UNIVERSITY OF THE WITWATERSRAND
FACULTY OF HEALTH SCIENCES
SCHOOL OF PUBLIC HEALTH
MSc EPIDEMIOLOGY

SPATIAL EPIDEMIOLOGY OF SELF-REPORTED HYPERTENSION IN GAUTENG PROVINCE

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DECLARATION

I **Mthokozisi Ngwenya** declare that this research report is my work. It is being submitted for the degree of [**Master's in Epidemiology**] at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signature:

Date: 11th day of February 2022 in Johannesburg, RSA

DEDICATION

I dedicate my work to my late mother Mrs. Emma Ngwenya whose constant encouragement, love, and support gave me the courage to follow my dreams. Special mention goes to my daughter, Mbalenhle Haile Ngwenya who always kept me smiling throughout the journey

ABSTRACT

Introduction

Hypertension has been identified as a leading cause of morbidity and mortality for cardiovascular-related diseases in sub-Saharan Africa. The aim of this study was to estimate the prevalence, determine factors associated with hypertension and identify the spatial distribution of self-reported hypertension in Gauteng province in South Africa.

Methods The primary study was a cross-sectional household survey done in 2015 by Gauteng City-Region Observatory. Secondary data analysis was done for the study. The primary study population constituted of 30,002 adults aged 18 years or older who resided in Gauteng province. A stratified multistage sampling technique was used in which 508 wards were divided into enumeration areas (EAs) which were the primary sampling units. SaTscan was used to identify significant primary and secondary clusters of people with self-reported hypertension. The prevalence level of self-reported hypertension was estimated as the proportion of respondents in the study who reported that they were hypertensive. Logistic regression was used to model the unadjusted and adjusted association between the hypertension status as an outcome and identified risk factors.

Results The estimated prevalence of self-reported hypertension was 15.5% (n=4,580) in women 16% (n=2,547) and 15% (n=2,033) in men. Factors significantly associated with hypertension in the adjusted model being female (aOR:1.13, 95% CI:1.06-1.21), above 55 years (old age) (aOR:1.17,95% CI:1.01-1.35.), white race (aOR: 2.37, 95% CI: 2.15 -2.62). Residing in formal settlements and renting status of individuals were also significantly associated with hypertension. Five significant spatial clusters of potential hypertension cases were identified in Ekurhuleni municipality

Conclusion The study findings strengthen existing evidence that sex, age, and race are significantly associated with hypertension. The results of the study show that hypertension in Gauteng province is high at 15.5% and it is higher in older females than in males. Public health interventions that target potential clusters or hotspots are recommended.

Keywords: **hypertension, prevalence, Gauteng province**

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LIST OF ABBREVIATIONS

aOR: Adjusted Odds Ratio

CAPI: Computer-Aided Personal Interviewing

CI: Confidence Interval

DALYS: Disability-adjusted life years

EA: Enumerator Area

GCRO: Gauteng City-Region Observatory

HIV: Human Immunodeficiency Virus

LMICs: Low- and Middle-Income Countries

NCDs: Non-Communicable Diseases

OR: Odds Ratio

PPS: Probability Proportional to Size

QoL: Quality of Life

SSA: Sub-Sahara Africa

SAL: Small Area Layer

WHO: World Health Organisation

CHAPTER 1: INTRODUCTION

1.1 General Introduction

This chapter will introduce the topic, including a detailed literature review, outline the problem statement and give a justification for the study. The burden of hypertension, globally and in South Africa, will be described in detail in this chapter. Factors associated with hypertension and the spatial distribution of hypertension will also be discussed in this chapter.

1.2 Description of hypertension

Hypertension is defined as a cardiovascular disease that results in blood continually flowing in the vessels at a higher pressure than normal (1). The South African hypertension practise guideline 2014 classifies hypertension into 3 categories: Grade 1, 2, and 3 are blood pressure levels of 140-159mmHg/90-99mmHg, 160-179mmHg/100-109mmHg, and ≥180mmHg/110mmHg, respectively (1).

Hypertension can also be classified into two groups (primary or secondary hypertension) based on its causes. Primary hypertension is high blood pressure without a known cause and it is the most common type affecting about 95% of the population with hypertension (2). Secondary hypertension affects about 5% of the population with hypertension and is caused by underlying medical conditions such as renal and adrenal diseases (3).

1.3 Background

Rapid economic expansion in Africa over the last decade has been linked to the emergence of new diseases such as hypertension and obesity. Individual lifestyle patterns are associated with the development of certain diseases (4). The most common cardiovascular disorder affecting approximately 1.4 billion people globally is hypertension (5). Globally the World Health Organization (WHO) identified hypertension as the leading cause of cardiovascular and cerebrovascular mortality (4). Worldwide hypertension is estimated to be associated with about 7.6 million deaths per year, which constitute approximately 13.5% of all deaths (5).

In Low- and middle-income countries (LMICs) hypertension is estimated to cause significant morbidity, and about 7% of all global disability-adjusted life years (DALY) lost is attributed to it

(5). Lower middle-income countries are those countries that have economies with gross national income per capita ranging between $1,036 and $4,045 (6). Hypertension also has economic and social effects on countries, globally it was estimated that hypertension and other non-communicable diseases (NCDs) would cost more than US$ 30 trillion, representing 48% of global GDP in 2010 and this would push millions of people below the poverty line (7). Globally approximately 17 million people die each year from cardiovascular disease and among these deaths, 9.4 million are due to hypertension (8).

The global burden of hypertension is exceedingly high; in 2008, about 40% of persons over the age of 25 were diagnosed with hypertension (8). The burden of hypertension in sub-Saharan Africa (SSA) is reported to be as high as 38 % (9). Hypertension (also commonly known as "high blood pressure") is increasingly becoming a major public health burden in SSA countries but the awareness, treatment, and control are lagging behind other countries (10).

NCDs have become the primary cause of death in South Africa, accounting for 40% of all deaths, with one-third of all deaths happening before the age of six (11). Hypertension, which can be caused by a variety of factors, was predicted to affect more than 38% of the population in 2016. Poor diet, physical inactivity, and ageing are thought to be the main causes of the increased prevalence of hypertension in South Africa. However, in South Africa, the vast majority of hypertensive people are completely unaware of their condition and do not seek treatment (12). Existing hypertension and other non-communicable diseases (NCD)-related risk factor surveillance and estimates in South Africa are mostly focused at the national or provincial levels, with local prevalence estimates receiving less attention. Gauteng province has complex health challenges, including an increasing burden of hypertension.

1.4 Problem statement

Hypertension has been identified as a leading cause of morbidity and mortality for cardiovascular-related diseases in South Africa (13,14). The prevalence of hypertension in South Africa was estimated to be 30.4% among the adult population which is high (15). The mortality rate due to hypertension is closely related to the high prevalence of hypertension. The South Africa 2016 Mortality and Causes of Death (MaCoD) report indicated that hypertension-related death was at 7.8% (16). Currently, there is little knowledge about determinants of the spatial distribution of self-reported hypertension and little knowledge about the determinants and other factors associated with self-reported hypertension in Gauteng Province. Studies on hypertension using self-reported data have been carried out in South Africa and other countries such as China and the United States of America (17). A study in eMbalenhle in Mpumalanga Province in South Africa sought to determine the relationship between self-reported hypertension and associated risk factors among adults (18). Epidemiological research on factors that are associated with self-reported hypertension as well as the spatial distribution of hypertension is limited in Gauteng Province. The municipality-specific associations between hypertension and other factors (e.g., gender, presence of NCDs, working status) in Gauteng province are not well researched. In Gauteng province, location-specific hypertension clusters are not known, and this affects hypertension management and prevention. The identification of hypertension hotspots and cold spots will allow for data-driven health resource allocation, preventing under- or over-resourcing of health services at the local level. There is little information that currently exists about the geographic distribution of hypertension in Gauteng. This gap in research warrants a study that will attempt to establish the determinants and spatial distribution of self-reported hypertension in Gauteng province.

1.5 Justification

This study will establish the prevalence of hypertension, determine spatial clustering of self-reported hypertension, and find factors that are associated with self-reported hypertension in Gauteng province in South Africa in 2015 for adults aged 18 years or older.

The study will contribute knowledge that may inform health planning and policymakers in Gauteng province about the geographic locations which have a high prevalence of self-reported hypertension. This information is important in identifying municipalities that are lacking in delivering accessible hypertension control and prevention programs.

1.6. Research Question

What are the determinants and the spatial distribution of self-reported hypertension among older adults residing in Gauteng Province in 2015?

1.7. Aim of the study

To investigate the determinants and the spatial distribution of self-reported hypertension among adults residing in Gauteng Province in 2015.

1.7.1 Objectives of the study

1. To estimate the prevalence of self-reported hypertension stratified by age and gender in Gauteng Province 2015.
2. To identity factors associated with self-reported hypertension in Gauteng Province in 2015.
3. To identify the spatial distribution of self-reported hypertension in Gauteng in 2015.

1.8. Literature Review

1.8.1 Prevalence of hypertension

According to WHO, hypertension was identified as a suitable condition for surveillance (3,7). Studies conducted in 2013 on the prevalence of cardiovascular diseases found that about a quarter of South Africans aged 15 years and older suffered from hypertension (5).

The prevalence of hypertension among adults in South Africa was estimated to be about 20% and the prevalence is higher in the urban areas compared to the rural population with a 15 percent difference (urban 25%, rural 10.5%) (19). The prevalence varies across different population groups within the country. The variability is due to behavioural, genetic, socioeconomic, and demographic factors. In addition, there are great disparities in the urban areas with the poor settlements having a higher prevalence than the middle class and affluent communities (19).

Hypertension has emerged as a common risk factor for the development of stroke, and congestive heart failure in SSA (20). In studies conducted in different countries in SSA (Kenya, South Africa, and Burkina Faso) the average prevalence of hypertension was estimated to be 33.3%, although the prevalence varied both from country to country and within countries (21). In the study, South Africa was found to have the highest hypertension prevalence sites (ranging from 41.6% to 54.1%) and Burkina Faso had the lowest (15%) (21). In studies carried out in South-Asia hypertension was a leading cause of mortality. The estimated prevalence of hypertension in Bangladesh was 17.9%, India (31.4%), Maldives (31.5%) and the highest prevalence rate was in Nepal (33.8%) (22).

In studies that were done in South Africa, hypertension prevalence was estimated to affect about 20% of the population (Mills et al. 2016). Within the country, the prevalence varies depending on which population groups are included. In South Africa, there is a significant variation in

hypertension prevalence by geographical location (23). These variations are influenced by behavioural, genetic, socioeconomic, and demographic factors. Researchers in South Africa discovered considerable differences in prevalence and distribution of hypertension in urban zones, with poor settlements having a higher prevalence than middle- and upper-class areas (24).

1.8.2 Factors associated with hypertension

Hypertension is a major public health problem in different parts of South Africa including Gauteng province, however, its treatment remains inadequate, and its control is also poor (25). In studies that were conducted in South Africa age, body weight, smoking, alcohol use, salt intake, and meat intake were found to be factors that were significantly associated with hypertension (26–28). Other studies conducted in South Africa showed that a high risk of hypertension was associated with low education levels and older age.

In South Africa, a high prevalence of hypertension has been associated with urbanization, affecting lifestyle patterns (29). Lack of physical activity, smoking, old age, drinking alcohol, obesity, and family history of stroke are some of the lifestyle patterns that have been positively associated with hypertension prevalence (30). Education level and income status were found to be independently associated with hypertension (31). Researchers in Botswana showed an association between gender and being hypertensive, with females being more likely to be hypertensive and hypertension was found to increase with age (32).

In studies that were done in Cameroon, researchers identified high serum triglyceride levels and a family history of heart failure and hypertension as independent predictors of hypertension (33).

1.8.3 Spatial distribution of hypertension.

Currently, few epidemiological studies have been done in South Africa and within Gauteng province to establish the spatial pattern of hypertension (34). Studies conducted in South Africa in

1998, established that there were spatial patterns in the distribution of hypertension and stroke within the population (15). Researchers found that hypertension prevalence was highly concentrated in the southwestern parts of the country (35).

In other countries, epidemiological studies attempted to establish spatial patterns of hypertension. In a study that was conducted in Canada, researchers noted spatial variations in hypertension and obesity prevalence, with higher risk clusters found to be located in the Northern and Atlantic regions, lower risk clusters were found in the Southern and Western regions of Canada (36). In a study carried out in Ghana researchers found that there were spatial patterns in the distribution of hypertension prevalence (37). Researchers established that hypertension prevalence was higher in low-income suburbs than the high-income suburbs (36). Researchers in China established spatial patterns in hospital admissions due to hypertension, with studies showing that the relative risk for hospital admission due to hypertension was high in the south and south-eastern Shenzhen (38).

The spatial distribution of hypertension was studied in Greece, and it was discovered that hypertension rates reduced as the socio-environmental level of the residential region improved; the study also found that the prevalence of hypertension was low in densely populated areas, owing to the availability of superior health facilities and other amenities that aid in hypertension control (39). This data could aid in the scaling up of health policies and intervention strategies targeted just at prevention and management of hypertension in Athens' densely populated areas.

Researchers discovered considerable disparities in hypertension prevalence between districts in studies conducted in South Africa, and this information is useful for developing preventative and control strategies that target high-prevalence districts.

Researchers in South Africa discovered statistically significant clusters of hypertension hot spots in KwaZulu-Natal and the Eastern Cape provinces, although these clusters were linked to other individual and demographic risk factors such as socioeconomic status, gender, and age (40).

Further in other studies on the geographical influence on the distribution of the prevalence of hypertension in South Africa, researchers established that there were significant differences in hypertension between districts. The districts that had a higher-than-average prevalence of hypertension were found in the south-west of the country, and those with a prevalence that was below the national average were found in the northern parts of the country (23).

Researchers used data from the National Income Dynamics Study in South Africa to explore the spatial distribution of multimorbidity in South Africa and discovered that the prevalence of multimorbidity increased from 2.73 % to 2.84 % in adults between 2008 and 2012. Clusters (hotspots) with higher multimorbidity (hypertension and diabetes) were discovered in KwaZulu-Natal and Eastern Cape districts (40).

CHAPTER 2: METHODOLOGY

2.1 Introduction

This chapter describes in detail the methods used in the study. The chapter is divided into six sections and these are: - study design and setting; study population; sampling and data collection methods; study variables and their descriptions; statistical analysis and ethical considerations.

2.2 Primary Study

The primary study was a household survey carried out by the Gauteng City-Region Observatory (GCRO). The household survey that was used by Gauteng City-Region Observatory (GCRO) used a structured questionnaire administered by trained field workers in 2015. The GCRO's Quality of Life (QoL) survey is a biennial household survey. This survey is designed to collect socio-economic data, satisfaction levels with services provided by the government and other service providers as well as gathering data on socio-political perceptions of residents in Gauteng province, South Africa (38). GCRO is a partnership between the University of Johannesburg (UJ), Witwatersrand University, and the Gauteng provincial government.

The GCRO used a stratified multistage sample design for the 2015 QoL survey (41). The sample contained a total of 30,002 participants who were adults (aged 18 years or older), drawn from 508 wards in Gauteng (41).

In Gauteng province there are 10 municipalities these are subdivided into 508 wards (42). In each ward enumerator areas (EAs) were sampled with probability proportional to size. Within these wards, there are Small Area Levels (SALs) which were derived from the Population Census Enumerator Area (EA) polygons. SAL codes and geography were derived from the Statistics South Africa information (43). A total of 5,860 EAs were drawn from Gauteng's 508 wards, the number of EAs varied between wards (41).

A structured questionnaire with a total of 228 questions (224 closed and four open-ended questions) was used to collect the data (41). This questionnaire was translated into local languages. A Computer-Aided Personal Interviewing (CAPI) method, which is a face-to-face interviewing method that utilises a portable electronic device such as a tablet, was used during fieldwork to collect the data (41). The data was exported into excel and SPSS files. Rigorous data quality checks and controls were implemented throughout the survey.

2.3 Study design

The current study is a secondary data analysis of data from the GCRO Quality of Life Survey (QOL-IV) in Gauteng Province in 2015.

2.4 Study site

The study was conducted in Gauteng province in South Africa. Geographically the province covers an area of 18,178 km^2 and it is the smallest province in South Africa. According to census statistics in South Africa, Gauteng province has the largest population in the country estimated to be 12,272,263 (24% of the national population) (43). It is bordered by Free State province to the south, North West province to the northwest, Limpopo province to the north, and Mpumalanga province to the northeast and southeast. Despite being the smallest province, it is the most populous province. It is by far the most densely populated with 680 persons per km^2 compared to the national population density of 42 (16). (The map of the study site is below on page 12).

Gauteng province has a total of ten municipalities of which three are metros (i.e. municipalities of Johannesburg, Ekurhuleni, and Tshwane) and others are district municipalities (i.e. Sedibeng and West Rand) (41). The district municipalities are subdivided into seven local municipalities. Sedibeng District is subdivided into Emfuleni, Lesedi, and Midvaal municipalities (41). West Rand district is subdivided into four local municipalities namely Merafong, Mogale, Randfontein, and Westonaria.

The map of the study site i.e. Gauteng province is shown below

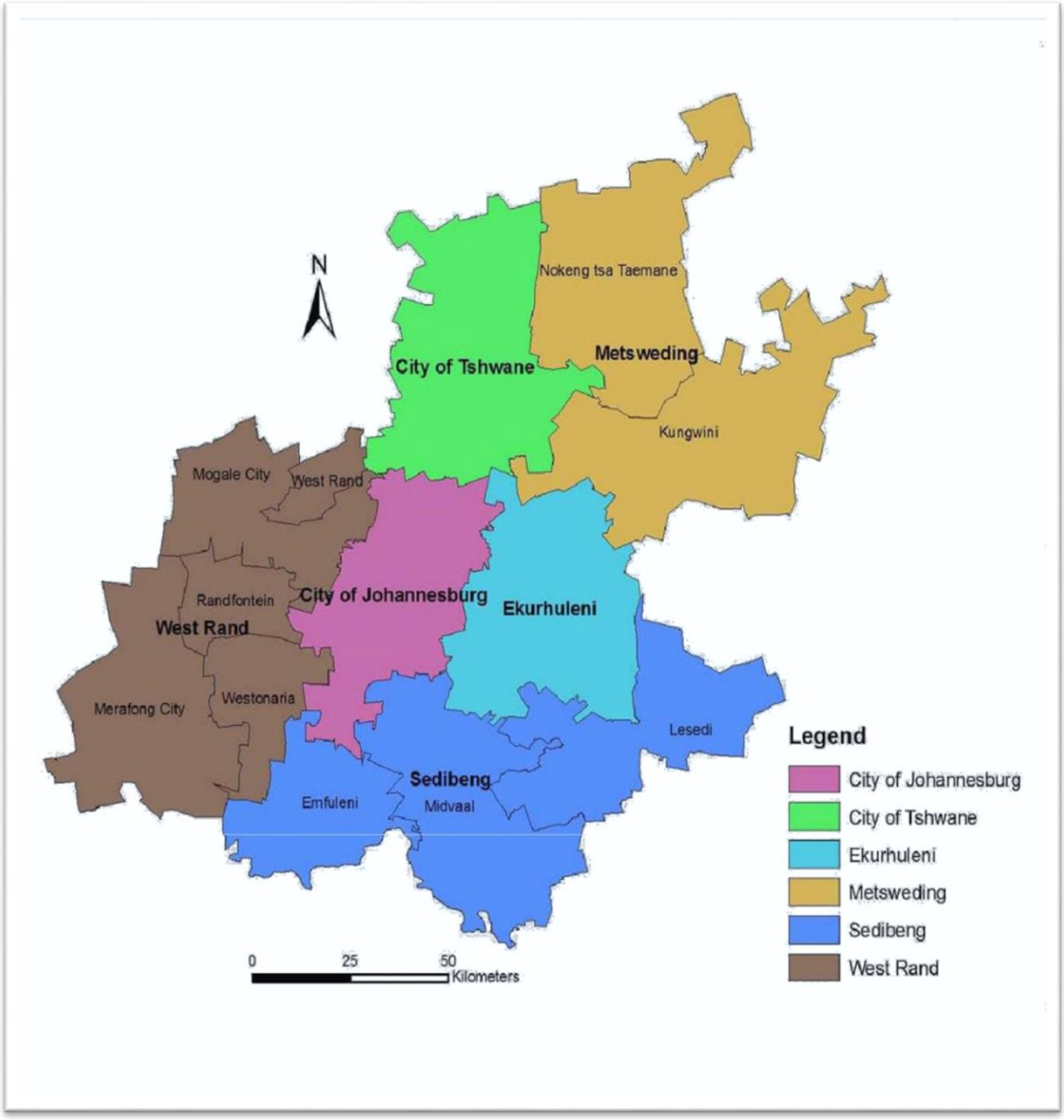

Figure 1:Administrative map of Gauteng Province**.**

2.5 Study population and sample size considerations

The primary study population consisted of 30,002 adults aged 18 years or older who resided in Gauteng province in 2015. Informed consent was sought from all the study participants. The primary study targeted 30-220 interviews per ward, with the highest number of interviews being conducted in Johannesburg. The data was collected using a multistage sampling design, clustering and sampling weights were considered in the analysis stage when the multiple logistic regression model was fitted. The data came from a survey; hence sampling weights play a role in estimating standard errors, therefore leaving them out of the analysis could lead to distorted results (41). Individuals in the research were not selected randomly but were picked from a cluster. At the analysis, the effects of clustering must be considered. If clustering is not considered in the analysis, the standard errors will be lower than they should be in our design (41)

2.6 Study period and data collection

The data collection was conducted from 6th July 2015 to 17th May 2016 by ASK Africa (41). The authority to use the dataset was granted by GCRO on 20th December 2016.

2.7 Study variables

The outcome and explanatory variables are described below.

2.7.1 Outcome variable

Hypertension: Hypertension status was the primary outcome of interest. Hypertension is defined as self-reported hypertension in our study. Study participants were asked a question whether they were on anti-hypertensive medication or had previously been diagnosed with hypertension.

In the study the response to being hypertensive was categorized as follows:

- 1-Yes
- 0-No

2.7.2 Explanatory variables

In the study, the following variables were explanatory variables.

2.7.2.1 Other self-reported medical conditions

Participants in the study were also asked whether they had any medical conditions apart from hypertension, either diagnosed by a physician or if they were taking medication for the condition. The medical conditions identified were cancer, asthma, TB, diabetes, heart disease, stroke, HIV/AIDS, obesity, and mental illness. If the respondent answered "yes," the relevant variable was coded 1; if the respondent answered "no," the relevant variable was coded 0.

Table 1**:** Variables used in the primary study.

Variable	QoL Categories			Categories to be used in the analysis
Outcome Variable				
Hypertension	1	Yes		1
	0	No		0
Explanatory variables				
Race	1	Black African		1
	2	Coloured		2
	3	White		3
	4	Indian		4
Sex (Respondent)	0	Male		0
	1	Female		1
Age	Age of respondents		18-24	0
			25-34	1
			35-44	2
			45-54	3
			55-64	4
			65-100	5
Education Level (of the respondent)	1	No Education		Categorised into :
	2	Primary Only		0
	3	Secondary Incomplete		1
	4	Matric		2
	5	More		3

Table 2**:** Variables used in the primary study: Continued**.**

Variable	QoL Categories		Categories to be used in the analysis	
Employment status (of the respondent)	1	employed -full-time informal sector	Categorised into :	1
	2	employed -full-time non- informal sector		2
	3	employed part-time-formal sector		3
	4	employed part-time -informal sector		4
	5	self-employed, own business, working from home		5
	6	self-employed, own business, not working from home		6
	7	self-employed, own business, informal sector		7
Renting Status (Respondent)	1	Free RDP House		1
	2	Occupation of vacant dwelling		2
	3	Other		3
	4	Personal owned- fully paid up		4
	5	Personal owned- Still paying up		5
	6	Rent Free		6
	7	Renting from Government		7
	8	Renting from a Private owner		8
	9	Transfer of Title Deed from government		9
Municipality				
	1	Ekurhuleni	1	Ekurhuleni
	2	Emfuleni	2	Emfuleni
	3	Johannesburg	3	Johannesburg
	4	Lesedi	4	Lesedi
	5	Merafong	5	Merafong
	6	Midvaal	6	Midvaal
	7	Mogale	7	Mogale
	8	Tshwane	8	Tshwane
	9	Westonaria	9	Westonaria
	10	Randfontein	10	Randfontein

Table 3 Continued: Variables used in the primary study**.**

Variable	QoL Categories			Categories to be used in the analysis	
Type Settlement	1	Formal		1	Formal
	2	Informal		2	Informal
	3	Other		3	Other
Cancer	1	Yes		1	Yes
	0	No		0	No
HIV/AIDS	1	Yes		1	Yes
	0	No		0	No
			Categorised into:		
Diabetes	1	Yes	**NCDs**		
	0	No			
Obesity	1	Yes		1	Yes
	0	No		0	No
Heart Disease/Stroke	1	Yes			
	0	No			

2.7.2.2. Socio-demographic characteristics

The following characteristics of the study participants were also collected: age, education level, sex, race, and employment status.

2.7.3 Descriptive analysis

Prevalence of self-reported hypertension (Objective 1)

The prevalence estimates of hypertension were calculated considering the sampling weights and the clustering of respondents within SALs. The prevalence of hypertension was estimated overall, by gender and by age group. Association between gender and hypertension and age-group and hypertension were investigated using the Rao-Scott correction to the chi-square test. The age categories that were used are 18-27,28-37,38-47,48-57,58-67,68-77,78-87,88-97,98-117.

2.7.4 Inferential analysis

To identify factors associated with self-reported hypertension (Objective 2)

To identify factors associated with self-reported hypertension, univariable logistic regression models for hypertension status were fitted on each explanatory variable to calculate the odds ratios (ORs) and associated 95% confidence intervals.

The explanatory variables that were used are age, municipality, race, education level, employment status, cancer, asthma, tuberculosis, diabetes, heart disease/stroke, HIV/ADIS, obesity, mental illness, and sex.

A multiple logistic regression model which used backwards elimination was fitted with all the explanatory variables, to determine the factors that are statistically significantly associated with hypertension at the 5% significance level. Since the data were collected using a multistage sampling design, clustering and sampling weights were considered when the multiple logistic regression model was fitted.

2.7.5 Spatial analysis

To identity the spatial distribution of self-reported hypertension in Gauteng (Objective 3)

SaTscan was used to identify significant primary and secondary clusters of hypertensive individuals who were within a radius of 10 km from each other within wards. A cluster is a group of individuals who are potential or expected hypertensive cases and residing within a radius of 10km. The primary cluster is the cluster of individuals who are potential or expected hypertensive cases who live within a specified radius and these have the highest probability of not being due to some random causes. Secondary clusters are those potential or expected hypertensive cases that are in rank order after cluster one and have associated values that are calculated by ignoring the

existence of the most likely cluster or primary that had already been detected (44). These clusters can be statistically identified using SaTScan statistics (44). A statistically significant cluster ($p< 0.05$) is a hotspot for hypertension.

SaTScan is software which analyses spatial and space-time data using spatial, scan statistics. Spatial scan statistics are designed to detect spatial disease clusters, perform geographical surveillance of diseases, and establish spatial clusters that are statistically significant (45). SaTscan statistics is modelled using geolocation of everyone, total population at risk, and several hypertensive cases.

To establish whether the potential clusters were statistically significant, Monte Carlo replication of the data sets was carried out with 999 iterations, to test the null hypothesis of absolute spatial randomness against the alternative of clustering, using a likelihood ratio test. Significant clusters were identified using the 5% significance level. These could either be spatial clusters of high prevalence or spatial clusters of low prevalence (34).

The data was scanned for areas or wards with clusters (high rate or low-rate clusters). A discrete Poisson probability model was used. The spatial cluster size was set to the default size of 50% of the population at risk and a circular spatial window was used. The default 999 replications were used to run the analysis p values were set at $p < 0.05$, being statistically significant. The Gini Index was used to select non-overlapping secondary clusters that were significant. Shapefiles showing cluster areas were generated using SaTscan.

2.7.8 Data management

The primary study data was stored in an excel spreadsheet. The data was imported into STATA 13.0 for analysis. For analysis, some variables were re-categorized, and others were generated as illustrated in Table 2.

2.8 Limitations of the study

One of the study's weaknesses is that hypertension is self-reported, which has the disadvantage of being prone to bias and misclassification errors. Individuals may be unaware of their hypertension condition.

2.9 Ethical consideration

The Human Research Ethics Committee (HREC) of the University of the Witwatersrand approved the ethics application for the study, on 03 April 2017, protocol number M161118 as seen in Appendix. To ensure the confidentiality of the participants, all personal identifiers were removed from the dataset.

CHAPTER 3: RESULTS

3.1 Introduction

This section presents the results of secondary data analysis based on the study objectives. The results in this section are presented in four parts. The first part is a descriptive analysis of the characteristics of the study population across all the municipalities in Gauteng province. The second part describes the prevalence estimates of self-reported hypertension. The third part describes the factors associated with self-reported hypertension. The final part of this section describes the spatial distribution of self-reported hypertension.

3.2 Characteristics of the study population

A total of 29,548 participants from the primary study were found to have complete household demographic data on all variables including self-reported hypertension. The highest number of participants in the primary study was in Johannesburg which constituted 33% (n=9,587), followed by Ekurhuleni with 25% (n=7,234), and the least number of participants was found in Lesedi and these constituted 1.2% (n =398). A total of 85% (n=25,205) of the study participants was drawn from formal settlements within Gauteng municipalities.

The majority of study participants were women who constituted 54% (15,831). Most of the study participants were under the age of 40, constituting 62% (n = 18,390). African race was the most dominant race, in the study, with 81% (n=23,848) participants, followed by whites, 13% (3,852). Indians were the least represented race with 2.2% (n= 624) participants.

The education level of study participants varied, the highest number of participants had secondary incomplete education, 41% (n=12,140), followed by those who had Matric, 32% (n=9,429). Participants with no education constituted 0.89% (n=255). Participants in the study also indicated their renting status, results show that the highest number of participants personally owned a fully

paid off accommodation, 28% (n=8,312) followed by those staying for free in RDP houses, 15% (n=4,374). The most common comorbidity amongst the study participants was self-reported HIV/AIDS, constituting 12% (3,442), followed by NCDs (either Diabetes, Heart Disease, or Obesity and cancer (1.2%).

Table 4**:** Characteristics of participants of the primary study

Characteristics	**Category**	**The municipality, n (%)**									
		Johannesburg	**Ekurhuleni**	**Emfuleni**	**Mogale**	**Westonaria**	**Merafong**	**Tshwane**	**Randfontein**	**Lesedi**	**Midvaal**
Sex	Female	1,472,100(17)	1,136,376(13)	280,438(3.0)	163,010(2.0)	53,481(1.0)	112,303(1.0)	1,097,071(13)	99,999(1.0)	52,056(1.0)	65,107(1.0)
		4,984(52)	3,881(54)	966(57)	593(57)	235(45)	448(51)	3863(54)	387(56)	213(52)	261(60)
	Male	1,344,919(16)	968,716(11)	207,412(3)	121,885(1)	64,426(1.0)	107,700(1.1)	920,806(11)	79,563(1.0)	47,629(1.0)	43,270(1.0)
		4,603(48)	3,353(46)	719(43)	499(43)	259(55)	425(49)	3,254(46)	300(44)	185(48)	170(40)
Age	18-24	401,526(5.6)	295,308(4.1)	64,026(9.0)	43,697(0.6)	20,464(0.3)	33,570(0.1)	296,971(4.2)	25,680(0.4)	14,519(0.2)	13,222(0.2)
		1,443(17)	1,082(17)	237(15)	165(18)	86(21)	140(18)	1,092(17)	102(17)	58(17)	54(15)
	25-34	753,717(11)	569,135(0.8)	137,767(11)	81,765(1.1)	32,010(0.5)	61,063(0.1)	539,842(7.6)	45,894(0.6)	26,171(0.4)	30,643(0.4)
		2,514(32)	1,925(32)	458(33)	288(33)	123(33)	234(33)	1,863(32)	170(31)	100(31)	111(34)
	35-44	532,934(7.5)	405,373(5.7)	93,607(1.3)	53,575(0.1)	18,486(0.3)	40,473(0.6)	391,499(5.5)	35,582(0.1)	18,089(0.3)	20,883(0.3)
		1,826(23)	1,381(23)	331(22)	199(22)	85(19)	159(22)	1,376(23)	132(24)	72(22)	84(23)
	45-54	290,388(4.1)	213,051(3.0)	53,197(0.1)	29,420(0.4)	12,968(0.2)	20,620(0.3)	197,836(2.8)	18,853(0.3)	8,837(0.1)	9,643(0.1)
		967(12)	722(12)	179(13)	106(12)	54(13)	82(11)	678(12)	74(13)	35(11)	39(11)
	55-64	206,947(2.9)	151,113(2.1)	37,285(0.1)	21,932(0.3)	6,889(0.1)	15,412(0.2)	151,539(2.1)	12,651(0.2)	8,621(0.1)	9,473(0.1)
		699(8.7)	514(8.5)	124(8.9)	82(8.9)	31(7.1)	62(8.3)	535(8.8)	53(8.4)	35(10)	37(10)
	> 65 years	183,066(2.3)	142,682(2.0)	31,341((0.1)	16,963(0.2)	6,129(0.1)	14,650(0.2)	135,165(1.9)	11,688(0.2)	6,957(0.1)	6,865(0.1)
		611(7.7)	479(8.0)	106(7.5)	60(6.9)	24(6.3)	54(7.9)	475(7.9)	42(7.8)	30(8.4)	28(7.6)

Table 5**:** Characteristics of participants of the primary study Continued**.**

Characteristics	Category	The municipality, n (%)									
		Johannesburg	**Ekurhuleni**	**Emfuleni**	**Mogale**	**Westonaria**	**Merafong**	**Tshwane**	**Randfontein**	**Lesedi**	**Midvaal**
Race	African	2,227,957(26)	1,697,870(26)	4,219,50(5.)	230,790(3.)	111,812(1.)	204,592(2.)	1,638,951(1)	134,828(1.1)	82,849(1.0)	62,003(0.7)
		7,578(79)	5,813(81)	1,464(86)	850(81)	467(95)	805(93)	5,773(81)	516(75)	334(83)	248(57)
	Coloured	180,010(2.1)	65,291(0.8)	4,927(0.6)	310(0.0)	894(0.1)	1,761(0.0)	47,631(0.1)	15,742(0.1)	687(0.0)	1,479(0.1)
		469(6.0)	231(3.0)	15(1.0)	1(0.0)	4(0.8)	7(0.9)	168(2.4)	63(0.9)	2(0.7)	5(1.4)
	Indian/Asian	100,658(1.2)	44,224(0.6)	5,273(0.2)	3,075(0.0)	-	282(0.0)	26,644(0.3)	285(0.0)	1,064(0.1)	1,181(0.1)
		331(3.6)	152(2.1)	22(1.1)	11(1.1)	-	2(0.0)	97(0.1)	1(0.0)	2(0.0)	4(0.1)
	Other	13,089(0.2)	8,428(0.1)	0(0.0)	724(0.0)	-	292(0.0)	8,472(0.1)	1,373(0.0)	722(0.0))	295(0.0)
		45(0.5)	33(0.3)	0(0.0)	3(0.0)	-	1(0.0)	29(0.4)	4(0.0)	2(0.0)	1(0.0)
	White	295,306(3.5)	289,279(3.4)	55,701(0.1)	49,996(0.6)	5,201(0.0)	13,076(0.1)	296,178(3.5)	27,334(0.3)	295(0.0)	433,90(0.1)
		1,023(10)	1,005(14)	184(11)	177(18)	23(4.4)	58(5.9)	1,050(15)	103(15)	1(0.0)	173(40)
Education	Matric	901,602(11)	655,763(7.9)	155,39(1.9)	82,391(0.1)	32,485(0.1)	65,715(0.8)	610,507(7.3)	55,299(0.7)	32,36(0.1)	32,971(0.1)
		3,092(32)	2,265(32)	536(32)	310(29)	136(28)	258(27)	2,177(31)	213(31)	134(33)	128(31)
	More than Matric	438,165(5.3)	306,318(3.7)	53,760(0.6)	39,938(0.4)	15,328(0.2)	26,862(0.3)	322,324(3.9)	24,702(0.3)	8591(0.1)	15,692(0.2)
		1,437(16)	1,016(15)	188(11)	148(14)	60(13)	102(12)	1,102(16)	91(14)	31(9)	64(15)
	No Education	27,437(0.3)	14,969(0.2)	2,798(0.1)	494(0.0)	1,013(0.0)	2,620(0.1)	20,691(0.2)	1,361(0.0)	792(0.0)	1,790(0.0)
		85(0.9)	50(0.1)	9(0.0)	2(0.0)	6(0.0)	13(0.0)	72(0.2)	6(0.0)	4(0.0)	8(0.0)
	Primary Only	314,350(3.8)	224,300(2.7)	50,412(0.6)	28,143(0.3)	17,076(0.1)	25,305(0.3)	217,920(2.6)	19,029(0.2)	13,292(0.1)	12,531(0.1)
		1,076(11)	788(11)	178(10)	102(10)	76(15)	107(12)	787(11)	75(11)	58(13)	54(12)
	Secondary Incomplete	1,097,330(13)	868,109(10)	220,571(2.7	129,598(1.)	51,793(0.6)	98,852(1.2)	819,534(10)	78,250(0.9)	44,243(0.)	44286(0.1)
		3,778(39)	2,995(46)	759(46)	467(46)	215(44)	390(45)	2,893(41)	299(44)	174(41)	174(41)

Table 6 Characteristics of participants of the primary study Continued

Characteristics	Category	The municipality, n (%)									
		Johannesburg	**Ekurhuleni**	**Emfuleni**	**Mogale**	**Westonaria**	**Merafong**	**Tshwane**	**Randfontein**	**Lesedi**	**Midvaal**
Comorbidity		329,363(3.9)	232,406(2.8)	58,716(0.1)	36,625(0.1)	15,089(0.1)	22,296(0.1)	238,130(2.8)	20,985(0.3)	12,224(0.1)	10,770(0.1)
	HIV	1,129(12)	804(11)	196(12)	136(13)	66(13)	93(10)	848(12)	80(12)	46(12)	44(10)
		305,94(0.4)	25,225(0.4)	3,878(0.1)	3,396(0.0)	809(0.0)	2,173(0.0)	25,825(0.3)	1,418(0.0)	2,209(0.0)	3,816(0.0)
	Cancer	105(1.1)	86(1.2)	13(0.8)	12(1.2)	4(0.0)	9(0.9)	89(1.3)	5(0.1)	7(0.2)	14(0.4)
		26,547(0.1)	14,464(0.1)	2,221(0.0)	2,029(0.0)	496(0.0)	1,251(0.1)	20,433(0.2)	1,400(0.1)	604(0.0)	880(0.1)
	Obesity	90(0.9)	49(0.6)	9(0.1)	8(0.1)	2(0.0)	4(0.0)	71(0.1)	6(0.0)	2(0.0)	4(0.0)
		85,825(0.1)	65,185(0.1)	15,794(0.0)	10,092(0.1)	5,526(0.0)	2,585(<1)	66,420(0.8)	7,318(0.1)	2,734(0.0)	2,585(0.0)
	Diabetes	291(3.0)	228(3.1)	60(3.2)	33(3.5)	22(4.7)	26(2.76)	229(3.3)	27(4.01)	11(2.7)	10(2.4)
Settlement		2,458,051(29)	1,782,005 (21)	417,771(5.0)	223,044(2.6)	71,094(0.8)	160,721(1.9)	1,756,613(21)	146,286(1.7)	90,484(1.1)	91,086(1.1)
	Formal	8,370(87)	6,137(85)	1,443(86)	823(78)	302(60)	635(73)	6,211(87)	561(81)	364(91)	359(84)
		339,374(4.0)	293,575(3.5)	57,043(0.7)	58,433(0.7)	34,754(0.4)	42,599(0.4)	23,6312(0.2)	28,543(0.3)	8,541(0.1)	16,661(0.2)
	Informal	1,151(12)	991(94)	196(12)	196(12)	144(29)	168(19)	817(12)	109(16)	32(8.6)	70(15)
		19,594(0.2)	29,513(0.4)	13,036(0.1)	13,036(0.1)	12,059(0.1)	16,683(0.2)	24,952(0.3)	4,734(0.1)	660(0.0)	629(0.0)
	Other	66(0.1)	106(1.4)	46(0.3)	46(0.3)	48(0.4)	70(0.8)	89(1.2)	17(0.3)	2(0.0)	2(0.0)

3.3 Prevalence of self-reported hypertension

The prevalence estimates took into account the survey design. A total of 4,580 study participants were found to have hypertension, the overall prevalence of self-reported hypertension in the study was 15.5%. A comparison across municipalities shows that Mogale City had the highest prevalence of self-reported hypertension at 30% (n=297). The municipality with the lowest prevalence of self-reported hypertension was Lesedi with 5% (n=21), this might be because Lesedi had few participants in the study. The prevalence of self-reported hypertension among people residing in formal settlements was 16% (n=4,155).

There was a small difference in the prevalence of hypertension between females (16%, n=2,547) and males (15%, n=2,033). Study participants aged 55 years and above had a higher prevalence of self-reported hypertension of 17% (n=700) compared to other age groups. A comparison of study participants by race shows that whites had the highest prevalence of self-reported hypertension at 29% (n=1,123), followed by Asians with 19% (n=127). A comparison of self-reported hypertension by education status shows that those individuals with no education had the highest prevalence of 19% (n=52), followed by those who had reached matric level (17%, n=730).

Participants who were formally employed on a full-time basis had the highest prevalence of self-reported hypertension at 18% (n=1,364). The prevalence of hypertension by renting status showed that study participants who personally- owned their accommodation but were still paying up bond/loan had the highest prevalence of 20% (n=801).

The prevalence of self-reported hypertension among those participants with other comorbidities was higher for those with obesity, 21% (n=49), followed by those with cancer, 19% (n=66).

Table 6**:**Showing the prevalence of hypertension adjusted for survey design.

Variable	Yes		No		Rao-Scott adjusted chi-square
	Adjusted, n (%)	Unadjusted, n (%)	Adjusted, n (%)	Unadjusted, n (%)	
Overall unadjusted prevalence =15.5%(N=4580)					
Municipality					
Johannesburg	369,636 (28)	1,273 (13)	2,447,383 (28)	8,314 (87)	41.2 (p<0.001)
Ekurhuleni	270,647 (21)	938 (13)	1,834,445 (26)	6,296 (87)	
Emfuleni	51,261 (3.9)	172 (11)	436,589 (6.1)	1,513 (89)	
Mogale	84,708 (1.0)	297 (3.0)	200,188 (2.4)	745 (70)	
Westonaria	16,857 (1.3)	69 (14)	101,050 (1.4)	425 (86)	
Merafong	38,940 (3.0)	154 (18)	181,062 (2.5)	719 (82)	
Midvaal	86,871 (1.2)	86 (20)	21,505 (1.7)	345 (80)	
Randfontein	36,319 (2.8)	137 (20)	143,244 (2.0)	550 (80)	
Tshwane	403,807(26)	1433 (20)	1,614,071(23)	5,684 (80)	
Lesedi	94,578 (1.3)	21 (5.0)	5,106(0.4)	377 (95)	
Gender					
Female	722,448 (56)	2,547 (16)	3,809,493 (53)	13,284 (84)	7.4(p=0.006)
Male	576,337 (44)	2,033 (15)	3,329,990 (47)	11,684 (85)	
Age					
18-24	178,633(16)	665(15)	1,030,351(17)	3,794(85)	7.2(p=0.007)
25-34	332,054(30)	1136(15)	1,945,954(32)	6,650(85)	
35-44	254,910(23)	890(16)	1,355,591(23)	4,755(84)	
45-54	140,030(13)	482(16)	714,692(12)	2,454(84)	
55-64	107,447(9.7)	380(17)	514,416(8.5)	1,792(83)	
> 65 years	93,262(8.4)	326(17)	462,242(7.7)	1,583(83)	
Race					
African	902,348 (69)	3,176 (13)	5,911,283 (83)	20,672 (87)	140.8 (p<0.001)
Coloured	39,946 (3.1)	136 (13)	278,788 (3.9)	970 (87)	
Indian/Asian	35,584 (2.7)	127 (19)	147,101 (2.1)	497 (81)	
Other	5,106 (3.9)	18 (15)	28,290 (4.0)	100 (85)	
White	315,802 (24)	1,123 (29)	774,020 (11)	2,729 (71)	
Education					
No Education	13,951 (1.1)	52 (19)	60,015 (8.5)	203 (81)	4.0 (p=0.004)
Primary Only	138,651 (11)	495 (15)	783,708 (11)	2,806 (85)	
Matric	405,716 (32)	1,442 (15)	2,218,786 (32)	7,807 (85)	
More than Matric	215,639 (17)	739 (17)	1,036,042 (15)	3,500 (83)	
Secondary Incomplete	506,739 (40)	1,795 (15)	2,942,826 (42)	10,345 (85)	

Table 7**:** Showing the prevalence of hypertension adjusted for survey design. Continued.

Variables	Hypertension		No Hypertension		Rao-Scott adjusted chi-square
	Adjusted, n (%)	Unadjusted, n (%)	Adjusted, n (%)	Unadjusted, n (%)	
Comorbidities					
Heart Disease	7,730(6)	28(15)	44,778(6.3)	161(85)	0.06(p=0.80)
Diabetes	41,763(3.2)	149(16)	225,807(3.2)	788(84)	0.03 (p=0.86)
Obesity	14,516(1.1)	49(21)	55,809(7.8)	196(79)	5.09 (p=0.024)
Cancer	18,772 (1.4)	66 (19)	80,572 (1.1)	278(81)	3.09 (p=0.08)
HIV	149,481 (88)	544 (15)	827,123 (88)	2,898 (85)	0.02(p=0.89)
Employment					
Employed full time, formal sector	388,029 (30)	1,364 (18)	1,818,370 (25)	6,374 (82)	8.3 (p<0.001)
Employed full time, informal sector	78,936 (6.1)	274 (16)	428,485 (6.0)	1,490 (84)	
Employed part-time, formal sector	61,811 (4.8)	221 (12)	442,064 (6.2)	1,555 (88)	
Employed part-time, informal sector	54,464 (4.2)	191 (12)	386,384 (5.4)	1,354 (88)	
Self-employed, own business, Not working	26,882 (2.1)	96 (15)	149,660 (2.1)	26,882 (85)	
Self-employed, own business, working from home	29,178 (2.2)	100 (14)	180,748 (2.5)	631 (86)	
Other	659,485 (51)	2,334 (15)	3,733,772 (52)	13,043 (85)	
Renting					
RDP House-Free	1,110,535(16)	510(11)	142,643(11)	203 (81)	18.7(p<0.001
Personal owned-fully paid up	1,956,991(27)	1,438(17)	403,630(31)	6,874(83)	
Personal owned- Still paying up	960,010(13)	801(20)	232,949(18)	3,349(80)	
Rent-free	573,920(8.0)	359(15)	101,155(7.8)	2,028(85)	
Renting from government	337,952(4.7)	247(17)	70,345(5.4)	1,191(83)	
Renting from a Private owner	1,436,131(20)	888(15)	250,644(19)	4,967(85)	
Awaiting private deeds from the government	330,042(4.6)	135(11)	39,444(3.0)	1,172(89)	
Other-Unspecified	194,866(2.7)	932.1)	26,764(3.2)	684(88)	

3.4 Factors associated with self-reported hypertension

3.4.1 Univariable logistic regression analysis

The odds of having hypertension were higher in women than men (OR: 1.10, 95% CI: 1.03- 1.17). A comparison of ethnic groups shows that odds of hypertension were higher in whites than in blacks (OR: 2.67, 95% CI: 2.45-2.91) followed by Indian/Asian (OR: 1.58, 95% CI: 1.29-1.95). A 10-year increase in age was positively associated with increased risks of hypertension. (OR:3.18, CI:0.95-10.57).

Individuals with no education have higher odds of hypertension (OR:1.35, 95% CI: 0.98-1.86) than those with secondary incomplete. The second category of individuals who had higher odds of hypertension were those who have more than matric, compared to those with secondary incomplete (OR:1.06, 95% CI: 0.98-1.15). In terms of working status, the odds of hypertension were higher in individuals who were employed full-time in the formal sector compared to individuals doing part-time informal work (OR: 1.51, 95% CI:1.28-1.80).

Individuals who were staying in personally owned accommodation but still paying off the bond had a higher odds of hypertension compared to those staying in RDP houses (OR: 1.89, 95% CI:1.66-2.15). Residing in the formal settlements was associated with higher odds of hypertension than those in informal settlements (OR:1.84, 95% CI 1.63-2.08). The results show no association between hypertension and other NCDs, HIV, and cancer.

The results of univariable models are shown in Table 9 below on page 29.

3.4.2 Multivariate analysis

The results of the adjusted model after controlling for other covariates indicated that sex, age, race, renting status, and type of settlement were significantly associated with self-reported hypertension.

Females were significantly more likely to have hypertension than their male counterparts (aOR:1.30, 95% CI:1.06-1.21). Race was significantly associated with hypertension. The odds of being hypertensive were two times higher in individuals who were whites compared to blacks (aOR: 2.08, 95% CI: 2.28 - 3.47). The Indian race group also had significantly higher odds of having hypertension (aOR:1.67, 95% CI:1.24-2.24.). Individuals who are aged 55-64 years were significantly associated with higher odds of hypertension compared to those aged 25-35 years (aOR:1.28, 95% CI:1.12-1.46.). After adjusting for other factors in the model education status was not associated with hypertension.

The settlement type was significantly associated with self-reported hypertension. The odds of hypertension were significantly higher for residents of formal settlements compared to residents of informal settlements (aOR: 1.70, 95% CI 1.47 - 1.96). Individuals who are staying in rent-free accommodation had higher odds of hypertension (aOR:1.67, CI:1.41-1.98) than those who were staying in RDP houses. Owners of personal homes which were fully paid up were significantly more likely to be hypertensive than those who were still paying up the bond (aOR:1.32, CI:1.15 - 1.51). Individuals with obesity were more likely to be hypertensive than those without obesity (aOR:1.28, CI:1.05-1.97).

Table 8**:** Logistic regression analysis of factors associated with self-reported hypertension**.**

Variable	Category	Unadjusted Analysis Odds Ratio (95% CI)	Adjusted Analysis Odds Ratio (95%CI)
Sex	Male	1(Ref)	1(Ref)
	Female	1.10(1.03-1.17)*	1.13(1.06-1.21) **p<0.0001
Race	African	Ref	Ref
	White	2.67(2.45-2.91**p<0.001	2.37(2.15-2.62) **p<0.001
	Indian/Asian	1.58(1.29-1.95**p<0.001	1.42(1.12-1.80) *0<0.004
	Coloured	0.94(0.77-1.49)	0.85(0.68-1.06)
	Other	1.18(0.71-1.98)	1.06(0.59-1.89)
Age	18-27	1(Ref)	1(Ref)
	28-37	1.10(0.96-1.15)	1.04(0.94-1.14)
	38-47	1.10(0.99-1.22)	1.09(0.98-1.21)
	48-57	1.21(1.08-1.36)*p=001	1.16(1.03-1.31)
	58-67	1.21(1.07-1.40)*p=0.003	1.16(1.01-1.34) *p=0.03
	68-77	1.21(1.01-1.45)*p=0.03	1.14(0.95-1.37)
	78-87	1.19(0.93-1.53)	1.13(0.88-1.45)
	88-97	3.18(0.95-10.57	2.38(0.67-8.43)
Education Status	Secondary Incomplete	Ref	Ref
	No Education	1.35(0.94-1.85)	1.76(1.22-2.55)*
	Primary Only	1.03(0.92-1.15)	1.01(0.88-1.14)
	Matric	1.06(0.98-1.15)	1.06(0.97-1.15)
	More than Matric	1.21(1.20-1.33)*	1.08(0.96-1.22)
Diabetes	No	1(Ref)	1(Ref)
	Yes	1.02(0.84-1.23)	1.08(0.88-1.33)
Heart Disease	No	1(Ref)	1(Ref)
	Yes	0.94(0.62-1.45)	0.89(0.55-1.43)
Obesity	No	1(Ref)	1(Ref)
	Yes	1.28(1.05-1.97)*	1.17(0.89-1.49)
Cancer	No	1(Ref)	1(Ref)
	Yes	1.28(0.97-1.70)	1.22(0.89-1.68)
HIV/AIDS	No	1(Ref)	1(Ref)
	Yes	0.99 (0.90-1.18)	0.98(0.87-1.20)
Type Settlement	Informal	1(Ref)	1(Ref)
	Formal	1.84(1.63-2.08)*p<0.0001	1.70(1.47-1.96)*p<0.0001
	Other-Unspecified	1.06(0.75-1.49)	1.01(0.71-1.42)

Table 9**:** Logistic regression analysis of factors associated with self-reported hypertension. Continued.

Variable	Category	Unadjusted Analysis Odds Ratio (95% CI)	Adjusted Analysis Odds Ratio (95% CI)
Employment Status	Employed part-time, informal sector	1(Ref)	1(Ref)
	Employed full time, formal sector	1.51(1.28-1.80) **<0.0001	1.14(0.94-1.3)
	Employed full time, informal sector	1.31(1.06-1.61)*	1.13(0.89-1.42)
	Employed part-time, formal sector	0.99(0.80-1.23)	0.93(0.73-1.18)
	Self-employed, own business, working from home	1.15(0.86-1.52)	1.04(0.77-1.41)
	Self-employed, own business, Not working	1.27(0.97-1.68)	1.00(0.76-1.33)
	Other	1.25(1.06-1.47)*	1.13(0.94-1.36)
Renting Status	RDP House	1(Ref)	1(Ref)
	Personal owned- fully paid up	1.61(1.43- 1.81) *p<0.0001	1.32(1.15-1.51) *p<0.0001
	Personal owned- Still paying up	1.89(1.66-2.15)**p<0.0001	1.44(1.23-1.67) **p<0.0001
	Rent free	1.37(1.18-1.60)**p<0.0001	1.67(1.41-1.98) **p<0.0001
	Renting from Government	1.62(1.361.93)*p<0.0001	1.63(1.35-1.99) **p<0.0001
	Renting from Private owner	1.36(1.20(1.54)**p<0.0001	1.27(1.20-1.46) **p<0.001
	Transfer of Title Deed from government	0.93(0.75-1.16)	0.92(0.71-1.14)
	Other-Unspecified	1.07(0.83-1.37)	1.55(1.17-2.07)*

3.4.5 Spatial analysis

A spatial analysis was performed to see whether hypertension was spatially clustered, using clusters with a 10 km radius. A total of five secondary clusters were observed and these were all statistically significant. These clusters were observed in Ekurhuleni municipality. These clusters were discovered in the municipality of Ekurhuleni, 312 persons in the largest spatial cluster reported having self-reported hypertension. The second-largest cluster, which was found in the Nigel and Springs neighbourhoods, had a total of 155 people with self-reported hypertension. The smallest cluster was discovered in Centurion, which is part of the Tshwane municipality, with 77 people reporting hypertension. There was no significant cluster in Tshwane (p=0.846), and there

was minimal difference in risk between those with hypertension and those without. The spatial distribution of the clusters is shown in the map below, page 32.

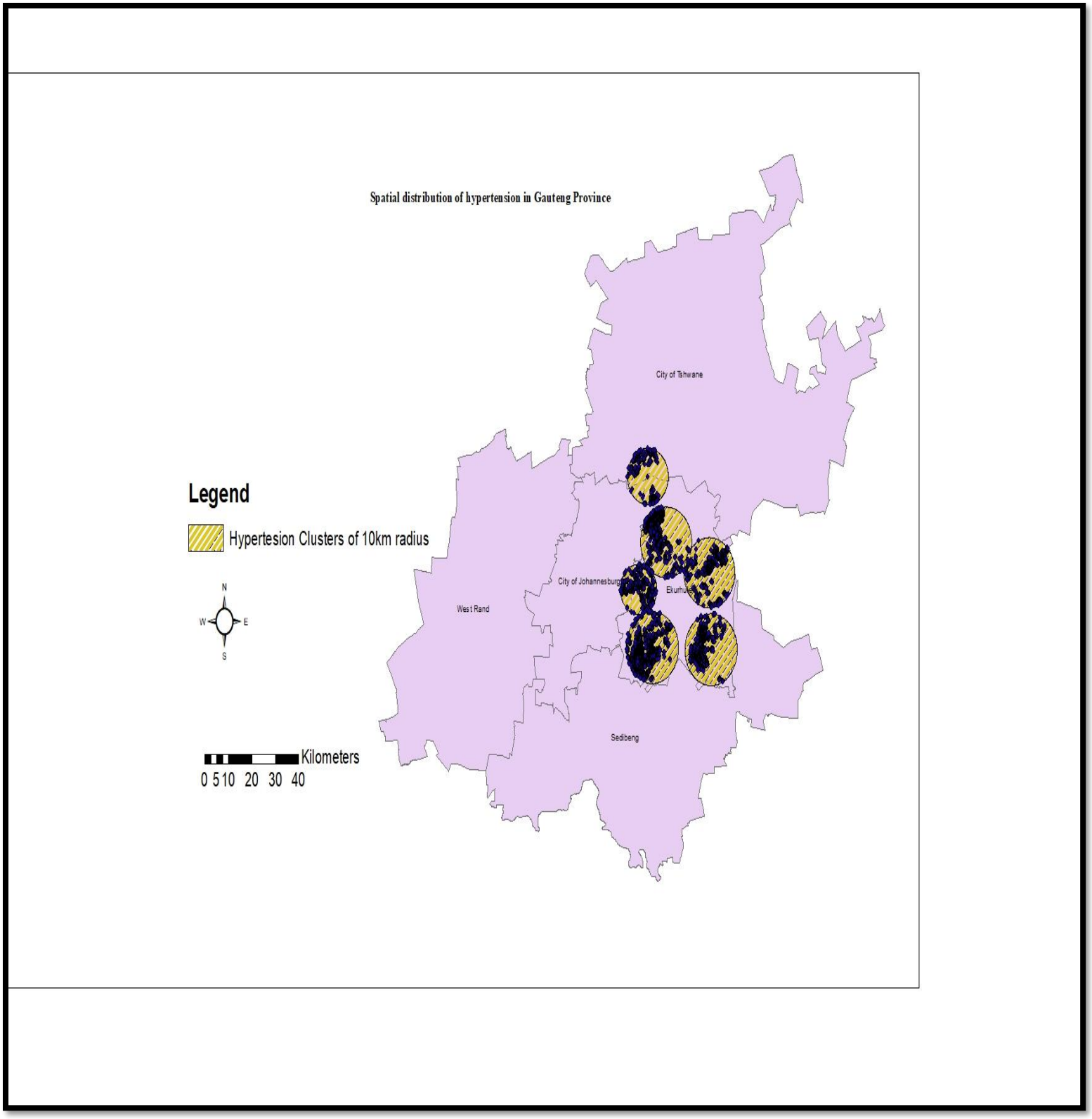

Figure 2 (a): shows the spatial distribution of hypertension clusters that are within a radius of 10km in Gauteng province**.**

A sensitivity test was performed to investigate the distribution of hypertension clusters within a 5-kilometre radius. The results are shown on the map below, page 34 (Figure 2(b). According to the findings of the sensitivity test, a total of 41 clusters were discovered within a 5km radius, 25 of which were statistically significant ($p<0.05$). A comparison of the distribution of hypertension within a 10-kilometre radius was undertaken, and six clusters were detected, five of which were statistically significant ($p<0.05$), indicating an improved model fit, as seen in the map below, page 34 (Figure 2(b).

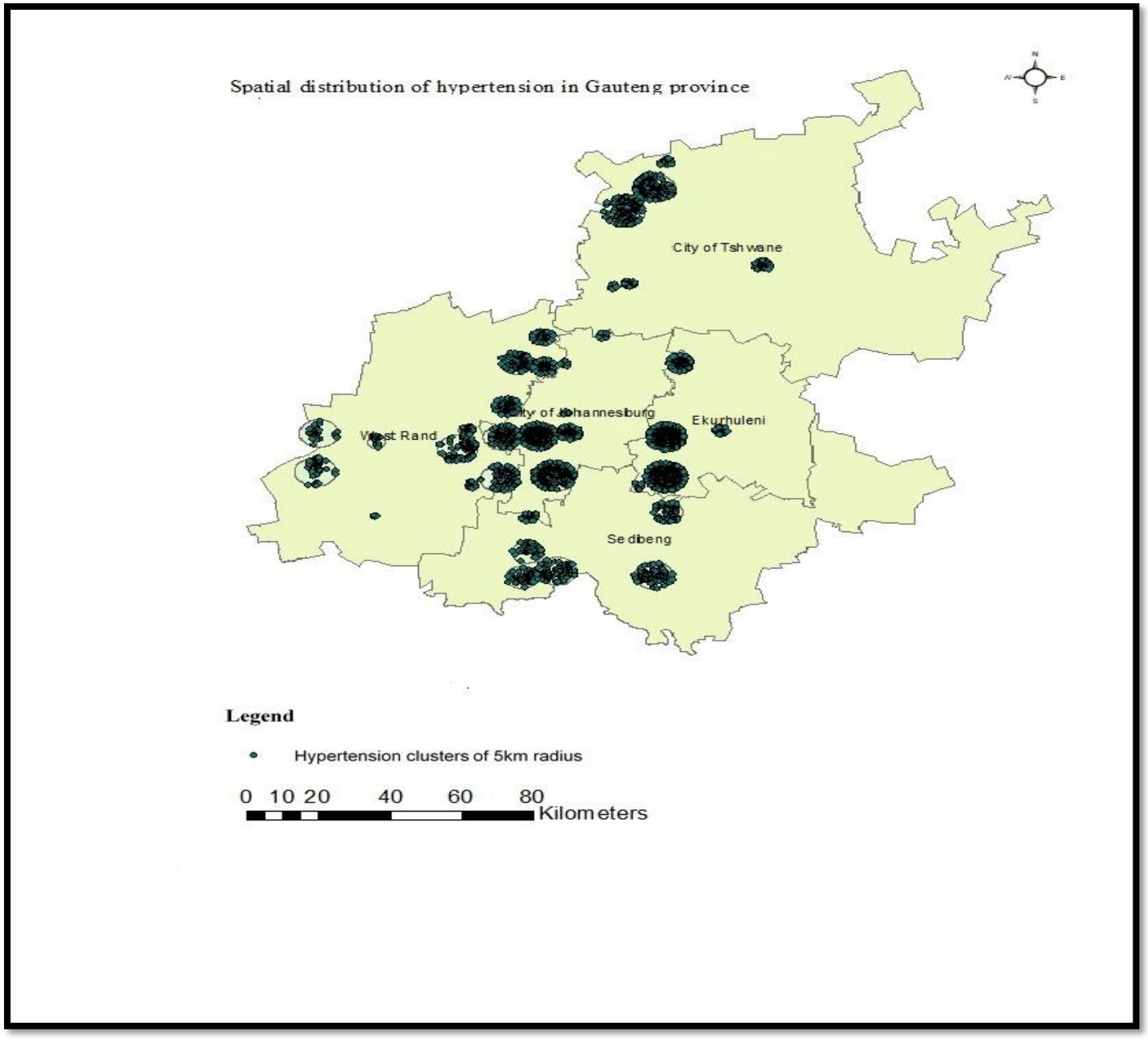

Figure 2 (b): shows the spatial distribution of hypertension clusters that are within a radius of 5km in Gauteng province.

Table 10**:**Secondary spatial clusters of hypertension and their location using SaTScan purely spatial analysis**.**

Municipality	**Cluster**	**Population**	**Number of Hypertension cases**	**Expected cases**	**Observed**	**Relative Risk**	**P-VALUE**
Ekurhuleni	1	2012	1364	311.92	4.3	5.8	p<0.0001**
Ekurhuleni	2	1351	908	209.44	4.34	5.16	p<0.0001**
Ekurhuleni	3	998	764	154.72	4.94	5.73	p<0.0001**
Ekurhuleni	4	979	543	151.77	3.58	3.92	p<0.0001**
Ekurhuleni	5	723	326	112.09	2.91	3.05	p<0.0001**
Tshwane	6	499	117	77.36	1.51	1.53	p=0.846

The results of analysis of the spatial distribution of hypertension identified five (5) statistically significant clusters and one cluster which was not significant. Each cluster is located where the observed number of hypertension cases are more than would be expected by chance residing within a radius of 5 km of each other. The number of individuals with hypertension in each cluster differed and each cluster was classified as a potential hotspot of hypertension.

CHAPTER 4: DISCUSSION

4.1. Introduction

This section will discuss the results of the study as they relate to the study objectives, the conclusions that can be drawn, and recommendations that can be made.

4.2 Prevalence of self-reported hypertension

The overall prevalence of self-reported hypertension in the study was 15.5%, which is lower than the national average estimate of 42%-54% (which is the highest in southern Africa) (21). In a similar study conducted in rural areas of South Africa namely Agincourt (Mpumalanga) and Dikgale (Limpopo) Health Demographic Surveillance System Centres the overall prevalence of self-reported hypertension was 40% which is significantly higher than the reported prevalence in our study (21,38).

The fact that our study focused on self-reported hypertension status rather than clinical hypertension measurement may explain the lower prevalence of hypertension in our study compared to other South African investigations. The prevalence of hypertension in South Africa differs depending on the location (34). According to the findings of this study, there were significant differences in hypertension prevalence at the municipality level. The study's findings could also suggest that hypertension prevention, treatment, and control may vary by municipality. (35). According to the results of this study, there were significant variations in hypertension prevalence at the municipality level. In this study, Mogale city had the highest prevalence of hypertension (30%), which could indicate that hypertension prevention, management, and control may be more difficult in Mogale than in other towns. The municipality of Lesedi had the lowest rate of 5%, implying that it has better hypertension prevention, therapy, and management methods. Over and above any individual-level risk factors, disparities in hypertension prevalence across municipalities could be related to socioeconomic, dietary, and environmental factors at the municipal level (15).

The findings of the study show that the prevalence of self-reported hypertension was higher in females (16 %) than males (15%). This could be attributed to the fact that women seek health care more frequently than males, as such women in the study were more likely to be aware of their hypertension status. These findings corroborate the evidence from studies that were conducted in

Nairobi and Limpopo province of South Africa where researchers found that the prevalence of hypertension was higher in females (53.45%) than in males (39.4%) (21).

4.3 Factors Associated with Self-Reported Hypertension

The results of this study show that sex, race, age, renting status, and type of settlement were significantly associated with self-reported hypertension after adjusting for other potential risk factors.

The findings of the study show that being female is significantly associated with self-reported hypertension. Women were found to be more likely to be hypertensive than men. This could be attributed to some forms of hypertension that occur exclusively in women, e.g. hypertension related to menopause, oral contraceptive use, or pregnancy (e.g. chronic hypertension, gestational hypertension, pre-eclampsia, or eclampsia hypertension) (46). This finding is similar to that from a study carried out in the Limpopo province of South Africa in which women were found to have a significantly higher prevalence of hypertension (38). Another possible explanation as to why women have a higher prevalence of hypertension than men is that women in South Africa have a longer life expectancy at birth (68.5years) than men (62.5years) (47). On average women are older than men, this could partly explain the higher prevalence of hypertension amongst women than men (48). Furthermore, women are more likely to be aware of their hypertension status since they have a higher health-seeking behaviour.

Age was found to be significantly associated with self-reported hypertension. In the study, the odds of hypertension increased with age. The households with older participants were more likely to have a hypertensive member than those who are younger. The burden of hypertension is higher in older people and age is a risk factor for hypertension (49). Studies on hypertension and ageing found that age was significantly associated with hypertension and blood pressure becomes difficult to control as people get older (49).

The findings of the study indicate that race was significantly associated with self-reported hypertension. The odds of hypertension were higher in individuals who were white and Indians than in blacks. The findings differ slightly from those of earlier studies conducted in South Africa, which revealed that coloured/mixed-race adults have a higher risk of hypertension than other races (50).

Renting status of the individuals was found to be significantly associated with self-reported hypertension. Renting status is an indicator of socioeconomic status. Individuals who were staying in their own houses (fully or still paying) renting (from government or private) were more likely to be hypertensive than those staying in free RDP houses. This might be due to the socio-economic status and lifestyle of individuals. High socioeconomic status is associated with less physical activities (walking and exercising), obesity, unhealthy lifestyle and these are risk factors for hypertension (51)

Staying in a formal settlement was significantly associated with hypertension. The type of settlement is an indicator of the socio-economic status of individuals. Individuals staying in an informal settlement were less likely to have hypertension. Since this is self-reported hypertension, it could also perhaps reflect less awareness about hypertension among individuals residing in informal settlements.

The results of this study further show that individual employment status and level of education were not significantly associated with hypertension. Individuals with NCDs (obesity, heart diseases, and diabetes), cancer, and HIV/Aids risk were not associated with hypertension. However, this is inconsistent with the literature, which points out that NCDs are a risk factor for hypertension (9).

4.4. Spatial distribution of self-reported hypertension

After accounting for demographic and individual factors such as age, sex, and level of education spatial variations of hypertension cluster were observed across municipalities; the spatial analysis identified five significant secondary clusters of hypertension which were located within a 10km radius in Ekurhuleni municipality. In the unadjusted results, the prevalence of hypertension in Ekurhuleni was 13% which is closer to the overall unadjusted of 15.5 per cent in the study, thus indicating a high burden of hypertension. This might indicate that Ekurhuleni municipality could be having more challenges in prevention, management, and control of hypertension than in other municipalities. One of the characteristics of Ekurhuleni municipality is the existence of a large migrant population particularly in Tembisa and Kempton Park, and existing studies show that the migrant population under-utilizes the health services. (51).

The adjusted logistic regression results from the study identified residing in informal settlements, working a formal job, belonging to the white or Indian race and being female as risk factors for

hypertension. Targeted intervention programmes in the identified statistically significant geographic clusters must target the identified risk factors of hypertension. These results indicate a need for comprehensive geographic-focused hypertension control and prevention programmes within Ekurhuleni municipality.

In the unadjusted logistic regression residing in the formal settlements was associated with hypertension and the spatial analysis identified five statistically significant clusters in formal settlements. Some formal settlements within the identified clusters include formal townships such as Thembisa, Katlehong, Thokoza, and Vosloorus. The spatial analysis results did not identify statistically significant clusters in other municipalities which were within a radius of 10 km apart. However, results from the adjusted logistic regression emphasise the need for special targeting focusing on groups who are high risks such as women, people above 55 years, whites and Indians.

The number of hypertensive individuals in each cluster varied according to geographic location and each cluster was classified as a potential hotspot of hypertension. This result is consistent with other studies which indicated that there was geographic variation in the distribution of hypertension (35,53). Another implication of these findings is that there could have been other risk factors associated with hypertension prevalence that were not included in the data and were distributed unequally among the districts.

4.5 Conclusion

The overall prevalence of hypertension in the adult population of Gauteng Province was 15.3% in the study, indicating that all municipalities in the province must speed up hypertension prevention, management, and control initiatives. The findings of this study show that sex, advanced age, and race were significantly associated with hypertension. The findings of this study suggest that there are geographic variations in the prevention, management, and control of hypertension within municipalities. This might be due to the uneven distribution of health resources and other risk factors within municipalities. In the municipality of Ekurhuleni, there were a total of five major hypertension clusters. This could mean that some elements in Ekurhuleni are preventing, managing, and controlling hypertension thus leading to a localised hypertension hotspot. Black women are more likely to be hypertensive, hence there is a need for gender-specific hypertension prevention, control, and management in all municipalities. Education, work position, the presence of NCDs, HIV/AIDS, and the presence of cancer were not linked to hypertension.

4.6 Recommendation

The results of the study point to a need for a robust hypertension surveillance system and a targeted community screening approach. It is recommended that a differentiated community screening model must be applied targeting high-risk population groups (such as individuals above 50 years, females, Whites, and Indians) and potential hotspots (such as Ekurhuleni municipality). It is further recommended that social awareness programmes on hypertension targeting individual behaviour change must be intensified.

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APPENDIX 1: Ethics Clearance Certificate

R14/49 Mr Mthokozisi Ngwenya

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M161181

NAME: (Principal Investigator)	Mr Mthokozisi Ngwenya
DEPARTMENT:	Epidemiology and Biostatistics University of the Witwatersrand School of Public Health
PROJECT TITLE:	Spatial Epidemiology of Self-Reported Hypertension in Gautang Province
DATE CONSIDERED:	25/11/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Jabulani Ncayiyana
APPROVED BY:	Professor P. Cleaton-Jones,Chairperson, HREC (Medical)
DATE OF APPROVAL:	03/04/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004,10th floor, Senate House/2nd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the the conditions under wh ch I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated,from the research protocol as approved, I/we undertake to resubmit t to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. in this case, the study was initially review November and will therefore be due in the month of November each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES