
	OR (95% CI)	0.397 (0.347, 0.454)	0.977 (0.877, 1.09)	0.939 (0.855, 1.03)	1.13 (1.01, 1.25)
	p-value		0.680	0.184	0.029*
2002	WP[α] (95% CI)	29.3 (27.8, 30.9)	28.7 (26.9, 30.5)	26.5 (25.2, 27.8)	30.6 (28.8, 32.4)
	OR (95% CI)	0.334 (0.291, 0.385)	0.953 (0.849, 1.07)	0.865 (0.782, 0.956)	1.06 (0.950, 1.19)
	p-value		0.418	0.004*	0.281
2003	WP[α] (95% CI)	30.0 (28.4, 31.7)	29.9 (28.0, 31.7)	28.0 (26.7, 29.3)	31.5 (29.8, 33.2)
	OR (95% CI)	0.297 (0.257, 0.344)	0.978 (0.870, 1.10)	0.899 (0.813, 0.994)	1.08 (0.965, 1.21)
	p-value		0.712	0.038*	0.181
2005	WP[α] (95% CI)	31.3 (29.7, 32.7)	29.7 (27.9, 31.6)	30.1 (28.8, 31.4)	31.5 (29.8, 33.3)
	OR (95% CI)	0.328 (0.283, 0.380)	0.918 (0.817, 1.03)	0.942 (0.855, 1.04)	1.02 (0.912, 1.14)
	p-value		0.150	0.226	0.741
2006	WP[α] (95% CI)	31.6 (29.6, 33.6)	28.5 (26.4, 30.7)	27.9 (26.4, 29.4)	29.8 (27.8, 31.7)
	OR (95% CI)	0.307 (0.258, 0.365)	0.860 (0.748, 0.989)	0.840 (0.745, 0.947)	0.919 (0.804, 1.05)
	p-value		0.035*	0.004*	0.211
2007	WP[α] (95% CI)	28.2 (26.2, 30.2)	28.4 (26.2, 30.6)	26.2 (24.7, 27.7)	28.3 (26.3, 30.3)
	OR (95% CI)	0.273 (0.227, 0.328)	0.989 (0.853, 1.15)	0.900 (0.795, 1.02)	1.00 (0.875, 1.15)
	p-value		0.886	0.097	0.952

2008	WP[α] (95% CI)	29.1 (27.1, 31.1)	30.1 (27.8, 32.5)	29.4 (27.8, 31.0)	29.8 (27.8, 31.9)
	OR (95% CI)	0.331 (0.274, 0.401)	1.03 (0.888, 1.20)	1.01 (0.894, 1.15)	1.04 (0.906, 1.20)
	p-value		0.687	0.836	0.570
2009	WP[α] (95% CI)	32.2 (30.3, 34.2)	30.3 (28.0, 32.6)	29.9 (28.3, 31.4)	30.3 (28.3, 32.4)
	OR (95% CI)	0.266 (0.221, 0.321)	0.894 (0.778, 1.03)	0.896 (0.800, 1.01)	0.918 (0.805, 1.05)
	p-value		0.119	0.065	0.197
2010	WP[α] (95% CI)	30.7 (28.9, 32.6)	29.5 (27.3, 31.8)	30.7 (29.3, 32.2)	32.0 (30.2, 33.8)
	OR (95% CI)	0.295 (0.249, 0.349)	0.924 (0.805, 1.06)	0.994 (0.891, 1.11)	1.06 (0.940, 1.20)
	p-value		0.267	0.921	0.339
2011	WP[α] (95% CI)	30.8 (29.1, 32.5)	28.6 (26.6, 30.5)	31.7 (30.3, 33.0)	29.8 (28.2, 31.5)
	OR (95% CI)	0.285 (0.242, 0.335)	0.882 (0.778, 1.00)	1.04 (0.937, 1.15)	0.957 (.854, 1.07)
	p-value		0.053	0.471	0.442
2012	WP[α] (95% CI)	30.1 (28.3, 31.9)	29.7 (27.6, 31.7)	30.7 (29.3, 32.1)	29.7 (28.0, 31.4)
	OR (95% CI)	0.303 (0.257, 0.358)	0.964 (0.847, 1.10)	1.02 (0.981, 1.14)	0.987 (0.878, 1.11)
	p-value		0.577	0.689	0.827
2013	WP[α] (95% CI)	32.1 (30.2, 34.1)	29.5 (27.4, 31.7)	30.7 (29.3, 32.1)	30.7 (29.1, 32.4)
	OR (95% CI)	0.308 (0.258, 0.367)	0.863 (0.751, 0.991)	0.925 (0.828, 1.03)	0.933 (0.828, 1.05)
	p-value		0.037*	0.165	0.251
2014	WP[α] (95% CI)	33.4 (31.0, 35.8)	28.0 (25.9, 30.1)	29.6 (28.2, 31.0)	31.6 (29.9, 33.4)
	OR (95% CI)	0.369 (0.282, 0.483)	0.758 (0.652, 0.881)	0.838 (0.736, 0.954)	0.934 (0.814, 1.07)
	p-value		< 0.001*	0.008*	0.327
2015	WP[α] (95% CI)	30.8 (28.8, 32.7)	30.7 (28.5, 33.0)	31.4 (29.9, 32.8)	32.0 (30.2, 33.8)
	OR (95% CI)	0.222 (0.183, 0.270)	0.978 (0.850, 1.13)	1.03 (0.917, 1.15)	1.08 (0.950, 1.22)
	p-value		0.755	0.631	0.244
2016	WP[α] (95% CI)	30.8 (29.0, 32.6)	28.1 (26.0, 30.2)	31.3 (29.8, 32.7)	31.1 (29.1, 33.0)
	OR (95% CI)	0.280 (0.233, 0.336)	0.858 (0.750, 0.983)	1.02 (0.910, 1.13)	1.02 (0.903, 1.16)
	p-value		0.027*	0.779	0.721
2017	WP[α] (95% CI)	31.3 (29.4, 33.1)	28.8 (26.5, 31.1)	31.9 (30.4, 33.4)	30.5 (28.5, 32.5)
	OR (95% CI)	0.272 (0.224, 0.329)	0.879 (0.762, 1.01)	1.02 (0.911, 1.14)	0.969 (0.853, 1.10)
	p-value		0.077	0.756	0.631
2018	WP[α] (95% CI)	31.1 (29.2, 33.1)	31.6 (29.3, 33.9)	31.6 (30.1, 33.2)	31.9 (29.9, 33.9)
	OR (95% CI)	0.275 (0.223, 0.339)	0.992 (0.861, 1.14)	1.01 (0.897, 1.13)	1.04 (0.907, 1.18)
	p-value		0.909	0.890	0.606

[α] WP: Weighted prevalence

* Significant at $P < 0.05$