Household environmental factors and childhood malnutrition:

Evidence from the SANHANES-1

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Siluleko Mkhize (843928)

Supervisor: Prof. Laurel Baldwin-Ragaven

Supervisor: Prof. Elena Libhaber

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Declaration

I, **Siluleko Mkhize,** declare that this dissertation is my own, unaided work. It is being submitted for the degree of Master of Science in Medicine Research **(MSc Med: Family Medicine & Primary Care)** at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signature: SA Mkhize **Date**: 02/09/2021

Dedication

Whatever you are doing, that which makes you feel the most alive…that is where G-d is

~ St Ignatius of Loyola

…In the 6029th year since Adam, September 02

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Outputs emanating from this research

Conference presentations

1. **Childhood food insecurity in South Africa: A household-level analysis of hunger**

   An oral presentation delivered at the Faculty of Health Sciences, University of the Witwatersrand, *School of Clinical Medicine Research Day (03 October 2019)*

2. **Childhood food insecurity in South Africa: A household-level analysis of hunger**

   A poster presentation delivered at the Faculty of Health Sciences, University of the Witwatersrand, *Faculty of Health Sciences Biennial Research Day, and Postgraduate Expo (19 September 2020)*

Manuscripts submitted

- **Childhood food insecurity in South Africa: A household-level analysis of hunger**

  Manuscript under editorial review with PLOS ONE (*submitted on 20 December 2020*). This manuscript corresponds to the analyses and results in Chapter 3.

Manuscripts in preparation

- **Household food insecurity was independently associated with the double burden of malnutrition in South African households with children**

  Manuscript in preparation for submission to a suitable journal (*possibly BMC Public Health*)

Abstract

Background: Food insecurity impacts childhood nutritional status as well as physical and cognitive development, and increases lifetime risk for chronic disease. Malnutrition, as evidenced by stunting, underweight, overweight and obesity, remains pervasive in the paediatric population. Children's dietary knowledge also has long-term implications on overall health and nutritional status via the development of lifetime feeding habits that endure into adulthood, predisposing to non-communicable diseases (NCDs) such as hypertension, heart disease, stroke, and diabetes. Previous South African studies have examined hunger at sub-national levels with a limited focus on children in the context of their immediate household environment. The true extent of childhood food insecurity as well as contributing factors in the environment have not yet been elucidated completely. **Aim:** We sought to determine the national prevalence of childhood food insecurity (0-19 years old) and identify factors associated with hunger within the household, with a particular focus on the household head. We also examined food insecurity in households without children. Furthermore, we explored the impact of food insecurity and dietary knowledge on childhood anthropometric indicators of malnutrition and ascertained the percentage of self-reported NCDs among adults (>19 years) living in households with children. **Methods:** Individual and household-level data were extracted from the first wave of the South African National Health and Nutrition Examination Survey (SANHANES-1) to conduct secondary data analyses. Food insecurity was assessed using the Community Childhood Hunger Identification Project (CCHIP) index. Nutritional status for children aged 0-60 months was assessed using Weight for Height (WHZ) and Height for Age (HAZ) scores which referenced the 2006 WHO Child Growth Standards. For children aged >5-19 years, nutritional status was assessed using BMI for age (BAZ) and HAZ scores which referenced the 2007 WHO Growth Reference for children aged >5-19 years. Dietary

knowledge of children aged 10-14 years was assessed using a general nutrition knowledge questionnaire. Multinomial logistic regression analyses were conducted on all households (with and without children) to determine the predictors of food insecurity with adjusted odds ratios (AOR) and 95% CI as measures of association. Two-way ANOVA tests with Tukey post hoc corrections were employed to assess the associations between anthropometric indicators and food security status among all children. **Results:** Of 5 098 households with complete CCHIP scores, 68.64% had children (0-19 years). Of the households with children, barely 40.25% were food secure while 32.55% [95% CI (29.51 – 35.73)] were experiencing hunger and 26.37% [95% CI (23.96 – 28.82)] were at risk of hunger. Among all the households, significant associations for households experiencing hunger were: the presence of children: AOR [95% CI]: 1.68 [1.12 – 2.53]; being female-headed: AOR [95% CI]: 1.53 [1.21 – 1.94] and informally-located; AOR [95% CI]: 1.61 [1.07 – 2.43]. Having a non-African household head (Coloured: AOR [95% CI]: 0.29 [0.19 – 0.44] and White/Indian/Asian: 0.12 [0.04 – 0.33]) was protective against experiencing hunger. Having a household head with a secondary/tertiary educational attainment was also protective against experiencing hunger; AOR [95% CI]: 0.40 [0.28 – 0.56] and being at risk of hunger; AOR [95% CI]: 0.69 [0.52 – 0.92]. Receiving social grants or remittances more than doubled the risk of experiencing hunger; AOR [95% CI]: 2.15 [1.49 – 3.09]. Children and adolescents (>5-19 years) from households that were at risk of hunger and those that experienced hunger were thinner (had lower BAZ scores) compared to children from food secure households ($p=0.013$) and ($p=0.019$), respectively. Also, children >5 – 19 years old from food insecure households (both at risk of hunger and experiencing hunger) were shorter (had lower HAZ scores) than their food secure counterparts ($p=0.004$) and ($p<0.001$), respectively. Among younger children (0-60 months), there was no association between food security status with WHZ; however, experiencing hunger was significant

for lower HAZ scores (p=0.038). Among children aged 10-14 years, dietary knowledge lacked associations with nutritional status. Lastly, hypertension (23.04%) was the most frequently self-reported NCD among adults from these households with children, followed by diabetes (7.59%)

Conclusion: This secondary analysis of the SANHANES-1 data points to the continued vulnerability of children and their maternal caregivers to the risks of food insecurity and poor nutritional status, with implications across the life course. This is in line with other South African research, including the finding that social grants are not protective against food insecurity. Teenagers have poor nutritional knowledge, which also impacts better food choices in late adolescence and into adulthood. The low self-reporting of NCDs in this adult sample is surprising but is perhaps indicative of people being unaware of their chronic health problems. These findings point to the need for renewed efforts to address the constitutional *right to food and basic nutrition,* and other social determinants of health, for children and the households they inhabit.

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List of abbreviations

ACO	Atlas of Childhood Obesity
ANOVA	Analysis of Variance
AOR	Adjusted Odds Ratio
BAZ	BMI for age Z-score
BiB	Born in Bradford
BMI	Body Mass Index
BFP	Bolsa Familia Programme (Brazil)
CCB	Canada Child Benefit
CCHIP	Community Childhood Hunger Identification Index
COVID-19	Coronavirus Disease of 2019
CI	Confidence Interval
CMA	Cow's milk allergy
DoH	Department of Health

DHS	Demographic and Health Survey
DALYs	Disability Adjusted Life-Years
DoAFF	Department of Agriculture, Forestry and Fisheries
EA	Enumerator Area
FAO	Food and Agriculture Organization
HAZ	Height for age Z-score
HSRC	Human Sciences Research Council
HFIAS	Household Food Insecurity Access Scale
HFSSM	Household Food Security Survey Module
HREC	Human Research Ethics Committee
IQR	Interquartile Range
LMICs	Low-Middle-Income Countries
NCDs	Non-Communicable Diseases
NHANES	National Health and Nutrition Examination Survey (USA)
NHI	National Health Insurance

NDP	National Development Plan
OR	Odds Ratio
RDA	Recommended Dietary Allowance
REC	Research Ethics Committee
SANHANES	South African National Health and Nutrition Examination Survey
SADHS	South African Demographic and Health Survey
SDHs	Social Determinants of Health
SDGs	Sustainable Development Goals
SES	Socio-Economic Status
SD	Standard Deviation
SNAP	Supplemental Nutrition Assistance Program (USA)
SSA	Sub-Saharan Africa
UN	United Nations
USA	United States of America
UHC	Universal Health Coverage

WAZ	Weight for age Z-scores
WHO	World Health Organization
WHZ	Weight for Height Z-scores
WHO GCHP	WHO Global Conference on Health Promotion
WHO MCGRS	WHO Multicentre Child Growth Reference Standards
WOF	World Obesity Federation

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Chapter 1: Introduction and literature review

1.1 Introduction

South Africa and the rest of sub-Saharan Africa (SSA) are experiencing rapid urbanisation, economic growth, mass media proliferation, and significant technological advances (Jones, 2018). In the meantime, South Africa has witnessed an unprecedented nutrition transition occurring at an expressed rate (Abarca-Gómez *et al.*, 2017; Jones, 2018). The nutrition transition theory concerns the large shifts in dietary habits that are occurring, including in the intake of essential staples (Wijnhoven *et al.*, 2015). This change in consumption trends has been shown to favour the "Western diet", a diet abundant in fats and refined sugars (Abarca-Gómez *et al.*, 2017). However, this nutritional transition to a Westernized diet has considerable adverse health implications (Gurnani, Birken & Hamilton, 2015). Two other theories of transition entail demographic and epidemiological shifts in society (Abarca-Gómez *et al.*, 2017; Jones, 2018). In the wake of these shifts, South Africa faces immense economic pressure, culminating in a health crisis (Ebbeling, Pawlak & Ludwig, 2002). Over the years, the incidence of non-communicable diseases (NCDs) such as hypertension, diabetes, strokes, heart disease and malnutrition has intensified in South Africa (Nkeh-Chungag *et al*., 2015; Silva *et al*., 2016).

Recognising the need to track the country's health status, the Human Sciences Research Council (HSRC) initiated the South African National Health and Nutrition Examination Survey (SANHANES) (Kêkê *et al.*, 2015). The SANHANES is a nationwide survey of South African households and their inhabitants patterned after the National Health and Nutrition Examination Survey (NHANES) of the United States (Labadarios *et al.*, 2011; Lee, 2012). Indeed, South Africa was the first African nation to follow suit and remains one of the very few (Kêkê *et al.*, 2015) countries to have conducted such a nationally representative inventory of adults and children. The sampling of households in the SANHANES was carried out to reflect the socio-demographic and

economic profile of the country. Of particular interest are areas of health and nutrition in the SANHANES that have not been completely explored as yet. Earlier research has focussed on the pathophysiology and patterns of malnutrition, given that South Africa is a developing nation with abject poverty in some parts of the country (Lobstein *et al.*, 2015; Ebbeling, Pawlak & Ludwig, 2002; Kumar & Kelly, 2017). Paradoxically, an expanding stream of work suggests that obesity is a disease of both under- and overabundance, i.e., poverty and affluence (Puoane *et al*., 2002). Although counterintuitive, recent studies have reported a greater frequency of childhood obesity in the lower socio-economic strata of developing nations; and South Africa is not exempt (Parsons & Power, 1999; Kiess *et al*., 2014).

According to actuarial projections of the key indicator report of the South African Demographic and Health Survey (SADHS), the prevalence of childhood obesity in South Africa is double the global average of 6.1% (Horner *et al*., 2018). Poignantly, malnutrition in all its forms, is a multifaceted phenomenon with overarching aetiologies (Lopes, 2012; Shields & Tremblay, 2010; Gonzalez-Casanova *et al*., 2013). In the medical literature, there is a large focus on adverse physiological changes in adiposity and the study of cardiometabolic processes that underlie malnutrition (Greydanus *et al*., 2018), but relatively few studies have concentrated on Social Determinants of Health (SDH) such as food security, socio-economic factors and dietary knowledge as potential mechanisms for the obesity pandemic.

1.2 Literature review

1.2.1 Food security

Food insecurity has emerged as a major public health concern; and, the obligation to realise the "*right to food and basic nutrition"* is enshrined in both the United Nations charter (OHCHR, 2006) and the South African Constitution (1996). The Food and Agriculture Organization (FAO) of the United Nations states that "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Skoet, Stamoulis & Food and Agriculture Organization of the United Nations. Economic and Social Department., 2006), emphasising that the availability of food must be beyond mere subsistence (Neuman, Eli and Nowicka, 2019; Labadarios *et al.*, 2011). In Sub-Saharan Africa, one in four people were undernourished in 2017 which represents about one third of the 821 million people suffering from chronic hunger globally (Fraval *et al.*, 2019). According to actuarial projections, Africa will be home to 90% of the world's poorest by 2030 (Fraval *et al.*, 2019; World Bank, 2018).

In 2017, 6.8 million South Africans were affected by hunger (Stats-SA, 2019). Although this number has halved from 13.5 million in 2002, about 1.7 million households across the country remain food insecure (Stats-SA, 2019). Moreover, a considerable but undocumented proportion of these households comprise children below the age of 20 years, who are vulnerable to food deprivation and hunger (Pérez-Escamilla, 2017; Neuman, Eli and Nowicka, 2019). Indeed, the presence of children in households may confer additional "*pressure of mouths to feed*" (Nord, 2009; Ngema, Sibanda & Musemwa, 2018). The present COVID-19 pandemic, occurring alongside household and child food and nutrition insecurity, presents a disconcerting syndemic (Pérez-Escamilla, Cunningham & Moran, 2020; Watanabe *et al.*, 2020) capable of reversing the

improvements witnessed between 2002-2017. Indeed, the COVID-19 pandemic has forced South Africa into an abrupt and prolonged lockdown threatening job and societal security (International Labour Organization, 2020); therefore, it is likely that food insecurity will pervade (Pedroso *et al.*, 2020; Roberton *et al.*, 2020) and possibly impede the country from realising its 2030 Sustainable Development Goal (SDG) of achieving zero hunger (Pérez-Escamilla, Cunningham and Moran, 2020).

Throughout the world, household food insecurity, as the experience of hunger, is associated with malnutrition, stunting and wasting among children (Webb *et al.*, 2018). In South Africa, severe-acute and moderate-acute malnutrition accounts for 25% of child mortality (Hall & Mokomane, 2018; Sung-King *et al.*, 2019). In 2015, malnutrition contributed 4% to under-five mortality globally (Pérez-Escamilla and de Toledo Vianna, 2012). According to Sung-King et al., (2019), ~48.8% of children under five years were malnourished; and, the South African National Health and Nutrition Examination Survey (SANHANES) in 2011/12 reported that 51.5% of children aged 0-14 years were malnourished (Shisana *et al*, 2013).

Hunger has profound health consequences that not only affect physical growth and cognitive development in childhood (Perez-Escamilla & de Toledo Vianna, 2012; Seligman, Laraia & Kushel, 2009), but endure throughout the life-course, into adulthood (Kirkpatrick, McIntyre & Potestio, 2010; Ke & Ford-Jones, 2015) and moreover extend into subsequent generations (Sparén *et al.*, 2003; Lumey *et al.*, 2007). Two longitudinal cohort studies of the consequences of hunger that began in the throes of the second World War, the Dutch Winter Famine (Lumey *et al.*, 2007) and the siege of Leningrad (Sparén *et al.*, 2003; Neyroud, 2015), indicate that the effects of intra-uterine exposure to food insecurity can traverse through multiple

generations, predisposing to a "thrifty phenotype" among progeny. Bjerregaard *et al.*, (2018) found that another form of malnutrition, obesity in childhood (measured at ages 7 and 13 years), significantly increased the hazards of developing type-2 diabetes in late adulthood among Danish men. Conversely, reversal of obesity in adolescence reduced the risk by 4%, a finding that may be explained, in part, by food insecurity given that obesity and type-2 diabetes are primarily diet-sensitive adverse health outcomes (Seligman, Laraia and Kushel, 2009; Pérez-Escamilla and de Toledo Vianna, 2012).

Food security status has been measured using various validated scales such as the Community Childhood Hunger Identification Project (CCHIP) index, Household Food Insecurity Access Scale (HFIAS), and the Household Food Security Survey Module (HFSSM) (Pérez-Escamilla and Segall-Corrêa, 2008). These experience-based food insecurity scales are the fundamental measure of food insecurity; however, only the HFSSM and its adaptations (including the CCHIP index Labadarios *et al*., 2001; Labadarios *et al*., 2005 and Human Sciences Research Council, 2015) used in the SANHANES-1) have proven validity across diverse socio-cultural settings (Pérez-Escamilla and Segall-Corrêa, 2008). Nonetheless, all experience-based food insecurity scales contain items that capture the conceptual and multidimensional nature of food insecurity such as the physical and psycho-emotional domains (Pérez-Escamilla and Segall-Corrêa, 2008).

In South Africa, three national surveys conducted in 1999-2008 estimated the prevalence of food insecurity using the CCHIP index (Labadarios *et al.*, 2005; Altman *et al.*, 2009). These studies indicated a marked decline of household food insecurity from 52.3% in 1999 to 25.9% in 2005. None of these studies, however, distinguished between households with and without children thus perhaps underestimating the true extent of childhood food insecurity (Vaezghasemi *et al.*,

2014; Mutisya *et al.*, 2016; Akadiri, Nwaka & Jenkin, 2018). Much of what is known about the sociodemographic correlates of food insecurity in South Africa has been gleaned from sub-national cross-sectional studies. Food insecurity measured using the HFIAS (Coates, J., Swindale, A., Bilinsky, 2013; Segall-Corrêa *et al.*, 2014) was markedly high across the rural-urban continuum of South African towns, with households in rural areas reporting higher scores, and therefore higher food insecurity than peri-urban households (households located in urban-informal settlements) (Chakona & Shackleton, 2018). Households that are reliant on private food charities and government assisted social grants are at a three-fold increased risk of food insecurity (Ruiters & Wildschutt, 2010). It is speculated that while social grants are regular and predictable, they are, however, not sensitive to the changing needs of a household (Waidler & Devereux, 2019; Akadiri, Nwaka & Jenkin, 2018). The gender of the household head is also an important factor predicting household vulnerabilities, with the highest prevalence of food insecurity in South Africa reported among female-headed households (Akadiri, Nwaka & Jenkin, 2018; Ruiters & Wildschutt, 2010).

1.2.2 Malnutrition: Stunting, wasting, overweight, and obesity

Food insecurity, an experience-based measure of hunger and a potent marker of material deprivation (Tarasuk, Fafard St-Germain & Mitchell, 2019), has been studied extensively. The paradoxical relationship between food insecurity and nutritional status (overweight/obesity) is more poorly understood. Empirical evidence has long held that food insecurity portends different forms of undernutrition among afflicted children such as underweightedness and stunting (Tydeman-Edwards, Van Rooyen & Walsh, 2018; Mahmudiono *et al.*, 2018). Counterintuitively, among adults, particularly women, studies have demonstrated strong positive associations between food insecurity and overweight/obesity (Neupane, Prakash & Doku, 2016; Mahmudiono *et al.*,

2018). Moreover, the mechanisms that underpin these differential effects of food insecurity on adult and child nutritional status remain a scientific enigma and highlight the "two-faced Machiavellian nature" (Uzêda *et al.*, 2019) of food insecurity as an antecedent to both under- and overnutrition. By corollary, it follows that food insecure households with children are fraught with colliding nutritional outcomes, i.e., both under- and overnutrition, simultaneously (Modjadji & Madiba, 2019b; Uzêda *et al.*, 2019; Rhodes *et al.*, 2020).

Overnutrition (overweight/obesity) may occur juxtaposed alongside undernutrition (underweight/stunting/wasting), or micronutrient deficiencies and diet-related non-communicable disease (Rhodes *et al.*, 2020; Hossain *et al.*, 2020; Modjadji & Madiba, 2019a). The simultaneous occurrence of contrasting forms of malnutrition has been observed at the individual, household and population levels (Sartorius *et al.*, 2020; Tomita *et al.*, 2020; Mahmudiono, Segalita & Rosenkranz, 2019). At the household level, this observation has been studied extensively in mother-child dyads more than any other combinations, capturing maternal overweight/obesity and different forms of undernutrition among children, such as underweight, stunting and wasting (Fongar, Gödecke & Qaim, 2019; Akombi *et al.*, 2017, 2019). Several hypotheses have been used to explain this phenomenon. Firstly, members of food insecure households rely on cheap, unhealthy, and energy-dense food bundles and are at an increased risk of overweight/obesity. In turn, overweight/obesity is associated with chronic NCDs such as type-2 diabetes and hypertension which raises health care costs (Tarasuk, Fafard St-Germain & Mitchell, 2019) thus limiting food expenditure and predisposing to severe food insecurity (Sartorius *et al.*, 2020). Secondly, with the worsening severity of food insecurity, the household head bears more strain. Their ability to provide for children is challenged and, consequentially, undernutrition becomes a reality within the household, particularly among children due to micronutrient restriction. As a result, food

insecurity is persistently associated with stunting, underweight and poor cognitive development among children which often reflects micronutrient restriction (Rhodes *et al.*, 2020).

Household food insecurity is a potent psychosocial stressor associated with poor mental health such as depression (Tomita *et al.*, 2020; Uzêda *et al.*, 2019) as heads from food insecure households are chronically under enormous amounts of pressure to provide for members under their care, including children (le Roux, Nel & Walsh, 2020). Atypical depression is associated with disruptions of normal physiological processes in the hypothalamic-pituitary-adrenal axis, which dampens the satiety response, leading to passive overconsumption during "*food plenty*" and subsequently overweight/obesity ensues (Anik Islam *et al.*, 2019; Kimani-Murage, 2013). More research has shown that food insecure households often rely on obesogenic low-quality food bundles such as ultra-processed foods leading to a positive nett energy balance (Hossain *et al.*, 2020; Gubert *et al.*, 2017; Fongar, Gödecke & Qaim, 2019) and hence obesity. Alongside sedentary behaviour, this dietary pattern has become widespread in Low-Middle-Income Countries (LMICs) passing through the nutrition transition (Chakona & Shackleton, 2018; Maitra, 2018). LMICs are particularly vulnerable to different forms of malnutrition, particularly stunting, underweight and obesity as income disparities are more apparent at the population level, and food insecurity may clarify these associations (Tydeman-Edwards, Van Rooyen & Walsh, 2018). More pertinently, food insecurity and malnutrition share common socio-demographic risk factors that often highlight the social vulnerability and precarious nature of female-headed households (Broussard, 2019), Black/African households (Morales, Morales & Beltran, 2020), households located in informal/peri-urban settings along the urban-rural gradient (Tomita *et al.*, 2020), households whose heads have low educational attainment (Alhogbi, 2017) and those that rely on government-assisted social grants and private remittances (Chakona & Shackleton, 2018).

1.2.3 Poverty, childhood dietary knowledge and non-communicable diseases in adulthood

Nationally and globally, health disparities, especially with regard to the burden of ill-health among people of low socio-economic status (SES), have gained significant attention in public health policy (Xin, 2017). Growing evidence points to the prevalence of such inequality, but also to the fact that lower socio-economic classes experience multiple deprivations (Fiscella & Williams, 2004). This is true within countries as well. In South Africa, poverty, inequalities in SES and inequalities in access to basic social services between sociodemographic classes, and socio-economic backgrounds are common and pervasive and contribute to worsening health inequalities (Xin, 2017). Poor people face multiple predisposing factors to poor health known as the social determinants of health, in addition to not being able to afford treatment for medical conditions (Weiner, 2001; Fiscella & Williams, 2004). Furthermore, coping mechanisms vary between the poor and the rich (Cordero-Ahiman, Santellano-Estrada & Garrido, 2018).

Several studies in South Africa indicate that the distribution of the use of health care and the gains (as calculated in monetary terms) from the use of services is biased in favour of the wealthy in most public facilities, particularly hospitals, and across all private sector services (Cordero-Ahiman, Santellano-Estrada & Garrido, 2018; Morales, Morales & Beltran, 2020; Alhogbi, 2017; Davis, Oaks & Engle-Stone, 2020; Xin, 2017; Fiscella & Williams, 2004; Weiner, 2001). It is important to equate these poor outcomes in the use of health services with the spread of ill-health across socio-economic groups. Previous research on the burden of ill-health in South Africa (although using relatively outdated datasets) have repeatedly shown that the vulnerable suffer most from the bulk of illnesses and abuse compared to the wealthy (Arpey, Gaglioti & Rosenbaum, 2017). However, these findings are focused on chosen diseases and have only

considered a particular point in time as they are cross-sectional in nature (Davis, Oaks and Engle-Stone, 2020).

Dietary or nutritional knowledge and awareness of appropriate food consumption refer to awareness of concepts and processes pertaining to diet and nutrition, including diet and disease, and dietary standards and recommendations (Medina *et al.*, 2020). Dietary knowledge is an important factor predicting the nutritional status of children and adults (Agbozo *et al.*, 2018). Dietary knowledge also has long-term implications on the overall health status of children via the development of lifetime feeding habits (Medina *et al.*, 2020). Therefore, the diet quality and diet diversity among pre-pubertal children and early adolescents (ages 10-14 years) has become an active area of research (Hooshmand & Marhamati, 2018; Setiono *et al.*, 2019; Medina *et al.*, 2020; Arpey, Gaglioti & Rosenbaum, 2017). In recent decades, significant attempts have been made to reform the diet and the types of foods eaten towards healthier outcomes, leading to the replacement of fast foods by healthier food alternatives (Kim & Lim, 2019). The majority of children, however, still do not meet the prescribed nutritional requirements (Recommended Dietary Allowance [RDA]) (Gidding *et al.*, 2005). Furthermore, as children grow up, their nutritional quality may be compounded by not only lower intake of fruits and vegetables but also increased consumption of sugar-sweetened beverages (Dereń *et al.*, 2019).

Health agencies have adopted a number of programmes in recent years to support young people's healthier eating patterns (Dereń *et al.*, 2019; Cordero-Ahiman, Santellano-Estrada & Garrido, 2018; Gidding *et al.*, 2005; Nyaradi *et al.*, 2013; Morales, Morales & Beltran, 2020), but these have had minimal impacts, which may be due to inadequate knowledge of food patterns and necessary strategies introduced in conjunction with children's ages (Davis, Oaks & Engle-Stone, 2020; Alhogbi, 2017; Hooshmand & Marhamati, 2018; Kim & Lim, 2019). Dietary effects may

differ with age, as demonstrated in a study by Weiner, (2001). Therefore, not all approaches are acceptable at all age categories. To date, however, there has been little research on dietary awareness, practices and behaviours of the young South African population, with no idea of possible disparities between different age groups and genders.

Chronic illness negatively impacts the quality of life of the household and its individual members, both adults and children. Parents of children with chronic disease report weaker self-development, constraints on their well-being and emotional stability, and worse levels of everyday functioning than parents of healthy children (Golics *et al*., 2013). According to the Food and Agriculture Organization of the United Nations, "food utilization is the proper biological use of food, requiring a diet providing sufficient energy and essential nutrients, potable water, and adequate sanitation" (Igi-global.com, 2021), therefore, individuals with illness may suffer nutrient insecurity even when the household is food secure because of impaired food utilization. Social isolation, according to Tomaka, Thompson, and Palacios (2006), is "an objective physical separation from other people," whereas loneliness is a "subjective experience, an unsatisfactory balance between actual and desired social contact." Social isolation and food insecurity are two issues that are frequently intricately intertwined for a large portion of the low-income senior population. Seniors' food security concerns are frequently compounded by social isolation. Not only has work been done to discover the causes of food insecurity, but also to provide solutions to the hunger that vulnerable elderly populations face.

1.3 Problem statement, justification, and rationale

To date, most studies on food insecurity in South Africa have focused largely on sub-national level (Weiner, 2001; Anik Islam *et al.*, 2019; Tomita *et al.*, 2020; Hanson *et al.*, 2018; Hossain *et al.*, 2020) and have not examined childhood nutrition nationally. The critical need to

address hunger in childhood necessitates particular attention to households with children. It is important to note that earlier research indicates that the presence of children confers greater odds of food insecurity and hunger (Modjadji & Madiba, 2019b). Therefore, drawing from a large-scale population-based sample of households, the SANHANES-1, the present dissertation will determine the prevalence of food insecurity in households with and without children as well as will assess associations between the socio-demographic characteristics of the household head and degrees of hunger. In this way, some of the drivers of childhood food insecurity at the household level will be ascertained. Additionally, in this dissertation, the impact of food insecurity on child anthropometric indicators of malnutrition including undernutrition (stunting and underweight), overnutrition (overweight and obesity) will be explored. To further elucidate the influence of the household's environment on child health, the present work seeks to interrogate whether associations exist between dietary knowledge, food security and nutritional status of children. Additionally, the present work seeks to ascertain the percentage of self-reported NCDs among adults (>19 years) from households with children. It is hoped that this study will contribute towards nutrition-sensitive interventions "…*that address the underlying determinants of foetal and child nutrition and development, food security; adequate caregiving resources at the maternal, household and community levels; and access to health services and a safe and hygienic environment, and incorporate specific nutrition goals and actions*" (Ruel & Alderman, 2013) to mediate the short-term, long-term, and inter-generational adverse health consequences of food insecurity and dietary knowledge of children.

1.4 Aim

To assess relationships between the household environment and anthropometric indicators of malnutrition among South African children

1.5 Specific objectives

1. **(a)** To estimate the prevalence of food security in households stratified by sociodemographic characteristics of the household head

   (b) To determine the association between household sociodemographic factors and food security in households with and without children

2. **(a)** To determine the nutritional status of children using WHZ and HAZ (0-60 months) and BAZ and HAZ (>5-19 years)

   (b) To determine associations between WHZ, HAZ and BAZ scores with household food security in children

3. **(a)** To assess the dietary knowledge of girls and boys aged 10-14 years

   (b) To assess associations between food security, dietary knowledge, BAZ and HAZ scores in children aged 10-14 years

   (c) To ascertain the percentage of non-communicable diseases (hypertension, stroke, heart disease and diabetes) among adults aged >19 years who live in households with children

Chapter 2: Methods

2.1 Data source

The data used in this research were derived from the 2012 South African National Health and Nutrition Examination Survey (SANHANES-1), which is the first in an intended "series of surveys designed to assess the health and nutritional status of adults and children in South Africa" (Shisana *et al*, 2013). Fieldworkers in the SANHANES-1 collected thousands of data elements, including quantitative, qualitative and anthropometric, from a cross-sectional nationally representative sample of households. The selection of these households employed a multi-stage disproportionate, stratified cluster sampling approach based on the 2001 census Enumeration Areas (EAs). While South Africa has about 86 000 EAs, the SANHANES was conducted in 500 EAs of these that were representative of the sociodemographic profile of South Africa. To ensure such national representativeness, the SANHANES-1 EA sampling was layered by type of locality (urban/rural and formal/informal); province (nine in South Africa); as well as by "race" in formal urban areas. Rather than suggesting any inherent biological differences between people, the use of "race" as a category allowed investigation of ongoing health disparities that have endured post-apartheid. Additional SANHANES sample selection details have been published in Shisana *et al*, (2013).

Within each of the 500 EAs, a random sample of 20 household visiting points was generated. This yielded a total sample size of 10 000 households, with 18 201 individual adults aged 15 years and older, and 8 880 individual children aged 0-14 years eligible to be interviewed. The characteristics of the excluded households have been reported in the original SANHANES-1 report (Shisana *et al*, 2013).

Proportions of non-response at household level were as follows:

- *1 289 (15.8%) refused to take part in the survey;*

• 573 (7.0%) were valid households but empty after repeated visits or the none-response involved other reasons

The highest non-response rates (refusal to participate/other) were reported at 40.4% among White households and only 6.7%, 14.8% and, 23.4% among African, Coloured, and Asian/Indian households, respectively. With regards locality, the highest non-response was reported among households in urban formal settings at 13.9% and only 3.8%, 3.4%, and 5.5% among households located in urban informal, rural informal, and rural formal settings, respectively. Notwithstanding non-response, due to the multistage cluster sampling design of SANHANES-1, some individuals had a greater or lesser probability of selection than others. This unequal sampling may result in the bias of estimates. To correct this potential bias, sample weights were introduced to correct for bias at the EA, household, and individual levels, and also adjusted for non-response. This sampling approach and the large number of participants in the study render the SANHANES a robust nationally representative data source, capturing the sociodemographic and anthropometric profile of the country.

2.2 Data sharing agreement and research ethics approval

Data access was obtained through a data sharing agreement with the Human Sciences Research Council (HSRC) (***Appendix 1***), the entity that conducted the SANHANES. The HSRC Research Ethics Committee approved the original SANHANES-1 study (**REC 6/16/11/11**). The present study received ethics approval from the Human Research Ethics Committee (HREC) (Medical) of the University of the Witwatersrand, Johannesburg, South Africa (**Clearance certificate number: M180775**) ***(Appendix 9)***.

2.3 Study design and sample characteristics

The present study is a secondary data analysis of selected variables extracted from the SANHANES-1. The HSRC supplied these variables in four separate databases.

From the original sample of 10 000 households in the SANHANES, 9 423 households had complete data, yielding the "Household Database" (dataset #1). In South Africa, a household is defined as "a group of people living in the same dwelling and sharing food from the same cooking pot" (Stats-SA, 2019). In the SANHANES-1, household membership was attributed to persons who occupied the same dwelling, and slept in that dwelling for at least four nights a week. The household head was identified as a physically present member who was designated internally as the head of that household. This person served as the main respondent for household-level data acquisition.

From the original sample of 18 201 adults, who were defined in the SANHANES as anyone aged 15 years and older, sociodemographic, and anthropometric data were collected on 17 926 individuals yielding the "Adult Database" (dataset #2). The full sample of 8 880 child individual-level data was used in the present study, constituting the "Child Database" (dataset #3), for those between ages 0 months to 14 years old; and, finally, anthropometric data were collected from a sample of 4 277 individual children (0 months to 14 years old) constituting the "Child Anthro Database" (dataset #4).

Prior to conducting the statistical analyses, the present study entailed extensive database management to reconcile adults and children back to their corresponding households, as well as to re-classify "adults" aged 15 – 19 years as children in order to allow comparison with international literature on nutrition and growth indicators that defines children from zero to 19 years old (Pérez-

Escamilla and de Toledo Vianna, 2012). In summary, from the original SANHANES database, we extracted 9 423 households and a combined sample of 26 806 individual adults and children.

2.4 SANHANES questionnaires, variable selection, variable scale measurements and units

Data collection for the SANHANES-1 included people of all ages residing in households in South Africa. Five separate but interrelated SANHANES-1 questionnaires were administered at household-level by a trained field worker capturing information on everyone living in an occupied household (between 1 and 20+ people). The variables of interest for this study were selected from each of the five questionnaires: Visiting Point (Household) Questionnaire (***Appendix 2)***; Child Questionnaire (***Appendix 3***); Child Clinical Examination Form (***Appendix 4***); Adult Questionnaire (***Appendix 5***) and the Adult Clinical Examination Form (***Appendix 6***).

2.4.1 Visiting Point (Household) Questionnaire

The head of each household was the main respondent for all questions at a household level, which included sociodemographic data for all household occupants and a determination of household food security. The household demographic variables selected for this study were: i); age, ii) sex (male or female), iii) race (African; Coloured; or, White/Indian/Asian) and iv) marital status (married; living together/civil union; never married; widowed; separated/divorced) of the household head; and v) number, age, and sex of children and other adults in the household; vi) the household head's main source of income (salaries/wages; social grants/remittances; sale of products and services; or, no income) and vii) educational attainment (no schooling; primary; secondary; or, tertiary/higher degree). Lastly, viii) locality (province; urban/rural; formal/informal) was predetermined from EA sampling.

Household food security was derived from the scores on the Community Childhood Hunger Identification Project (CCHIP) index (***Appendix 2.1***), a validated tool for the assessment of food insecurity at the household level (Swindale & Bilinsky, 2006)**.** Five of the eight questions are child-referenced, making the CCHIP a specific tool for measuring *childhood* food insecurity. In the SANHANES-1, the CCHIP was also administered to households without children, generalising the child-referenced questions to everyone in the household. A score of ≥5 affirmative responses indicates the presence of hunger, expressed as "*experiencing hunger*". A score of 1-4 affirmative responses indicates that the household is "*at risk of hunger*", and recorded as such. Lastly, a score of zero indicates that the household is "*food secure*". In this way, the CCHIP encompasses the four main reporting domains for food insecurity, namely: Availability, Accessibility, Utilization, and Stability, of which, all four of these domains must be intact for full food security, in accordance with the Food and Agriculture Organisation (Food and Agriculture Organization, 2006).

2.4.2 Child Questionnaire: 0-14 years

The Child Questionnaire (***Appendix 3***) collected information on the health and nutritional status of each individual child, 0–14 years of age. The relationship of the household head informant to the child was either the biological parent, legal guardian or any other type of familial relation even if not related by blood.

Dietary knowledge in children aged 10-14 years (***Appendix 3.1***) was assessed through responses to six general nutrition questions using a food group display card (***Appendix 3.2***). This age group was selected because of their comprehension level and ability to provide intelligible responses on the dietary knowledge questionnaire. Age 14 was the upper limit for designating a child in the SANHANES-1. Children were asked to "…*state the items that should be included in*

their meals in high and low quantities in order to properly recognise healthy alternatives between pairs of foods and to properly identify healthier fats" (Altman *et al.*, 2009). Children were shown the food group display card and asked the following six questions, beginning with the stem: "*What foods do you think: (1) should be included the most in meals? (2) should be most restricted in meals? (3) contains foods with lots of fibre? (4) best provides the body with energy? (5) best builds the body's muscles? And (6) protects the body from illnesses*?" A composite dietary knowledge score was calculated based on the number of correct answers, from the total six equally weighted questions. A score of 0-2 was assigned as *low* general nutrition knowledge; a score of 3-4 a *moderate* general nutrition knowledge; and, 5-6 a *high* general nutrition knowledge.

2.4.3 Child (0-14 years) and Adult (≥15 years) Clinical Examination Forms

All child and adult anthropometric variables were contained in the Child (***Appendix 4***) and Adult Clinical Examination (***Appendix 6***) Forms. Anthropometric measurements selected for this study (***Appendices 4.1 and 6.1***) included height (centimetres for children and meters for adults) and weight (kilograms). The mean of five measurements was taken for the weight and height.

2.4.4 Adult Questionnaire: 15 years and older

The Adult Questionnaire (***Appendix 5***) asked individual level information about the health and nutritional status of all persons 15 years of age and older living in a household. One such question asked about the presence/absence of non-communicable diseases (NCDs) (***Appendix 5.1***). Self-reported presence of NCDs was ascertained by a single stem for four NCDs: "*Has a doctor or nurse or a health worker at a clinic or hospital told you that you have or have had any of the following conditions: i) heart disease, ii) hypertension, iii) diabetes and iv) stroke*?" One of

three possible responses (Yes/No/Don't know) for each of the four specified chronic disease conditions was captured as variables for this study.

2.4.5 Child anthropometric measurements: Weight for Height Z-score (0-60 months), BMI for Age Z-score (>5 – 19 years old) and Height for Age Z-score

Using height (cm), weight (kg), and age (months) for children aged 0-19 years (which includes those SANHANES-1 "adults" aged 15 – 19 years who were reconciled back as children for the present study), we applied the *zanthro* function in STATA version 16.1 (STATA Institute Inc., College Station, TX, USA) to generate weight for height (WHZ) Z-scores (for children aged 0-60 months), height for age (HAZ) Z-scores (for all children 0-19 years) and BMI for age (BAZ) Z-scores (for children aged >5-19 years), which referenced the WHO Multicentre Child Growth Standards (2006) (de Onis *et al*., 2006) for children aged 0-60 months and the WHO Growth Reference (2007) (de Onis *et al*., 2007) for children aged >5-19 years. The WHO Growth Standards were derived from growth indicator data of children in the following six countries: Brazil, Ghana, India, Norway, Oman, and the United States of America (de Onis *et al*., 2006). For children aged >5-19 years, the WHO Growth Reference 2007 was applied. *"The WHO Growth Reference 2007 is a reconstruction of the 1977 National Center for Health Statistics (NCHS)/WHO reference. It uses the original NCHS data set supplemented with data from the WHO child growth standards sample for under-fives. To develop this reference the same statistical methodology was used as in the construction of the WHO standards. This reference compliments the WHO child growth standards for 0-60 months published in April 2006"* (de Onis *et al*., 2007).

In accordance with the accepted interpretation of these growth indicators (Medical Research Council of the United Kingdom, 2014), a child is considered malnourished under the

following conditions: severely wasted (WHZ ≤ -3SD), wasted (-3SD < WHZ ≤ -2SD), normal (-2SD < WHZ ≤ +1SD), possible risk of overweight (+1SD < WHZ ≤ +2SD), overweight (+2SD < WHZ ≤ +3SD), and obese (WHZ> +3SD). Using HAZ, a child is considered malnourished under the following conditions: severely stunted (HAZ ≤ -3SD), stunted (-3SD < HAZ ≤ -2SD), and not stunted (HAZ> -2SD). Lastly, using BAZ a child is considered malnourished when the following have been met: severely thin (BAZ ≤ -3SD), thin (-3SD < BAZ ≤ -2SD), normal (-2SD < BAZ ≤ +1SD), overweight (+1SD < BAZ ≤ +2SD), and obese (BAZ > +2SD). **Table 2.2 s**hows the summary of anthropometric indicators (Z-scores) and their cut-off points by age categories.

2.5 Data management

Figure 2.1 illustrates the database management, organisation and integration of the different household and individual-level variables from the five SANHANES-1 questionnaires shared in the four separate databases ('adult dataset', "household dataset', 'child dataset' and 'child anthro dataset') described earlier. This database management was necessary because the variables of interest were scattered throughout the four different datasets. Furthermore, we needed to reconcile data from adults and children with data contained in the household dataset for CCHIP scores as well as some anthropometric data; and, the "adults" aged 15 – 19 years had to be re-classified as children.

In order to reach the final analytic sample of 5 098 households and their occupants, both adults and children, with complete CCHIP scores, we performed the following steps with the four separate datasets:

1. Firstly, we extracted all persons between the ages of 15 – 19 years from the ‘adult dataset’ to re-classify them as children. This resulted in a decrease in the number of true adults to 15 007, with re-classified children numbering 2 626.
2. Then, we merged the two child datasets (‘child dataset’ and ‘child anthro’), yielding 8 893 children. We then appended the 2 626 re-classified children to the 8 893, yielding a final child database sample of 11 519.
3. From the original ‘household dataset’ of 9 423, we excluded 3 175 households where we could not confirm the inhabitants of the household due to inconsistent unique household identifiers and individual questionnaire numbers. A further 1 824 households without children were set aside (but not excluded) as these households did not require merging with child data. The resulting ‘household dataset’ comprised 4 392 households with children.
4. We then merged the child and adult datasets with this ‘household dataset’ using individual questionnaire numbers and household identifiers to link the individuals within the same household. In this way, we reconciled 10 420 adults and 9 997 children back to their corresponding households (n = 4 348 households with children).
5. At this point, households without children (n= 1 824) were appended to this dataset after which (n= 1 074) households with missing CCHIP scores were dropped, yielding a final analytic sample of 5 098 households with complete CCHIP scores.

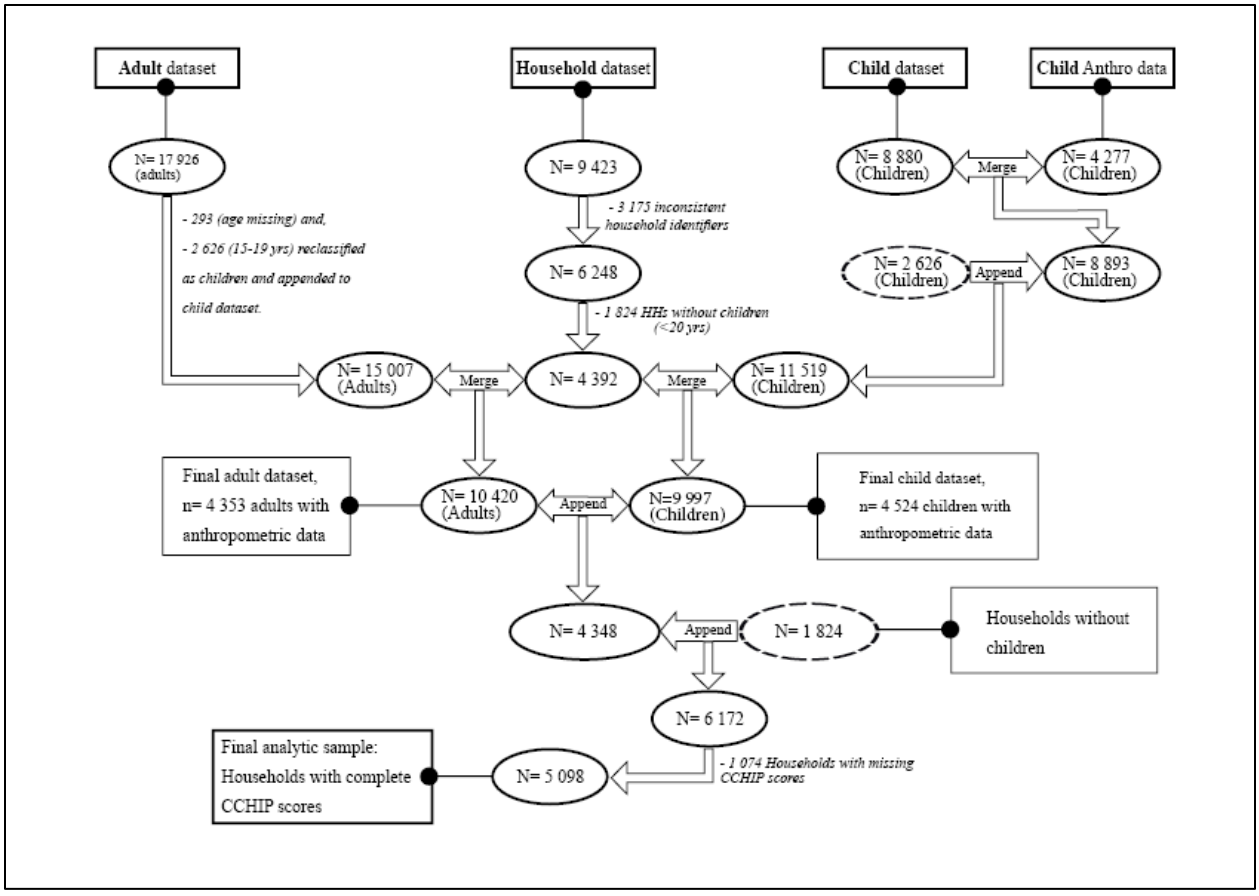

Figure 2.1: Database management, organisation and integration of data extracted from the four household and individual level datasets of the SANHANES-1.

2.6 Statistical analysis

STATA software, version 16.1 (STATA Institute Inc., College Station, TX, USA), GraphPad Prism, version 7.00 for Windows (GraphPad Software, La Jolla, California USA) and the R programming language (RStudio software, version 3.2.3.) were used for database management and statistical analyses. Results are presented as frequencies and percentages for categorical variables. Mean ± SD *or* Median [IQR] were used for continuous variables, normally and not normally distributed data, respectively. Comparisons between households with and without children were performed using a Mann-Whitney U test, and a Kruskal-Wallis test for

continuous non-normally distributed data, as appropriate. Categorical variables were compared using a Chi-Square test.

All analyses were performed using the *svy* function in STATA, incorporating sample weights and stratified cluster sampling design to provide estimates. The analyses were weighted to offset for the over-allocation of EAs in areas where Indian, Coloured or White racial groups prevailed, to ensure the minimum required sample size in those minority groups. Weighted prevalence of food security in households with children, stratified by sociodemographic characteristics of the household heads, were compared with a Chi Square test, with the exception of age for which we used a Kruskal-Wallis test. Bonferroni *post hoc* correction was employed to adjust for multiple comparisons between 2x2 categories.

To improve statistical power in the multiple regression models, the following variables were either combined and/or dichotomised: locality to formal vs informal (whether urban or rural); educational attainment (primary; secondary/tertiary/higher degrees; and, no schooling); marital status (married; never married; living together/civil unions; and, widowed/separated/divorced). Weighted univariable and multivariable multinomial logistic regression analyses with robust standard errors were carried out to determine factors associated with being "at risk of hunger" and "experiencing hunger", where the "food secure" category was used as the referent group for comparison in all households, and separately in households with and without children. Statistical significance was set at $p<0.05$. Multivariable multinomial logistic regression for "risk of hunger" and "experiencing hunger" using adjusted odds ratios with 95% confidence intervals as measures of association are presented as forest plots.

Nutritional status was expressed as categories of WHZ, HAZ and BAZ for boys and girls and compared using Chi-square tests. Two-way ANOVA tests with a Tukey *post hoc* correction

was used to determine the association between categories of food security and WHZ, BAZ and HAZ scores. A Kruskal-Wallis test with Bonferroni-adjusted multiple Mann-Whitney U tests was carried out to compute for differences in BAZ scores of children (10-14 years) across categories of food security and dietary knowledge. The presence of self-reported NCDs among adults (>19 years) living in households with children is expressed as frequencies and percentages.

Table 2.1: Statistical analyses plan

Objective	Variables	Statistical analyses
1. (a) To estimate the prevalence of food security in households stratified by sociodemographic characteristics of the household head	**Food security score:** 0 (Food secure), 1-4 (At risk of hunger) and, >5 (Experiencing hunger) **Sociodemographic factors:** Age, household size, sex, race, marital status, educational attainment, main source of income, and locality	Prevalence: % [95% CI] Mann-Whitney U test Chi-Square tests with 2 by 2 multiple analyses (bonferroni corrections) Kruskal-Wallis test with multiple 2 by 2 Mann-Whitney with bonferroni correction
(b) To determine the association between household sociodemographic factors and food security in households with and without children	**Sociodemographic factors:** Educational attainment, locality, and main source of income	Multivariable multinomial logistic regression analyses
2. (a) To determine the nutritional status of children using WHZ and HAZ (0-60 months) and BAZ and HAZ (>5-19 years)	**Age** (0 - 24 months; 25 months – 5 years; >5 – 9 years; 10 – 14 years; 15 -19 years), **WHZ, BAZ, HAZ**, and **sex** (boys/girls)	Chi-Square tests

Objective	Variable	Statistical analyses
(b) To determine associations between WHZ, HAZ and BAZ scores with household food security in children	Food security, WHZ, BAZ, and HAZ scores	2-way ANOVA with Tukey correction
3. (a) To assess the dietary knowledge of girls and boys aged 10-14 years	**Dietary knowledge**: low (0-2), moderate (3-4), and high (5-6) **Sex**: girls/boys	Chi-Square tests with 2 by 2 multiple analyses (bonferroni corrections)
(b) To assess associations between food security, dietary knowledge, BAZ and HAZ scores in children aged 10-14 years	Food security Dietary knowledge BAZ HAZ Sex: girls/boys	Chi-Square tests with 2 by 2 multiple analyses (bonferroni corrections) Kruskal-Wallis test with multiple Mann-Whitney U tests (bonferroni correction) 1-way ANOVA with Tukey correction 2-way ANOVA with Tukey correction
(c) To ascertain the percentage of adults (aged >19 years) self-reporting the presence of an NCD (hypertension, stroke, heart disease and diabetes)	**NCDs:** hypertension, stroke, heart disease, and diabetes	Frequency (n) and percentages (%)

Table 2.2: Summary of anthropometric indicators (Z-scores) and their cut-off points by age categories

Anthropometric indicator	Aged 0-60 months	Aged >5-19 years
Weight for Height Z-score (WHZ)		
Severe wasting	≤ -3 SD	-
Wasting	> -3 SD to ≤ -2 SD	-
Normal	> -2 SD to ≤ +1 SD	-
At risk of overweight	> +1 SD to ≤ +2 SD	-
Overweight	> +2 SD to ≤ +3 SD	-
Obese	> +3 SD	-
Height for Age Z-score (HAZ)		
Severely stunted	≤ -3 SD	≤ -3 SD
Stunted	> -3 SD to ≤ -2 SD	> -3 SD to ≤ -2 SD
Not stunted	> -2 SD	> -2 SD
BMI for Age Z-score (BAZ)		
Severely thin	-	≤ -3 SD
Thin	-	> -3 SD to ≤ -2 SD
Normal	-	> -2 SD to ≤ +1 SD
Overweight	-	> +1 SD to ≤ +3 SD
Obese	-	> +3 SD

Adapted from: Website of the Medical Research Council of the United Kingdom (https://dapa-toolkit.mrc.ac.uk/anthropometry/anthropometric-indices/growth)

Chapter 3: Household environmental factors and food insecurity

3.0 Specific objectives addressed in this chapter

1. To estimate the prevalence of food security in households stratified by sociodemographic characteristics of the household head
2. To determine the association between household sociodemographic factors and food security in households with and without children

The first manuscript (***Appendix 7***) includes results emanating from this chapter. At the time of submission of the present dissertation for examination, this manuscript was under editorial review with PLOS ONE.

3.1 Household composition and living arrangements of household heads

Table 3.1 shows the characteristics of South African households with and without children, and the living arrangements of the heads of households. Of the 5 098 households with complete CCHIP scores 3 499 (68.6%) households contained children aged 0-19 years. Households with children were occupied by 9 505 adults and 9 184 children, while those without children were occupied by 3 243 adults. Households with children were 2.5 times larger than those without children ($p<0.0001$). Forty percent of all households in South Africa that contain children were female headed. Of the households containing children, nine were child-headed. When comparing households with and without children, the proportions of African- and Coloured-headed households were not different ($p=0.417$). White/Indian/Asian households had a greater proportion of childless households compared to African ($p<0.0001$) and Coloured ($p<0.0001$) households. No differences between urban formal and urban informal settings were found following two by two comparisons ($p=0.361$). The proportion of households with children was higher in urban formal settings than in rural formal ($p<0.0001$) and rural informal ($p<0.0001$) settings. Rural informal

households, however, had greater proportions of households with children compared to urban informal households (p<0.0001).

Table 3.1: Characteristics of occupied South African households with and without children, and sociodemographic characteristics of household heads

	Households All=5 098		**p value**
	With children N=3 499	**Without children N=1 599**	
Household characteristics			
Household size (n=21 932)	5 [4 – 6]	2 [1 – 2]	<0.0001[&]
No. of Adults, ≥20 years (n=12 748)	2 [2 – 3]	2 [1 – 2]	<0.0001[&]
No. of Children, <20 years (n=9 183)	2 [1 – 3]	-	-
Gender (n=5 092)			
Male	1 532 (31.77)	899 (15.76)	<0.0001[#]
Female	1 963 (40.44)	698 (12.02)	
Age, years (n=5 093)			
Age	49.22 ± 14.67	52.07 ± 15.91	<0.0001[&]
Race (n=5 090) †			
African	2 465 (60.88) [a]	849 (19.86)	
Coloured	659 (6.86) [b]	263 (2.48)	<0.0001[#]
White/Indian/Asian	373 (4.54) [ab]	481 (5.39)	
Locality (n=4 889) †			
Urban formal	1 838 (39.25) [ab]	892 (16.15)	
Urban informal	464 (7.1) [cd]	155 (2.54)	<0.0001[#]
Rural formal	359 (4.16) [ace]	222 (6.3)	
Rural informal	838 (22.82) [bde]	121 (1.68)	
Marital status (n=4 998) †			
Married	1 678 (34.68) [a]	687 (11.15)	
Living together/civil union	310 (6.1) [bc]	73 (1.28)	
Never married	757 (16.02) [abd]	486 (9.5)	<0.0001[#]
Widowed	522 (11.38) [d]	236 (4.07)	
Separated/divorced	156 (3.9) [c]	93 (1.93)	

Data presented as median [IQR]; mean ± SD and n (%): unweighted (n) and weighted (%).

[&]Denotes p values obtained from Mann-Whitney U tests when comparing households with and without children for continuous variables (household size, number of adults and age of household head).

[#]Denotes p values obtained from overall Chi-Square tests when comparing households with and without children for categorical variables (gender, race, locality, and marital status).

[†]Denotes results from multiple 2x2 comparisons with Bonferroni correction: $p<0.05$ if categories share the same letter (a, b, c, d, and e) when comparing households with and without children. Specifically, for race and locality, $p<0.0001$ for African vs White/Indian/Asian, Coloured vs White/Indian/Asian, urban formal vs rural formal, and urban formal vs rural informal. For marital status, $p=0.001$ in married vs never married and living together vs never married, $p=0.036$ in Separated/divorced vs living together/civil unions and lastly $p=0.013$ in never married vs widowed.

3.2 Prevalence of food insecurity in households with children

In households with children, the prevalence of *experiencing hunger* and being *at risk of hunger* was 32.55% [95% CI (29.51 – 35.73)] and 26.37% [95% CI (23.96 – 28.82)], respectively (**Figure 3.1**).

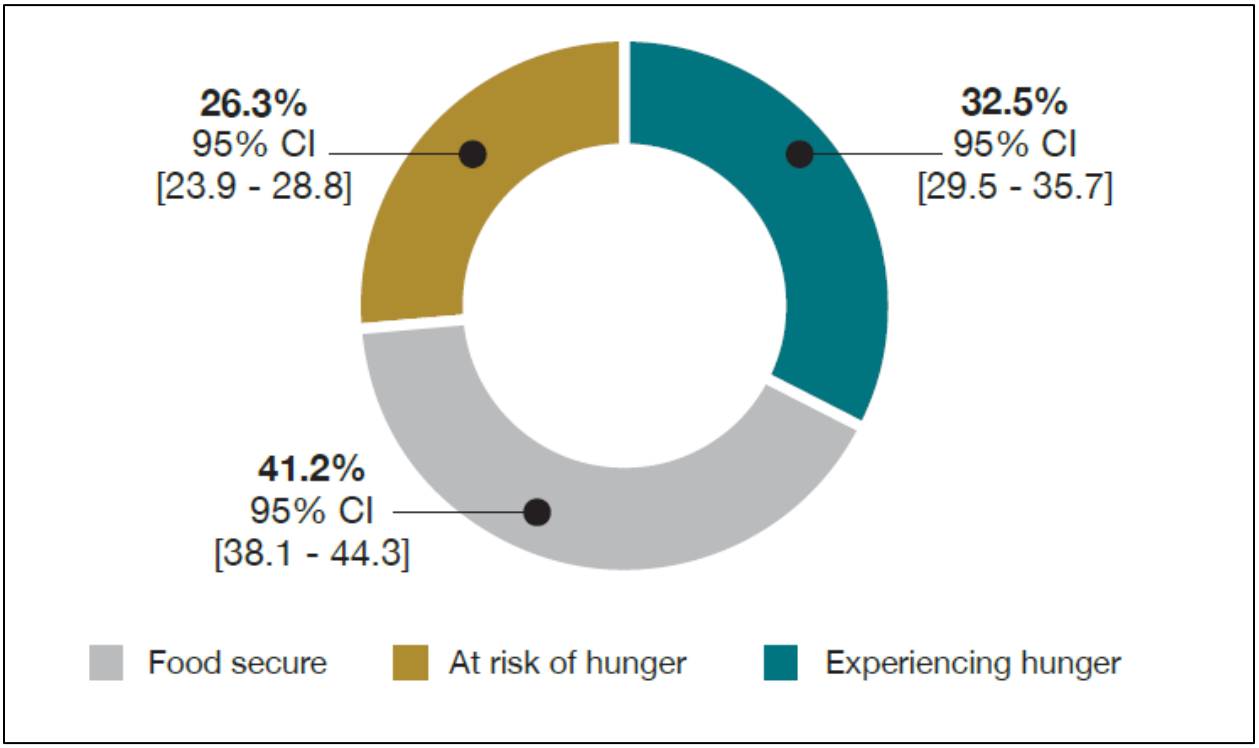

Figure 3.1: National prevalence of food insecurity in households with children

3.3 Prevalence of food insecurity in households with children stratified by sociodemographic characteristics of the household head

Table 3.2 shows weighted prevalence of food insecurity stratified by household head sociodemographic characteristics. Households in which the household head was female, older, of African race, unmarried, not having a formal education, dependent on social grants/pensions and other remittances and having no income showed a higher prevalence of experiencing hunger or being at risk of hunger ($p<0.0001$). Furthermore, regardless of urban or rural location, households in informal settings were more at risk of hunger (all $p<0.0001$); while rural-urban differences were observed in formal settings when comparing households at risk of hunger and those who were experiencing hunger ($p=0.001$).

Table 3.2: Weighted prevalence of household food security, stratified by sociodemographic characteristics of designated household heads of South African households with children

	Total N	Food secure n (%)	†At risk of hunger n (%)	‖Experiencing hunger n (%)	p value[#]
Gender (n=3 495)					
Male	1 532	813 (22.16)	356 (11.09)	363 (10.75) a	<0.0001
Female	1 963	739 (19.07)	502 (15.13)	722 (21.8) a	
Age, years (n=3 499)					
Age (Mean±SD)	3 499	47.87±13.85 *	49.76±15.15	50.70±15.25	0.0001
Race (n=3 497)					
African	2 465	845 (30.18)	662 (23.16) ab	958 (30.89) ab	
Coloured	659	388 (5.85)	155 (22.6) a	116 (1.38) ac	0.0001
White/Indian/Asian	373	319 (5.16)	43 (0.85) b	11 (0.27) bc	
Marital status (n=3 423)					
Married	1 678	899 (23.43)	375 (12.3) a	404 (12.39) abc	
Living together/civil union	310	112 (3.16)	80 (22.9)	118 (3.01) a	
Never married	757	256 (6.85)	212 (6.25) a	289 (9.13) b	0.0001
Widowed	522	196 (5.69)	134 (3.98)	192 (6.12) c	
Separated/divorced	156	61 (1.96)	44 (1.38)	51 (2.07)	
Educational attainment (n=3 499)					
Primary	820	243 (6.48)	223 (6.28) a	354 (10.34) ab	
Secondary	1 524	762 (18.27)	390 (12.11) b	372 (11.49) acd	
Tertiary/higher degree	353	280 (8.4)	50 (1.81) abc	23 (0.81) bce	<0.0001
No schooling/other	802	268 (8.05)	197 (6.05) c	337 (9.91) de	
Source of income (n=3 118)					
Salaries or wages	1 330	774 (22.93)	285 (9.32) ab	271 (9.01) ab	
Social grants/remittances	1 006	329 (10.69)	266 (9.34) a	411 (14.5) a	
Products and services	138	71 (2.11)	37 (1.46)	30 (1.08) c	<0.0001
No income	644	208 (5.54)	174 (5.86) b	262 (8.15) bc	
Locality (n=3 499)					
Urban formal	1 838	1 049 (27.85)	410 (12.9) ab	379 (12.77) abc	
Urban informal	464	131 (2.59)	140 (3.11) a	193 (3.98) a	<0.0001
Rural formal	359	128 (2.18)	80 (1.19)	151 (2.3) b	
Rural informal	838	245 (8.58)	230 (9.05) b	363 (13.49) c	

[#]Denotes the p value from overall Chi-Square test when comparing food security status (food secure, at risk of hunger and experiencing hunger) across categorical variables (gender, race, marital status, educational attainment, source of income and locality), of which all were statistically significant. However, *p<0.001 for age when comparing food secure vs at risk of hunger and food secure vs experiencing hunger (Kruskal-Wallis with Bonferroni correction).

On multiple 2 by 2 analyses with Bonferroni correction, statistically significant differences within categories of sociodemographic characteristics are indicated by sharing the same letter: a, b, c, d or e, when comparing food secure vs at risk of hunger and food

secure vs experiencing hunger. Specifically, p<0.01 between food secure vs. experiencing hunger except for: ⁋Primary vs no schooling, salaries vs products/services; pensions/grants vs product/services and no income; p<0.01 between food secure vs. at risk of hunger except for: †Coloured vs White/Indian/Asian; primary vs secondary; primary vs no schooling and secondary vs no schooling; salary vs product/services, pension/grants vs product/services, pension/grants vs no income and product /services vs no income; p<0.01 between food secure vs at risk of hunger and food secure vs experiencing hunger for married vs never married and married vs widower; p<0.01 between food secure vs experiencing hunger for married vs living together.

3.4 Factors associated with experiencing hunger and being at risk of hunger in all households with and without children

Weighted univariable multinomial logistic regression (**Table 3.3**) of all the households exhibits that household heads who were female, unmarried/widowed/separated vs married were at higher risk of hunger and of experiencing hunger. Age was only associated with experiencing hunger but not being at risk of hunger.

However, when performing a weighted multivariable multinomial logistic regression (**Figures 3.2A & 3.2B**), age was no longer associated with experiencing hunger. Yet, female-headed households had ~1.53 times increased odds of experiencing hunger as compared to male-headed households (p<0.001). Having a larger household size and households with children present were predictors of experiencing hunger; AOR [95% CI]: 1.06 [1.00 – 1.21] and 1.68 [1.12 – 2.53], respectively. Having a household head who was either Coloured or White/Indian/Asian as opposed to African was protective against both experiencing hunger and being at risk of hunger; AOR [95% CI]: 0.29 [0.19 – 0.44] and 0.12 [0.04 – 0.33] for experiencing hunger, respectively, and being at risk of hunger; AOR [95% CI]: 0.54 [0.39 – 0.75], 0.22 [0.12 – 0.40], respectively. Furthermore, secondary/tertiary education was protective against both experiencing hunger; AOR [95% CI]: 0.40 [0.28 – 0.56] and being at risk of hunger; AOR [95% CI]: 0.69 [0.52 – 0.92]. Households relying on pensions/social grants/remittances, or not having any source of income were ~1.76 to 2.15 times more at risk of hunger and experiencing hunger than those receiving a salary/wage.

Table 3.3: Weighted univariable multinomial logistic regression analysis of factors associated with being at risk of hunger and experiencing hunger against being food secure

Characteristics	At risk of hunger			Experiencing hunger		
	OR	95% CI	p value	OR	95% CI	p value
Household size	0.99	0.95 – 1.04	0.862	1.15	1.10 – 1.20	<0.001
Children						
Without	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
With	1.06	0.87 – 1.29	0.557	2.97	2.24 – 3.93	<0.001
Gender						
Male	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Female	1.44	1.18 – 1.77	<0.001	2.42	1.98 – 2.97	<0.001
Age, years						
Age	1.00	0.99 – 1.00	0.541	1.00	1.00 – 1.01	0.005
Race						
African	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Coloured	0.49	0.36 – 0.65	<0.001	0.23	0.15 – 0.33	<0.001
White/Indian/Asian	0.24	0.11 – 0.53	<0.001	0.05	0.01 – 0.15	<0.001
Marital status						
Married	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Living together/civil union	1.43	1.03 – 2.01	0.033	1.86	1.32 – 2.62	<0.001
Never married	1.79	1.37 – 2.35	<0.001	2.05	1.57 – 2.66	<0.001
Widowed	1.50	1.13 – 1.98	0.004	2.11	1.55 – 2.88	<0.001
Separated/divorced	1.63	1.06 – 2.52	0.025	1.83	1.12 – 2.98	0.015
Educational attainment						
Primary	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Secondary	0.65	0.50 – 0.84	0.001	0.37	0.29 – 0.48	<0.001
Tertiary/Higher degree	0.18	0.12 – 0.29	<0.001	0.04	0.02 – 0.08	<0.001
No schooling/other	0.73	0.52 – 1.01	0.064	0.79	0.60 – 1.04	0.098
Source of income						
Salaries and/or wages	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Pensions/Grants/Remittances	1.98	1.53 – 2.55	<0.001	3.16	2.36 – 4.23	<0.001
Sale of products and services	1.36	0.83 – 2.21	0.210	1.16	0.58 – 2.31	0.670
No income	2.96	2.17 – 4.05	<0.001	3.75	2.67 – 5.28	<0.001
Locality						
Urban formal	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Urban informal	2.57	1.76 – 3.75	<0.001	3.19	2.09 – 4.85	<0.001
Rural formal	2.04	1.40 – 2.96	<0.001	2.12	1.43 – 3.13	<0.001
Rural informal	2.00	1.48 – 2.68	<0.001	3.58	2.60 – 4.92	<0.001

OR; Odds Ratio, 95% CI; 95% Confidence Intervals

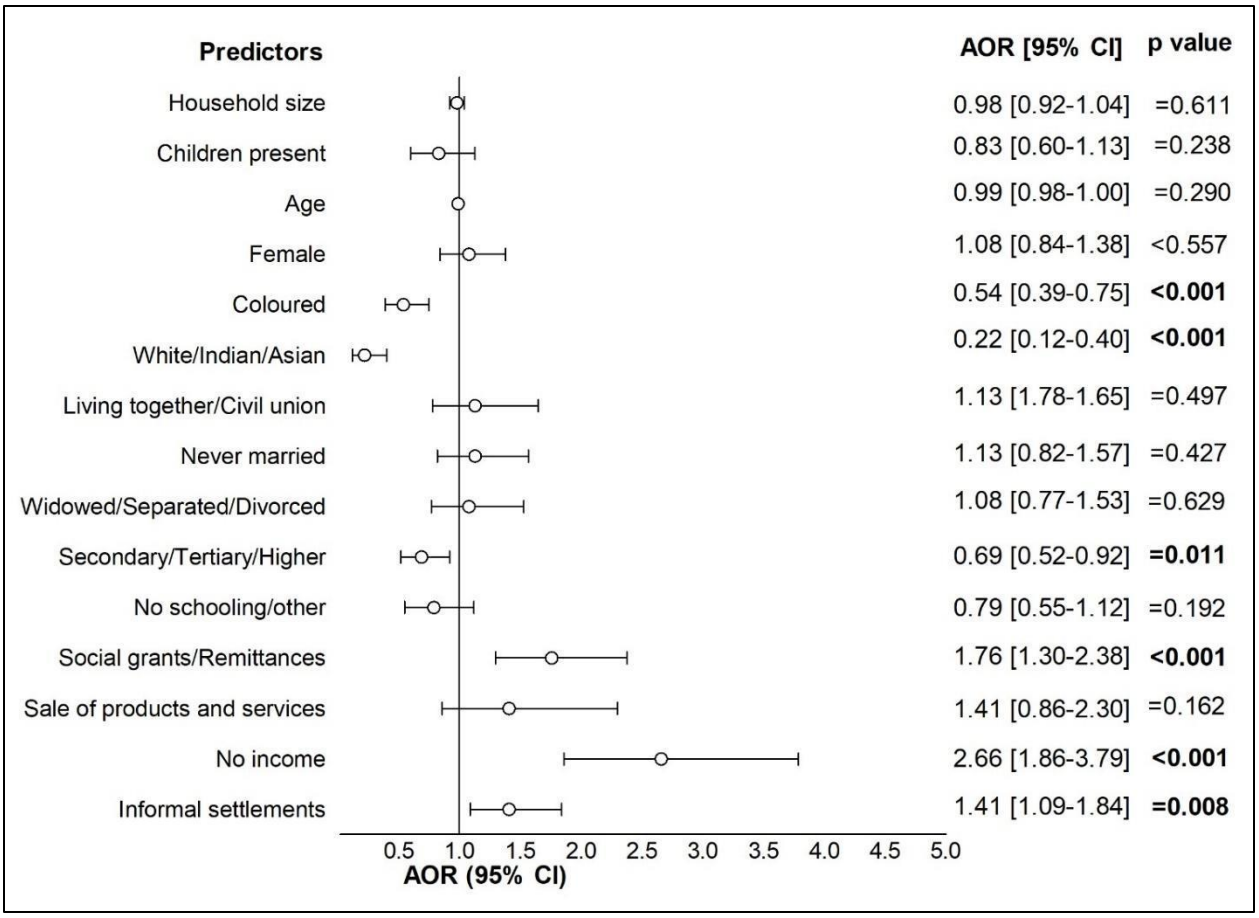

Figure 3.2A: Factors associated with being at risk of hunger, data presented as adjusted odds ratios (AOR) and 95% Confidence intervals (95% CI)

Reference categories: *Presence of children (no children present), Gender (male), Race (African), Marital status (married), Educational attainment (primary), Source of income (salaries/wages), Locality (formal)*

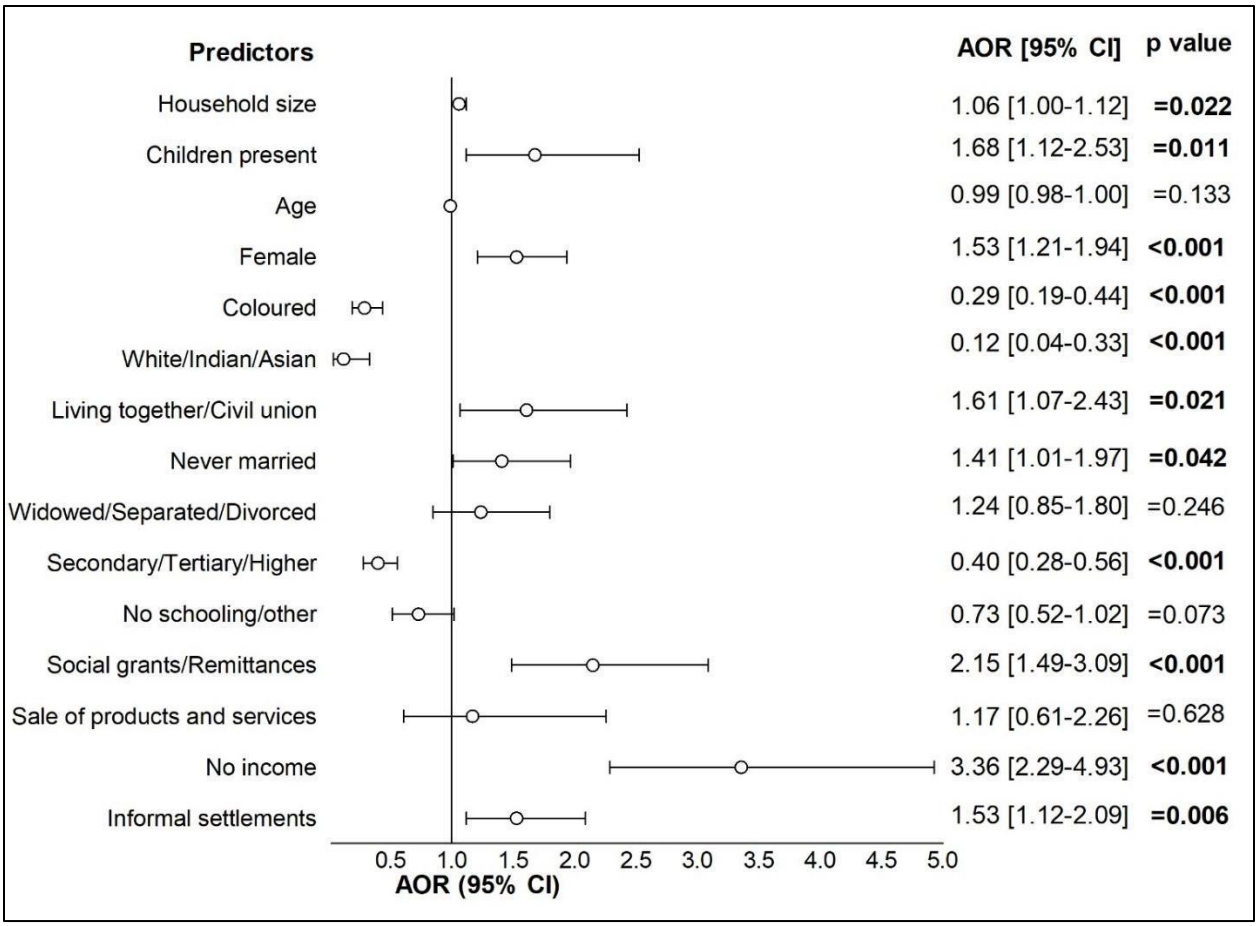

Figure 3.2B: Factors associated with experiencing hunger, data presented as adjusted odds ratios (AOR) and 95% Confidence intervals (95% CI)

Reference categories: *Presence of children (no children present), Gender (male), Race (African), Marital status (married), Educational attainment (primary), Source of income (salaries/wages), Locality (formal)*

3.4.1 Differential risk of food insecurity in households with, and without, children

3.4.1.1 Factors associated with experiencing hunger, and being at risk of hunger in households without children

Table 3.4A shows the weighted multivariable multinomial logistic regression analysis of factors associated with being at risk of hunger and experiencing hunger against being food secure when the analysis was restricted to households without children. In households without children, the non-African race i.e., Coloured AOR [95% CI]: 0.44 [0.27 – 0.73] and White/Indian/Asian 0.28 [0.15 – 0.53] race groups and, secondary/tertiary/higher degrees 0.52 [0.30 – 0.88] were protective of being at risk of hunger. No income 3.78 [2.01 – 7.08] was a predictor of being at risk of hunger. The female sex AOR [95% CI]: 2.00 [1.15 – 3.50] and no income 5.16 [2.25 – 11.82] conferred increased odds of experiencing hunger while the Coloured 0.15 [0.06 – 0.34] and White/Indian/Asian 0.12 [0.03 – 0.38] race groups and households with heads who attained secondary/tertiary/higher degrees 0.31 [0.14 – 0.70] were protected from experiencing hunger.

3.4.1.2 Factors associated with experiencing hunger and being at risk of hunger in households with children

Table 3.4B shows the weighted multivariable multinomial logistic regression analysis of factors associated with being at risk of hunger and experiencing hunger against being food secure when the analysis was restricted to households with children. In households with children, only the non-African race groups were protected from being at risk of hunger, Coloured AOR [95% CI]: 0.64 [0.45 – 0.92] and White/Indian/Asian 0.16 [0.07 – 0.33]. Whereas pensions/social grants/remittances 1.69 [1.18 – 2.42], no income 2.08 [1.41 – 3.07] and informal location 1.64 [1.20 – 2.24] increased the odds of being at risk of hunger. Again, the non-African race groups, Coloured 0.36 [0.24 – 0.55] and White/Indian/Asian 0.11 [0.03 – 0.36] were protected from

experiencing hunger. Households with children were characterised by a host of factors that increased the odds of experiencing hunger; namely, household size AOR [95% CI]: 1.06 [1.00 – 1.12], female sex 1.45 [1.07 – 1.95], living together/civil unions 1.72 [1.11 – 2.68], never married 1.46 [1.02 – 2.09], relying on social grants/pensions/remittances and sale of products and services 1.92 [1.31 – 2.79], having no income 2.83 [1.89 – 4.24] and residing in informal settings 1.78 [1.27 – 2.49].

Table 3.4A: Weighted multivariable multinomial logistic regression analysis of factors associated with being at risk of hunger and experiencing hunger against being food secure in households without children

Characteristics	At risk of hunger		p value	Experiencing hunger		p value
	AOR	95% CI		AOR	95% CI	
Household size	0.95	0.79 – 1.14	0.589	1.13	0.93 – 1.36	0.206
Gender						
Male	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Female	1.11	0.71 – 1.75	0.619	2.00	1.15 – 3.50	0.014
Age, years						
Age	0.99	0.97 – 1.01	0.458	0.99	0.96 – 1.02	0.744
Race						
African	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Coloured	0.44	0.27 – 0.73	0.001	0.15	0.06 – 0.34	<0.001
White/Indian/Asian	0.28	0.15 – 0.53	<0.001	0.12	0.03– 0.38	<0.001
Marital status						
Married	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Living together/civil union	0.95	0.43 – 2.10	0.915	1.00	0.31 – 3.14	0.997
Never married	1.39	0.85 – 2.27	0.395	1.40	0.63 – 3.11	0.395
Widowed/ Separated/divorced	1.56	0.87 – 2.79	0.129	1.22	0.53 – 2.83	0.633
Educational attainment						
Primary	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Secondary/Tertiary/Higher degree	0.52	0.30 – 0.88	0.015	0.31	0.14 – 0.70	0.005
No schooling/other	0.73	0.52 – 1.01	0.064	0.76	0.36 – 1.59	0.468
Source of income						
Salaries and/or wages	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Pensions/Remittances/Sale of products and services	1.51	0.89 – 2.56	0.124	2.00	0.94 – 4.26	0.071
No income	3.78	2.01 – 7.08	<0.001	5.16	2.25 – 11.82	<0.001
Locality						
Formal	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Informal	0.89	0.53 – 1.51	0.687	0.94	0.45 – 1.93	0.870

AOR; Adjusted Odds Ratio, 95% CI; 95% Confidence Intervals

Table 3.4B: Weighted multivariable multinomial logistic regression analysis of factors associated with being at risk of hunger and experiencing hunger against being food secure in households with children

Characteristics	At risk of hunger		p value	Experiencing hunger		p value
	AOR	95% CI		AOR	95% CI	
Household size	0.98	0.92 – 1.05	0.711	1.06	1.00 – 1.12	0.025
Gender						
Male	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Female	1.11	0.80 – 1.54	0.507	1.45	1.07 – 1.95	0.015
Age, years						
Age	0.99	0.98 – 1.00	0.454	0.99	0.98 – 1.00	0.198
Race						
African	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Coloured	0.64	0.45 – 0.92	0.019	0.36	0.24 – 0.55	<0.001
White/Indian/Asian	0.16	0.07 – 0.33	<0.001	0.11	0.03 – 0.36	<0.001
Marital status						
Married	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Living together/civil union	1.20	0.80 – 1.80	0.363	1.72	1.11 – 2.68	0.015
Never married	1.04	0.70 – 1.56	0.819	1.46	1.02 – 2.09	0.037
Widowed/ Separated/divorced	0.90	0.59 – 1.37	0.648	1.22	0.81 – 1.85	0.323
Educational attainment						
Primary	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Secondary/Tertiary/Higher degree	0.77	0.56 – 1.05	0.103	0.42	0.29 – 0.62	<0.001
No schooling/other	0.81	0.54 – 1.22	0.333	0.74	0.50 – 1.08	0.122
Source of income						
Salaries and/or wages	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Pensions/Remittances/Sale of products and services	1.69	1.18 – 2.42	0.004	1.92	1.31 – 2.79	0.001
No income	2.08	1.41 – 3.07	<0.001	2.83	1.89 – 4.24	<0.001
Locality						
Formal	***REF***	***REF***	***REF***	***REF***	***REF***	***REF***
Informal	1.64	1.20 – 2.24	0.002	1.78	1.27 – 2.49	0.001

AOR; Adjusted Odds Ratio, 95% CI; 95% Confidence Intervals

3.5 Discussion

To the best of our knowledge, the present study is the first to objectively quantify the burden of childhood food insecurity in South Africa and draw associations using a large-scale, population-based sample of households with children under 20 years of age. No studies in South Africa have disaggregated households with and without children thus possibly underestimating the true extent of childhood food insecurity and limiting direct comparisons to the present study. Indeed, there is an observed discrepancy (increase in food insecurity by 6.6%) between the prevalence estimate reported for 2008 by Altman *et al.*, (2009) and the estimate generated in the present study; however, these findings may be accounted for, by the enduring socio-political and economic challenges sustained over the years (Drimie & Ruysenaar, 2010; Altman *et al.*, 2009; de Oliveira *et al.*, 2020). Drawing from a cross-sectional, population-based national sample of South African households, we have shown that the prevalence of food insecurity in households with children was nearly 60%. In a multivariable model, adjusting for sociodemographic characteristics, the presence of children conferred ~1.68 increased odds of food insecurity (experiencing hunger) compared to households without children. Having a female vs male household head, having an African household head compared to all other race groups, living in informal settings vs formal settings and having no income compared to relying on salaries or wages increased the household risk of experiencing hunger between 53% and 300%. Secondary/tertiary/higher educational attainment of the household head reduced the risk of experiencing hunger by at least 40% relative to primary education. However, having a household head with no formal schooling was not a predictor for experiencing hunger. In addition, marital status of the household head was not independently associated with being at risk of hunger but living together/civil unions and never married increased the odds of experiencing hunger by 61% and 41%, respectively. Relying on

social grants and remittances as the main source of income was not protective against food insecurity.

3.5.1 Gender, presence of children, racial differences, rurality, and informality

The majority of households with children in our sample were headed by women, had African household heads, or were living in urban informal or rural informal areas; therefore, the increased vulnerability of households with children may be explained, in part, by the additive effects of these known predictors of food insecurity (Farrell *et al.*, 2018). According to Dungumaro (2008), some of the reasons for the gender disparity in household headship include labour migration by male adults, resulting in 'left-behind' female heads (mostly spouses of male migrant labourers), and female labour migration which results in (even if transitory) female household headship. Moreover, socio-cultural changes that erode the extended family structure and make single parenthood more permissible have become more pronounced with time (Dungumaro, 2008). A mounting body of evidence has corroborated that the presence of children below age 18 years in households is independently associated with food insecurity, beyond sociodemographic characteristics and measures of socioeconomic status (Chinnakali *et al.*, 2014; Mortazavi *et al.*, 2017; Tantu, Gamebo & Sheno, 2017; Sisha, 2020). Additional research has demonstrated that the sex of the household head is an important factor predicting household vulnerabilities, with the highest prevalence of hunger reported among female-headed households (Ruiters & Wildschutt, 2010; Akadiri, Nwaka & Jenkin, 2018), a risk that worsens with rural location (Akadiri, Nwaka & Jenkin, 2018). In contrast to a study by Chakona and Shackleton, (2018), in which food insecurity increased along the urban-rural continuum of South African towns selected along an agro-ecological gradient, we show that the risk of food insecurity transcends rural-urban differences and becomes more salient when stratifying by formal vs informal type of household location. In

their large-scale, population-based longitudinal analysis of the Indonesian Family Life Survey, Vaezghasemi *et al.*, (2014) further argued that while women, who are at the bottom of the family hierarchy with low social capital, may be conscious of healthy food options but are nonetheless defenceless against household hunger. Given South Africa's colonial and apartheid history, racial differences still persist in the prevalence of food insecurity, with black or African households bearing the greatest burden compared to minority groups (Mutisya *et al.*, 2016).

3.5.2 Main source of household income and social grants

Using self-reported main source of income to indicate a household's economic stability, we show that not having any source of income predicts that a household will experience a three-fold increase in experiencing hunger. Furthermore, similar to Ruiters and Wildschutt, (2010), receiving government social grants and pensions, or remittances, did not completely alleviate hunger or the risk of being food insecure. Other contexts show mixed results for government assistance programmes on food security. Tarasuk, Fafard St-Germain and Mitchell, (2019) have shown that in Canada, household before-tax income adjusted for family size was protective against food insecurity; however, households receiving social assistance were three times more likely to be food insecure. In contrast, Brown and Tarasuk, (2019) reported reductions in severe food insecurity among households with children subsequent to the roll-out of the Canada Child Benefit (CCB), a country-wide non means-tested cash transfer programme. In Brazil (de Sousa *et al.*, 2019), participation in the Bolsa Familia Programme (Costa *et al.*, 2017; Paranaense, Londrina & Campinas, 2012) and in the United States receiving Supplemental Nutrition Assistance Program (SNAP, formerly the Food Stamp Program) support, were not effective in preventing food insecurity (Cook *et al.*, 2006). In one South African study where, social grants did show improvements in household food security and diet quality, Waidler and Devereux, (2019) argue

that these findings were not accompanied by concomitant improvements in anthropometric indicators of child malnutrition.

3.5.3 Educational attainment

Previous studies have demonstrated strong positive associations between the lowest levels of educational attainment and food insecurity, mitigated by higher levels of educational attainment (Mutisya *et al.*, 2016; Devereux *et al*., 2018). Likewise, we found that improved levels of education (secondary and tertiary educational attainment) reduced the risk of food insecurity by at least 40%; however, having no formal schooling, when compared to primary education, was not associated with food insecurity. As Chakona and Shackleton, (2018) also found, we posit that household heads without a formal education may rely on subsistence farming or implement other skills-based practices which act as a *safety net* against food insecurity, thereby insulating the adverse effects of any financial shocks on household food expenditure.

3.5.4 Marital status

The Born in Bradford cohort, a longitudinal study in the United Kingdom, showed associations between cohabitation status and food insecurity, where pregnant women not living with a partner had a two-fold increased risk of food insecurity (Power *et al.*, 2017). Hanson, Sobal and Frongillo, (2007) further demonstrated that marital status was associated with food insecurity among men, but not women. In concert with these findings, we found significant associations between the marital status of the household head and risk of experiencing hunger, even after adjustments for sex, where living together/civil unions and never married increased the odds of experiencing hunger by 61% and 41%, respectively. We postulate that unmarried women in extended families may share food costs with other adults co-resident in the household; it is possible

that over generations there is resilience and better coping strategies within the household as the burden of providing food is shared among members.

Chapter 4: Anthropometric indicators of malnutrition in children and associations with household food security

4.0 Specific objectives addressed in this chapter

1. To determine the nutritional status of children using WHZ and HAZ scores (0-60 months) and BAZ and HAZ (>5-19 years)
2. To determine associations between WHZ, HAZ and BAZ scores with household food security in children

4.1 Sociodemographic characteristics of South African boys and girls aged 0-19 years

Table 4.1 shows the sociodemographic characteristics of South African girls and boys aged 0-19 years old. No significant statistical differences were noted between girls and boys in mean age, race, and locality.

Table 4.1: Sociodemographic characteristics of South African girls and boys aged 0-19 years old

	All N=6 905	**Boys**	**Girls**	**p value**
		n= 3 433	**n= 3 472**	
Age, years mean (SD)	10.73 (5.94)	10.63 (5.92)	10.83 (5.96)	0.177
Race, n (%)	**6 570**	**3 246**	**3 324**	
African	4 627	2 277 (40.57)	2 350 (38.86)	
Coloured	1 075	527 (3.93)	548 (3.46)	0.496
White/Indian/Asian	868	442 (7.05)	426 (6.12)	
Locality, n (%)	**6 905**	**3 433**	**3 472**	
Urban formal	2 899	1 451 (21.18)	1 448 (19.25)	
Urban informal	951	462 (5.29)	489 (5.27)	0.788
Rural formal	1 034	518 (4.27)	516 (4.06)	
Rural informal	2 021	1 002 (21.25)	1 019 (19.43)	

Sample size (n) is unweighted and weighted percentages (%) add to the total sample size (all children together). Age as a continuous variable was compared using a Mann-Whitney U test and categorical variables (race and locality) were compared using a Chi-square test.

4.2 Nutritional status of South African boys and girls aged 0-60 months

Table 4.2A shows the Weight for Height (WHZ) and Height for Age (HAZ) scores of South African children from 0-60 months disaggregated by boys and girls and by ages 0-24 and 25-60 months. In comparing WHZ scores for younger children aged 0-24 months with those aged 25-60 months, statistically significant differences were found with younger children falling less into the "normal" category compared with those over age two. This was true for both boys and girls, with an overall $p<0.0001$. The proportion of overnutrition (Risk of overweight/overweight/obese) in boys 0-24 months was 54.28% in comparison to 30.41% among those aged 25-60 months old, with a similar pattern observed between younger and older girls. For HAZ, statistically significant differences were found when comparing children aged 0-24 months and those aged 25-60 months among boys ($p<0.0001$) and girls ($p<0.0001$). Among younger boys, 27.22% were either stunted/severely stunted compared to only 16.44% among boys aged 25-60 months. A similar pattern among the girls was observed.

Table 4.2B shows the BMI for Age (BAZ) and Height for Age (HAZ) Z-scores of South African boys and girls aged >5-19 years, stratified into three age categories (>5-9; 10-14; 15-19). For boys, there were no differences of BAZ between the age groups ($p=0.151$). Among the girls, significant differences in BAZ were found when comparing the age groups ($p=0.031$): 81.46% of the girls aged >5-9 years had normal BAZ, whereas below 70% of girls in both the 10-14 and 15-19 age categories had normal BAZ scores. With increased age in girls, aged 10-19, the percentage of overweight/obese was nearly 30%, whereas among girls aged >5-9 years old, the percentage was 17.32%. The prevalence of stunting/severe stunting was not different among either of the three age categories of boys (10.26%, 14.04%, 10.38%; $p=0.604$;) or girls (8.99%, 10.02%, 9.33%; $p=0.239$).

Table 4.2A: Nutritional status of South African boys and girls aged 0-60 months

	Boys Age, months (N= 886)		**Girls** Age, months (N= 876)	
	0-24 n= 374	**25-60** n= 512	**0-24** n= 395	**25-60** n= 481
[*]WHZ, n (%)				
Severely wasted	7 (1.99)	3 (0.26)	2 (0.12)	1 (0.19)
Wasted	11 (2.23)	8 (1.79)	10 (1.95)	8 (0.99)
Normal	177 (41.50)	354 (67.54)	182 (41.53)	359 (70.94)
Risk of overweight	81 (26.06)	95 (18.12)	89 (22.86)	72 (18.60)
Overweight	45 (14.34)	35 (8.34)	43 (14.31)	23 (4.89)
Obese	53 (13.88)	17 (3.95)	69 (19.22)	18 (4.40)
[#]HAZ, n (%)				
Severely stunted	41 (10.65)	32 (4.57)	48 (11.29)	17 (2.36)
Stunted	80 (16.57)	73 (11.87)	72 (15.71)	68 (13.93)
Not stunted	253 (72.78)	407 (83.56)	275 (73.00)	396 (83.71)

[*]**Weight for Height Z-scores**: severely wasted (WHZ≤ -3SD), wasted (-3SD < WHZ ≤ -2SD), normal (-2SD < WHZ ≤ +1SD), possible risk of overweight (+1SD < WHZ ≤ +2SD), overweight (+2SD < WHZ ≤ +3SD), and obese (WHZ> +3SD).

[#]**Height for Age Z-scores**: severely stunted (HAZ ≤ -3SD), stunted (-3SD < HAZ ≤ -2SD), and not stunted (HAZ> -2SD).

Overall p<0.0001 (Chi-square test) comparing 0-24 and 25-60 months in both boys and girls for WHZ and HAZ.

Table 4.2B: Nutritional status of South African boys and girls aged >5-19 years

	Boys			**Girls**		
	Age, years (N= 1 498)			**Age, years (N=1 564)**		
	>5-9	**10-14**	**15-19**	**>5-9**	**10-14**	**15-19**
	n= 632	**n= 625**	**n= 241**	**n= 588**	**n= 670**	**n= 306**
***BAZ, n (%)**						
Severely thin	9 (0.73)	6 (0.37)	2 (0.32)	2 (0.11)	10 (0.95)	-
Thin	16 (1.88)	37 (4.77)	15 (6.79)	9 (1.11)	19 (1.80)	4 (1.10)
Normal	532 (85.93)	498 (80.13)	197 (83.88)	479 (81.46)	493 (68.00)	218 (69.21)
Overweight	47 (7.01)	54 (10.43)	18 (6.03)	70 (12.14)	100 (22.52)	57 (20.79)
Obese	28 (4.45)	30 (4.30)	9 (2.98)	28 (5.18)	48 (6.72)	27 (8.90)
#HAZ, n (%)						
Severely stunted	13 (1.28)	19 (1.66)	4 (1.51)	19 (1.79)	17 (1.54)	-
Stunted	65 (8.98)	88 (12.38)	25 (8.87)	46 (7.20)	65 (8.48)	32 (9.33)
Not stunted	554 (89.74)	518 (85.96)	216 (89.62)	523 (91.00)	588 (89.97)	279 (90.67)

***BMI for Age Z-scores**: severely thin (BAZ ≤ -3SD), thin (-3SD < BAZ ≤ -2SD), normal (-2SD < BAZ ≤ +1SD), overweight (+1SD < BAZ ≤ +2SD), and obese (BAZ > +2SD)

#**Height for Age Z-scores**: severely stunted (HAZ ≤ -3SD), stunted (-3SD < HAZ ≤ -2SD), and not stunted (HAZ> -2SD)

Overall p=0.031 (Chi-square test) comparing >5-9 years, 10-14 years and 15-19 years among the girls

4.3 Nutritional status of South African boys and girls by food security

Table 4.3A shows the Weight for Height Z-scores of South African boys and girls aged 0-60 months stratified by food security status. On 2-way ANOVA, neither food security status (p=0.367) nor sex (p=0.398) was associated with WHZ.

Table 4.3B shows the Height for Age Z-scores of South African boys and girls aged 0-60 months stratified by food security status. On 2-way ANOVA, food security (p=0.049) was modestly associated with HAZ; however, sex (p=0.614) was not associated with HAZ. Upon Tukey *post hoc* correction, children from households that experienced hunger were significantly shorter than those from households that were food secure (p=0.038). No statistically significant differences were found when comparing food security vs At risk of hunger (p=0.355), and At risk of hunger vs Experiencing hunger (p=0.686).

Table 4.3C shows the BMI for Age Z-scores of South African girls and boys aged >5-19 years stratified by food security status. On 2-way ANOVA, food security status (p=0.007) and sex (p<0.001) were both associated with BAZ. Upon Tukey *post hoc* correction, children from food secure households were heavier than those from households that were at risk of hunger (p=0.013) and those that experienced hunger (p=0.019). However, no statistically significant differences were observed when comparing At risk of hunger vs Experiencing hunger (p=0.861).

Table 4.3D shows the Height for age Z-scores of South African boys and girls aged >5-19 years stratified by food security status. On 2-way ANOVA, food security status (p<0.001) and sex (p=0.002) were both associated with HAZ. Upon Tukey *post hoc* correction, children from food secure households were shorter than children from households that were at risk of hunger

(p=0.004) and those that experienced hunger (p<0.001). No significant differences were observed between At risk of hunger vs experiencing hunger (p=0.822).

Table 4.3A: Weight for Height Z-scores of South African boys and girls aged 0-60 months stratified by food security status

	Boys			Girls		
	n	**Mean WHZ**	**95% CI**	**n**	**Mean WHZ**	**95% CI**
Overall	739	0.48	0.39 – 0.58	706	0.41	0.32 – 0.50
Food security						
Food secure	251	0.46	0.28 – 0.64	217	0.49	0.33 – 0.64
At risk of hunger	182	0.51	0.32 – 0.70	181	0.50	0.31 – 0.68
Experience hunger	306	0.49	0.36 – 0.61	308	0.30	0.16 – 0.45

2-way ANOVA test: food security (p=0.367) and sex (p=0.398) were not associated with WHZ

Table 4.3B: Height for age Z-scores of South African boys and girls aged 0-60 months stratified by food security status

	Boys			Girls		
	n	**Mean HAZ**	**95% CI**	**n**	**Mean HAZ**	**95% CI**
Overall	782	-1.06	-1.17 - -0.95	768	-1.02	-1.12 - -0.92
Food security						
Food secure	267	-0.92	-1.11 - -0.74	240	-0.91	-1.08 - -0.74
At risk of hunger	195	-1.08	-1.30 - -0.85	199	-1.03	-1.23 - -0.83
Experience hunger	320	-1.16	-1.34 - -0.99	329	-1.10	-1.26 - -0.95

2-way ANOVA with Tukey correction: Food secure vs Experience hunger (p=0.038)

Table 4.3C: BMI for age Z-scores of South African boys and girls aged >5-19 years stratified by food security status

	Boys			Girls		
	n	**Mean BAZ**	**95% CI**	**n**	**Mean BAZ**	**95% CI**
Overall	1 324	-0.18	-0.25 - -0.12	1 402	0.10	0.04 - 0.16
Food security						
Food secure	428	-0.10	-0.23 - 0.01	462	0.23	0.11 - 0.34
At risk of hunger	342	-0.22	-0.35 - -0.10	327	0.01	-0.10 - 0.14
Experience hunger	554	-0.22	-0.31 - -0.13	613	0.05	-0.03 - 0.14

2-way ANOVA with Tukey correction: Food secure vs At risk of hunger (p=0.013) and Food secure vs Experience hunger (p=0.019)

Table 4.3D: Height for age Z-scores of South African boys and girls aged >5-19 years stratified by food security status

	Boys			Girls		
	n	**Mean HAZ**	**95% CI**	**n**	**Mean HAZ**	**95% CI**
Overall	1 449	-0.91	-0.97 - -0.86	1 558	-0.76	-0.82 - -0.71
Food security						
Food secure	471	-0.77	-0.87 - -0.66	530	-0.63	-0.72 - -0.54
At risk of hunger	373	-0.99	-1.10 - -0.88	359	-0.79	-0.91 - -0.66
Experience hunger	605	-0.98	-1.06 - -0.89	669	-0.86	-0.94 - -0.77

2-way ANOVA with Tukey correction: Food secure vs At risk of hunger (p=0.004) and Food secure vs Experience hunger (p<0.001)

4.4 Discussion

4.4.1 Nutritional status of South African children: Comparison with the SANHANES-1 (2011/12) and the 2019 Atlas of Childhood Obesity

In the present study, we found that ~53% boys aged 0-24 months fell into the nutritional status categories "risk of overweight/overweight/obese", whereas among older boys aged 25-60 months, these findings were only ~30%, with a similar pattern observed among girls between both age groups. In addition, ~27% of boys aged 0-24 months were stunted/severely stunted. Among girls aged >5-19 years, almost 30% of those aged 10-19 fell into the combined nutritional status category of overweight/obese vs 17.32% in the younger age group of >5-9 years old.

According to the 2019 Atlas of Childhood Obesity (World Obesity Federation, 2019), 65% of countries reported higher rates of obesity among boys than girls aged 5-9 years. The same has been observed in 60% of countries for children aged 10-19 years. This trend has emerged in the significant majority of high-income and upper middle-income countries (Case & Menendez, 2009). In 50% of these high-income and upper-middle-income counties, the rates of obesity among boys were almost twice as that observed among girls when comparing within age groups (Case & Menendez, 2009). On the contrary, in low-medium-income countries, including South Africa, the prevalence of obesity among boys and girls is reversed (Shah *et al.*, 2020). The 2016 Obesity Atlas reported that the prevalence of obesity in South African children was 10.7% among boys and 12% for girls aged 5-9 years and, 9.4% and 13.2% for boys and girls respectively aged 10-19 years (World Obesity Federation, 2019). However, unlike Shah *et al.*, (2020) and the Obesity Atlas (2019), boys and girls were analysed separately in the present study therefore precluding the determination of any sex-specific differences with regards overnutrition.

4.4.2 Associations between food security status and anthropometric indicators

In the present study, we found that among children aged 0-60 months, food security status was not associated with WHZ but showed modest associations with HAZ (children that experienced hunger were shorter than their food secure counterparts). Among children aged >5-19 years, food security status was associated with BAZ (children and adolescents who experienced hunger and those that were at risk of hunger were thinner than their food secure counterparts). Among children aged >5-19 years, food security status was associated with HAZ (children and adolescents who experienced hunger and those that were at risk of hunger were shorter than their food secure counterparts). Our analyses only showed unadjusted associations; therefore, these associations may be mediated by other child, adult and household-level characteristics in multivariate analyses, which were not conducted. Notwithstanding the lack of adjustments, the present study links household food insecurity with anthropometric indicators in South Africa, using a nationally representative sample of children and adolescents aged 0-19 years.

In contrast to our study, Dinku, Mekonnen and Adilu (2020) found no associations between food security status and any of the anthropometric indicators examined in their study (WHZ, HAZ, WAZ and BAZ) in a sample of children aged 6-59 months from North Central Ethiopia. In addition, Kimani-Murage (2013) also found no evidence of associations between food security status and BAZ in rural South Africa; however, child sex was a predictor of food security. In contrast, Kimani-Murage (2013) found that food security status was positively associated with WHZ (children in the "enough food security" category were heavier than those in the "not enough" category). These results may be attributable to the use of an unvalidated food security questionnaire. Lastly, Maehara *et al*., (2029) corroborated the lack of associations between food security and nutritional status of children aged 12-18 years in Indonesia when using BAZ and HAZ as anthropometric indicators.

In concert with our findings, Wolde *et al*., (2015) found evidence of associations between food security status and stunting/underweight (measured using BAZ and HAZ) in children aged 7-14 years. Particularly, the authors reported that mild and moderate food insecure children had greater odds of being underweight (WAZ). Only moderate food insecurity showed greater odds of wasting (BAZ). All categories of food insecurity had greater odds of stunting (HAZ), which is similar to our findings for children of all ages. Moreover, Betebo *et al*., (2017) demonstrated that food insecurity status was associated with underweight and stunting but not wasting among children aged 6-69 months. This study also adjusted for health status of the mother during pregnancy and antenatal care which showed associations with child nutritional status beyond maternal, child and household-level sociodemographic characteristics. Lastly, in Brazil, Kac *et al*., (2012) reported lack of associations between WHZ scores and food security among children aged 0-60 months, a finding that is similar to that observed in the present study. Furthermore, Kac *et al*., (2012) hold that a potential explanation for the lack of the positive association between food security and higher WHZ scores relies on differential stages of the nutritional transition experienced by diverse socioeconomic sub-groups and individuals at different periods of the life-cycle, during the last several decades. It has already been documented earlier that the dynamics regarding a shift from undernutrition to obesity tends to follow a pattern that usually occurs first in adults, followed by adolescents, and only later in time by children (Monteneiro *et al*., 2002). This nutrition transition pattern has been extensively documented for the Brazilian population having as reference some of the most important nationally representative surveys from the last 20 years (Monteneiro *et al*., 2002; Kac *et al*., 2003). This may also be true in the South African context and is an area for possible future research.

Chapter 5: Dietary knowledge among children aged 10-14 years, and Non-Communicable Diseases among adults in households with children

5.0 Specific objectives addressed in this chapter

1. To assess the dietary knowledge of girls and boys aged 10-14 years
2. To assess associations between food security, dietary knowledge, BAZ and HAZ scores in children aged 10-14 years
3. To ascertain the prevalence of non-communicable diseases (hypertension, stroke, heart disease and diabetes) among adults aged >19 years who live in households with children

5.1 Food security, dietary knowledge, and anthropometric indicators of malnutrition among children aged 10-14 years

Table 5.1 shows the choice of answer (by percentage) for the dietary knowledge test for each specific question among South African boys and girls. Only 13.92% of the children correctly answered that, (**option B**): brown bread, rice, samp, and mealie meal should be included the most in meals while the vast majority (47.68%) incorrectly stated that, (**option A**): meat, chicken, fish, and eggs should be included the most in meals. Most of the children (47.89%) correctly answered that, (**option E**): sugar and sweets should be most restricted in meals. Only 24.26% of the children correctly stated that, (**options C or D**): vegetables, and fruits contain lots of fibre; whilst the vast majority (46.56%) incorrectly stated that, (**option B**): brown bread, rice, samp, and mealie meal contain lots of fibre. The distribution of answers to the question "which food group best provides the body with energy" varied among the children, with 13.97% of the children correctly choosing (**option B**): brown bread, rice, samp, and mealie meal; while 23.49% incorrectly chose (**option D**): fruits, 17.81% chose (**option C**): vegetables, and 16.97% chose (**option G**): milk, maas, yoghurt, and cheese. The majority of the children (46.60%) correctly identified (**options A or G**): meat, chicken, fish, eggs, and milk, maas, yoghurt, and cheese as the food groups that best build

the body's muscles. Lastly, 52.61% of the children correctly stated that, (**options C or D**): vegetables, and fruits protect the body against illnesses. While the children's dietary knowledge was generally poor, there were no differences observed when comparing boys to girls.

Table 5.2 shows the prevalence of food security, dietary knowledge, and differences in BAZ among South African children aged 10-14 years. No differences were found in the prevalence of food security when stratifying by sex (p=0.075), school attendance (p=0.935) and relationship to the household head (p=0.173). More children from African households (42.55%) experienced hunger compared to both Coloured and White/Indian/Asian households (p<0.0001). More children from households located in informal settings experienced hunger (26.25%) compared to children from households located in formal areas (18.54%) (p=0.038), regardless of urban/rural location. The association between food security and nutritional status categories is inconclusive due to 19.5% fewer observations of food security (CCHIP scores) in this age group compared to those with complete BAZ scores. With 253 fewer observations of both CCHIP and BAZ scores, the proportion of nutritional status categories differ from the 10-14 years age group described previously in Chapter 4 (Table 4.2). Dietary knowledge was not associated with either sociodemographic parameters, or was it associated with BAZ scores.

Table 5.1: Choice of answer by percentage for the dietary knowledge test for each specific question among South African boys and girls

Which food group…	All (N=1 040) %	Girls (n=548) %	Boys (n=492) %
Q1: Should be included the most in meals?			
A	47.68	45.61	49.91
B (correct)	**13.92**	**14.07**	**13.95**
C	21.19	23.11	19.32
D	7.97	8.51	7.16
E	2.67	2.61	2.59
F	1.71	1.56	1.79
G	4.86	4.52	5.28
Q2: Should be most restricted in meals?			
A	10.63	11.09	10.22
B	11.12	9.96	12.28
C	12.61	12.75	12.37
D	5.40	5.15	5.73
E (correct)	**47.89**	**47.69**	**48.12**
F	7.34	8.47	6.09
G	5.01	4.89	5.20
Q3: Contains foods with lots of fibre?			
A	11.67	11.60	11.62
B	46.50	47.78	45.05
C or D (correct)	**24.26**	**23.89**	**24.86**
E	3.52	3.23	3.78
F	5.42	5.32	5.50
G	8.63	8.20	9.19
Q4: Best provides the body with energy?			
A	13.22	12.42	13.86
B (correct)	**13.97**	**13.12**	**14.85**
C	17.81	19.60	16.02
D	23.49	23.97	22.95
E	8.51	8.84	8.19
F	6.04	5.69	6.39
G	16.97	16.36	17.73
Q5: Best builds the body's muscles?			
A or G (correct)	**46.60**	**45.84**	**47.29**
B	13.07	12.69	13.65
C	15.33	16.19	14.20
D	11.44	12.34	10.67
E	3.67	3.67	3.62
F	9.89	9.27	10.58
Q6: Protects the body from illnesses?			
A	11.95	11.95	11.47
B	9.03	8.88	9.30
C or D (correct)	**52.61**	**52.99**	**52.48**
E	5.18	4.48	5.96
F	7.96	7.91	8.13
G	13.27	13.80	12.65

For all questions (1-6), the possible choices of food groups were **A:** Meat, chicken, fish, and eggs **B:** Brown bread, rice, samp, mealie meal **C:** Vegetables, **D:** Fruits, **E:** Sugar, sweets **F:** Fats, oils **G:** Milk, maas, yoghurt, cheese. Questions 3, 5 & 6 each have two possible correct answers, either of which was awarded one point.

Table 5.2: Prevalence of food security and dietary knowledge scores among South African children aged 10-14 years old

	Food security			p value		Dietary knowledge			p value
	Food secure	**At risk of hunger**	**Experience hunger**			**Low 0-2**	**Moderate 3-4**	**High 5-6**	
Sex, n (%)	**336 (32.31)**	**265 (25.48)**	**439 (42.21)**			**740 (71.15)**	**197 (18.94)**	**103 (9.90)**	
Male	160 (15.58)	139 (14.35)	193 (21.59)	0.075		343 (36.77)	94 (9.99)	55 (4.76)	0.879
Female	176 (15.91)	126 (9.48)	246 (23.09)			397 (33.92)	103 (10.21)	48 (4.35)	
Race, n (%)	**335 (32.34)**	**262 (25.29)**	**439 (42.37)**			**739 (71.33)**	**195 (18.82)**	**102 (9.85)**	
African	210 (24.4)	207 (21.48)	378 (42.55)			564 (62.83)	155 (17.58)	76 (8.03)	
Coloured	104 (4.48)	49 (1.97)	59 (2.17)	**<0.0001**[#]		153 (6.35)	35 (1.36)	24 (0.91)	0.467
White/Indian/Asian	21 (2.53)	6 (0.36)	2 (0.02)			22 (1.7)	5 (1.12)	2 (0.12)	
School attendance n (%)	**316 (31.95)**	**251 (25.38)**	**422 (42.67)**			**707 (71.49)**	**183 (18.50)**	**99 (10.01)**	
≤Grade 3	32 (2.45)	15 (1.51)	31 (3.56)			57 (5.41)	13 (1.36)	8 (0.76)	
Grade 4-6	127 (13.42)	115 (11.15)	195 (20.35)	0.935		301 (30.24)	88 (10.47)	48 (4.21)	0.359
≥Grade 7	157 (15.22)	121 (11.08)	196 (21.26)			349 (35.72)	82 (7.74)	43 (4.1)	
Locality, n (%)	**336 (32.25)**	**265 (25.43)**	**441 (42.32)**			**741 (71.11)**	**198 (19.00)**	**103 (9.88)**	
Urban formal	105 (15.16)	76 (8.8)	165 (14.47)			309 (27.42)	75 (7.97)	37 (3.04)	
Urban informal	43 (1.88)	150 (3.26)	30 (4.79)	**0.036**[#]		91 (6.3)	27 (2.33)	19 (1.3)	0.585
Rural formal	48 (3.12)	151 (2.48)	52 (4.07)			115 (6.09)	35 (2.21)	26 (1.37)	
Rural informal	69 (11.27)	64 (9.25)	89 (21.46)			226 (30.9)	61 (7.68)	21 (3.39)	
Relation to head n (%)	**336 (32.25)**	**265 (25.43)**	**441 (42.32)**			**741 (71.11)**	**198 (19.00)**	**103 (9.88)**	
Son/Daughter	192 (18.29)	122 (11.27)	218 (22.55)	0.173		377 (36.37)	92 (10.25)	63 (5.49)	0.442
Other	144 (13.14)	143 (12.51)	223 (22.23)			364 (34.34)	106 (9.94)	40 (3.6)	
BAZ scores Mean ± SD	0.09±1.34	-0.16±1.28	-0.18±1.17	**0.006***		-0.05±1.28	-0.24±1.22	-0.03±1.22	0.293

[#]Multiple 2 by 2 comparisons with Bonferroni post hoc **p=0.006** when comparing African vs White/Indian/Asian in Food secure vs At risk of hunger, and **p<0.001** when comparing African vs Coloured and, African vs White/Indian/Asian in both Food secure vs At risk of hunger and Food secure vs Experiencing hunger (for

race, significance was considered at p<0.008). For locality, **p<0.001** when comparing formal vs informal in food secure vs Experiencing hunger (for locality, significance was considered at p<0.004).

*Kruskal-Wallis with multiple Mann-Whitney U tests, significance set at p<0.017: When comparing BAZ in food secure vs At risk of hunger p=0.020, and **p=0.002** when comparing BAZ in food secure vs Experiencing hunger, and p=0.821 when comparing BAZ in At risk of hunger vs Experience hunger.

Associations between food security and anthropometric measurements

Figures 5.1A & 5.1B illustrate the differences in anthropometric measurements among South African children by food security status. Children from food insecure households (both at risk of hunger and experiencing hunger) were significantly shorter (lower mean HAZ scores) than those from food secure households ($p<0.05$). Furthermore, children from food insecure households (both at risk of hunger and experiencing hunger) had significantly lower mean BAZ scores compared to their food secure counterparts ($p<0.05$).

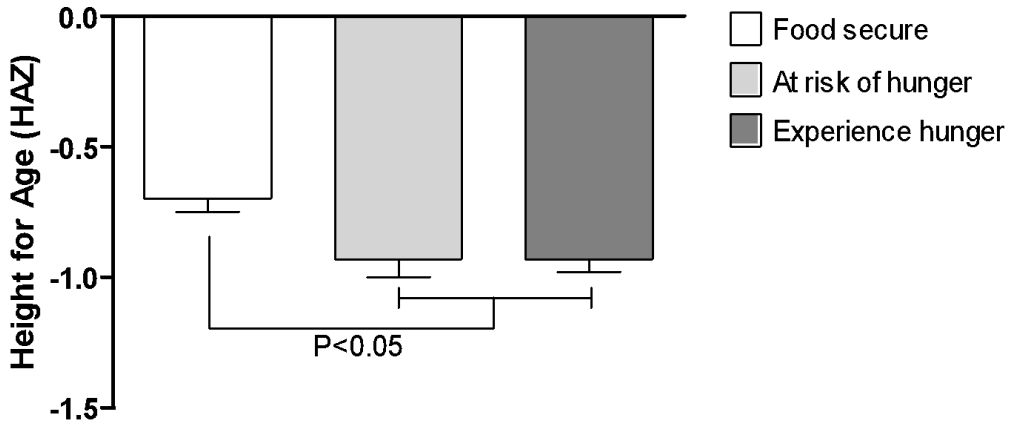

Figure 5.1A: Height for age Z-scores for boys and girls aged 10-14 years

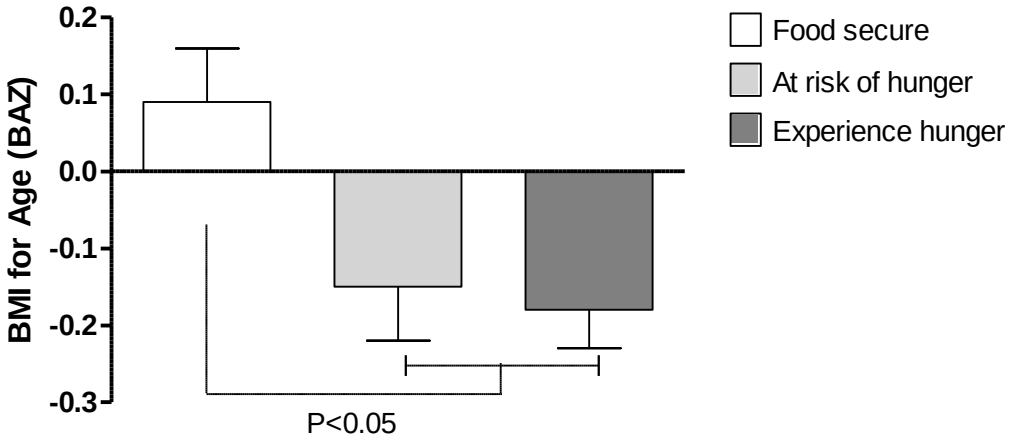

Figure 5.1B: BMI for age Z-scores for boys and girls aged 10-14 years

5.2 Association of dietary knowledge scores with BAZ scores

Figure 5.2 shows the relationship between BAZ scores and dietary knowledge among South African children aged 10-14 years. No statistically significant differences were observed in BAZ scores across categories of dietary knowledge (p=0.293).

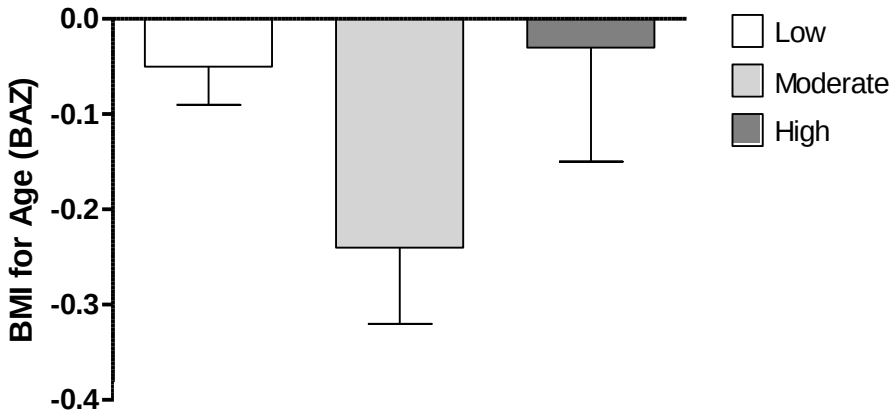

Figure 5.2: BMI for age Z-scores for boys and girls aged 10-14 years, stratified by low, moderate, and high dietary knowledge scores (p= 0.293). Data presented as mean (SEM)

5.3 Association of dietary knowledge scores with BAZ scores stratified by sex

Figures 5.3 illustrates the differences in BAZ scores in boys and girls across levels of dietary knowledge. No statistically significant differences were found in BAZ scores of South African boys and girls when stratifying by dietary knowledge (p=0.166).

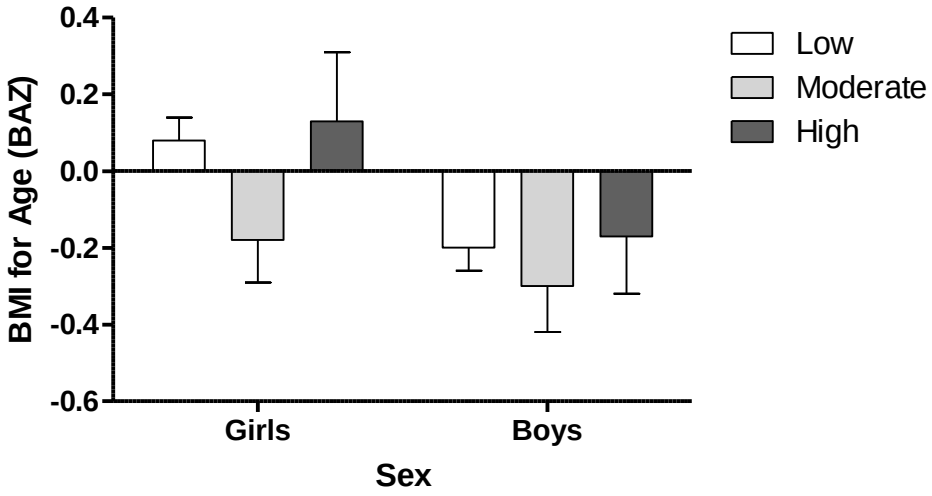

Figure 5.3: BMI for age Z-scores for boys and girls aged 10-14 years with standard error stratified by dietary knowledge scores (p=0.165). Data presented as mean (SEM)

5.4 Percentage of adults self-reporting the presence of non-communicable disease (NCD) in households with children

Table 5.3 shows the percentage of adults (aged 20-98 years, age mean±SD: 42.21±16.39, 57.88% female) who self-reported at least one NCD. From the 15 007 adults in households with children, a minimum of 13 051 responded to the questions on self-reported NCDs (minimum response rate of per question of ~87%). Of the four NCDs, hypertension was the most frequently reported (23.04%) followed by diabetes (7.59%), heart disease (3.15%), and stroke (2.56%).

Table 5.3: Percentage of self-reported NCDs among South African adults aged 20-98 years living in households with children

Response	Hypertension n=13 148	Stroke n=13 109	Heart disease n=13 086	Diabetes n=13 051
	n (%)	n (%)	n (%)	n (%)
Yes	3 029 (23.04)	336 (2.56)	412 (3.15)	991 (7.59)
No	9 855 (74.95)	12 655 (96.54)	12 476 (95.34)	11 866 (90.92)
Don't know	264 (2.01)	118 (0.90)	198 (1.51)	194 (1.49)

5.5 Discussion

In a subset of South African children aged 10-14 years, food security was associated with race and location of where they lived, whereby African children were disproportionately food insecure (at risk of hunger and experiencing hunger) compared to their Coloured and White/Indian/Asian counterparts. Food insecurity was more prevalent among children from informally located households than those in formal settings. These findings of the association of food insecurity with various demographic factors in children are similar to those affecting household food security, which is not surprising given that food security is a household level variable applying to all household members (who possibly share the same key sociodemographic characteristics such as race).

The child's biological relationship to the household head (son/daughter) did not confer a protective role against being food insecure. In addition, dietary knowledge was not associated with any sociodemographic factors of the children and nor was it associated with BAZ scores. There were no sex-specific differences with regards dietary knowledge and BAZ scores. Lastly, in line with the national prevalence of NCDs in South Africa (Department of Health Replublic of South Africa, 2018), hypertension was the most frequently reported NCD among adults living in households with children, followed by diabetes, heart disease and stroke.

The importance of food insecurity becomes more apparent when considering its associations with adverse health outcomes (Gundersen & Ziliak, 2015). For example, individuals from food insecure households appear to show poorer physical fitness, anxiety or depressive symptoms, lower self-esteem, and poorer general mental health status (Gundersen & Ziliak, 2015; Martin *et al.*, 2015). In fact, children living in food insecure households are more likely to suffer social distress, poorer quality of life, and poor academic success (Child, 2005; Roncarolo and

Potvin, 2016; Coleman-Jensen *et al.*, 2019). In the literature, researchers therefore have referred to food insecurity as "a symptom of a complex and multidimensional social disorder" (Roncarolo & Potvin, 2016).

Moreover, in the United States and South Africa, the burden of household food insecurity is not spread evenly, since this burden is overwhelmingly high among historically disadvantaged racial/ethnic groups (Coleman-Jensen *et al.*, 2019; Odoms-young & Sciences, 2019; Seivwright, Callis & Flatau, 2020; Sell & Zlotnik, 2010). Despite the fact that food poverty had returned to pre-recession levels in 2018 (Martin *et al.*, 2015), households led by Black/African heads were still overwhelmingly impacted by food insecurity (Sell & Zlotnik, 2010), with 21.2% and 16.2%, respectively, compared to the national average of 11.1%. Food insecurity has a nuanced association with race and locality since it is intertwined with other risk factors like education and unemployment (Setiono *et al.*, 2019; Martin *et al.*, 2015). Research has indicated that a significant predictor of their higher food insecurity rates is the concentration of social and economic deficits (preponderance of socioeconomic disadvantage) among racial/ethnic groups and worsens with rural/informal locality (Raskind, Haardorfer & Berg, 2019). Food insecurity and hunger are significant issues globally, as demonstrated by their importance on the public health agenda (Raskind, Haardorfer & Berg, 2019; Odoms-young & Sciences, 2019; Seivwright, Callis & Flatau, 2020). By 2030, the Sustainable Development Goal (SDG) 2.1 seeks to “end hunger and ensure access to healthy and adequate food for all people, including the poor and vulnerable, and children (Case & Menendez, 2009). There is, moreover, a need to explore the root causes of food insecurity in order to achieve these goals.

In our data, we found that South African children had poor dietary knowledge. There were no discernible differences in dietary knowledge among boys and girls. Dietary knowledge also did

not improve or worsen among older children compared to younger children. Dietary knowledge was not associated with any sociodemographic factors nor was it associated with anthropometric indicators of malnutrition. More specifically, South African children performed poorly on the question pertaining to the consumption of carbohydrates; whereby, only 13.92% correctly answered that brown bread, rice, samp and mealie meal should be included the most in meals. Unsurprisingly, the vast majority (47.68%) of children incorrectly answered that meat, chicken, fish, and eggs should be included the most in their meals. We surmise that this answer might be heavily influenced by a strong African culture of prioritising meat over other food options (Taljaard, Jooste & Asfaha, 2006). Furthermore, this may mean that South African children are ill informed of the nutritional value of complex carbohydrates and would rather attribute more value to food options containing meat perhaps because meat seems to be the option most favoured by adults in their households and is almost always included in every meal. Almost half (47.89%) of the children were aware that fats and oils should be most restricted in their meals. This finding may be explained, in part, by the enduring vast amounts of knowledge in society, which has vilified and implicated fats in weight gain and the development of adverse cardiometabolic diseases (Wang & Hu, 2017). Only 24.26% of the children correctly (according to the correct answers supplied by the SANHANES-1) stated that vegetables and fruits contain lots of fibre whilst the vast majority (46.56%) *incorrectly* stated that brown bread, rice, samp, and mealie meal contain lots of fibre. We believe, however, that the children correctly chose brown bread, rice, samp, and mealie meal as foods containing lots of fibre. This food option contains complex carbohydrates, of which, fibre is one (Palmer, 1990). Perhaps the language used in this specific question was too advanced for children to understand. Moreover, there are other alternative terms that refer to fibre, such as, roughage. In addition, the food group display card should include more obvious sources of fibre,

such as, whole grains, nuts, seeds, and legumes. The majority of the children (46.60%) correctly identified meat, chicken, fish, eggs; and, milk, maas, yoghurt, and cheese as the food groups that best build the body's muscles. Ke and Ford-Jones, (2015) studied the intake of dairy products in developing countries and found that girls eat less milk than recommended because they believe it induces weight gain and because their parents either do not consume milk or encourage their children to do so, among other factors (Altman *et al.*, 2010). In the African context, particularly among Black/African households, girls are discouraged from consuming dairy products because dairy is believed to hasten the development of secondary sexual characteristics (*personal observation*). Additional evidence shows that in South Africa the prevalence of true cow's milk allergy (CMA) is hard to ascertain. No accurate figures are available for the South Africa population (du Toit *et al*., 2010). Globally, it is believed that 2% of children under the age of two are truly allergic to cow's milk; and, in adults, CMA is rare. The prevalence of lactose intolerance in the USA is estimated at 11.03%, with higher rates among African Americans and Asians (du Toit *et al*., 2010).

Early adolescence (age 10-14 years) is a transformation period where behaviours that endure into adult life are established (Shah *et al.*, 2020). Exercise and a balanced diet are likely to have several advantages, including better academic performance (Raskind, Haardorfer & Berg, 2019). Nutritional patterns are significant among the top 20 risk factors of disability-adjusted life years (DALYs) worldwide, with high consumption of refined, energy-dense foods, high BMI, and iron deficiency (Nugent *et al.*, 2020). These conditions raise threats to NCDs in adulthood, which are responsible for two out of every three deaths worldwide (Prevention, Division and Health, 2010). In terms of diet and physical exercise, gender roles are often more detrimental than helpful (World Bank, 2018; Costa *et al.*, 2017; Ngema, Sibanda & Musemwa, 2018; Felker-Kantor &

Wood, 2012). Girls are more likely than boys to be subjected to a culture of overdieting and inappropriate weight loss, and many feel that fitness is unfeminine and athletic women are masculine (Swindale & Bilinsky, 2006; Mutisya *et al.*, 2016). Kirkpatrick, McIntyre and Potestio, (2010) found that girls favour body appearance over wellbeing. While media, parents and peers can promote negative images, they can also help in implementing better alternatives to weight loss and diet (Sell & Zlotnik, 2010; Martin *et al.*, 2015; Jones & Ejeta, 2016). Erskine, Whiteford and Pike, (2016) have demonstrated that while the rates of eating disorders such and anorexia and bulimia nervosa (as indexed by age-standardised DALYs) continue to rise in the Global North, the prevalence is increasing in LMICs. In a study by Mchiza *et al.*, (2015) it appears as though South Africa is a nation that is either biased in terms of its body image or simply has inaccurate perception of body size, judging from the fact that 84.5% of South Africans aged 15+ years either under- or over-estimate their body size. Additionally, Pedro *et al.*, (2016), in exploring the qualities that male and female rural South African teenagers ascribe to female silhouettes of varying body sizes, found that the majority of teenagers linked the overweight/obese phenotype with positive qualities such as greater respect, being the strongest, and being the happiest; whereas the underweight silhouette was associated with mainly negative attributes such as weakness and unhappiness. This is most likely related to the sociocultural context of African ideal beauty standards persisting in rural areas. It is important to note, however, that rates of eating disorders, such as anorexia nervosa and bulimia, while increasing in the Global North, are also becoming more prevalent in LMICs, likely due to exposure of adolescent women to the influences of "Western media" (Erskine, et al., 2016).

Chapter 6: Summary of findings, limitations, recommendations, and conclusions

6.1 Summary of findings

The present work has elucidated the health and nutritional status of South African children in the context of their immediate household environments at a national scale. This work provides a comprehensive analysis of the drivers of food insecurity in households with and without children. We looked at associations between food security and anthropometric indicators of malnutrition in children aged 0-19. We also explored associations between food insecurity and dietary knowledge with anthropometric indicators of malnutrition in children aged 10-14. Lastly, the findings shed light on the presence of self-reported NCDs among adults living in households with children. Subsequent to the SANHANES-1, no other national survey has used the CCHIP index as an instrument to measure food insecurity of children at household level. The National Income Dynamics Survey-Corona Virus Rapid Mobile Survey (NIDS-CRAM) and the 2016 Demographic and Health Survey (DHS) explored the inability to satisfy food needs "in the past 12 months" with a single question; whereas, the SANHANES-1, in using the CCHIP index, employed an experienced-based hunger scale that documents the context and loci within which food insecurity exists. This more accurately reflects the FAO comprehensive description of food security encompassing the four dimensions, namely: Availability, Accessibility, Utilization, and Stability, of which, all four of these domains must be intact for full food security, in accordance with the Food and Agriculture Organisation (Food and Agriculture Organization, 2006).

The household environment was explored in various contexts. Firstly, we determined the national prevalence of household food insecurity, with particular attention to households with children, the unit of analysis for the present study. We found that the presence of children in these households confers ~1.68 greater odds of food insecurity compared to households without children. Additional risks for food insecurity were bigger household size and informal location

(regardless of whether rural or urban). Furthermore, the household head's sociodemographic characteristics that increased the risk of food insecurity were African female and living together/civil unions and never married. In line with previous work (Ruiters and Wildschutt, 2010), we show that government-assisted social grants and remittances do not confer a protective role against food insecurity. In fact, households that relied on social grants, pensions and/or remittances had two folds greater odds of being food insecure while lack of income increased the risk of being food insecure by at least three-fold. Lastly, the non-Black/African racial minorities (Coloured and White/Indian/Asian) and secondary/tertiary/higher educational attainment conferred protection against being food insecure. A clear message from these findings is that food insecurity is pervasive in South Africa, particularly among historically disadvantaged groups.

We also found differences in the prevalence of WHZ, BAZ and HAZ scores for South African children (0-19 years old) in comparison to the WHO's child growth norms for both younger children (0-60 months) and older children (>5-19 years). Importantly, children >5-19 years from households that were food insecure (both at risk of hunger and those that experienced hunger) were thinner (had lower BAZ scores). Children aged 0-60 months who experienced hunger were shorter (had low HAZ scores) than children from households that were food secure. For older children (>5-19 years), all the children's HAZ scores were significantly lower in children that experienced hunger and those that were at risk of hunger. In children aged 0-60 months, food security was not associated with WHZ scores but was modestly associated with HAZ.

In a sub-cohort of girls and boys aged 10-14 years, we show that South African children have poor nutritional knowledge. It was important to study children in this age group because early adolescence (10-14 years) may represent a critical period in development where feeding habits are established that go on to shape children's lives in adulthood, increasing the risk of chronic disease.

A clear message from these findings is that South African children are ill informed about the nutritional value of complex carbohydrates, fats and oils, and fibre. We posit that the children's dietary knowledge may reflect a strong African culture of prioritising meat over other food options (Taljaard, Jooste & Asfaha, 2006) which was evidenced by the finding that most children incorrectly stated that meat should be included in meals in large quantities. The children's dietary knowledge lacked independent associations with anthropometric indicators of malnutrition, but their residential locality and race remained associated with food insecurity as previously highlighted in other age groups. Among adult members living in households with children, hypertension was the most frequently self-reported NCD, followed by diabetes, heart disease, and stroke. With almost one out of four adults having an NCD, children are being exposed to the presence of nutritionally related health outcomes.

6.2 Limitations

The present study is not without limitations. Firstly, the SANHANES-1 was conducted in 2011/12, and the data are at least eight years old and may not reflect the current status of food security in South Africa. Secondly, we used educational status, the primary source of household income and, location (formal vs informal) as indicators of household economic stability; yet there exist more comprehensive measures of socioeconomic status which could add greater granularity to our understanding. Thirdly, biological relationships of household members were not captured for all household occupants (adults and children) limiting the results of the multivariate analyses for the whole sample. For children aged >5-19 years, the WHO growth norms (2007) may not provide a suitable reference for South African children. In addition, when considering the relationship between food security and anthropometric indicators (especially the WHZ), we did not adjust for maternal characteristics and feeding practices. Finally, since the presence of NCDs

was not assessed objectively through physical examination and laboratory tests, this might have affected the accuracy of reporting.

6.3 Recommendations

The findings obtained in the present study, the first wave of the SANHANES-1, explicitly confirm that South African children face a major challenge of food insecurity and malnutrition that is fuelled by a number of risk factors, necessitating multi-sectoral intervention and healthy public policies including the need to focus on the social determinants of health. Regarding the 10–14-year-old age group (early adolescence), which has poor nutritional knowledge, and which precedes the onset of the differences in nutritional outcomes, a critical window of opportunity might exist to target malnutrition in all its forms. Nutritionists and dieticians could be incorporated into schools to implement dietary approaches such as reviewing the National School Feeding Scheme (NSFS) as well as developing appropriate curricula, together with better physical education programmes. Alongside the 2020 Child Health Gauge (South African Child Gauge, 2020), we advocate for stronger social protections, for example increasing the value of the Child Support Grant, for households with heads who are African, female, unmarried, and living in informal settings.

6.4 Conclusions

This secondary analysis of the SANHANES-1 data points to the continued vulnerability of children and their female caregivers to the risks of food insecurity and poor nutritional status, with implications across the life course. This is in line with other South African research, including the finding that social grants may not be fully protective against hunger in childhood. Teenagers have poor nutritional knowledge, which also impacts better food choices in late adolescence and into adulthood. The low self-reporting of NCDs in this adult sample is surprising but is perhaps indicative of people being unaware of their chronic health problems. These findings point to the

need for renewed efforts to address the constitutional *right to food and basic nutrition*, and other social determinants of health, for South African children and the households they inhabit.

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Appendices

1. **Data sharing agreement**

Human Sciences Research Council
Lekgotla la Dinyakisišo tša Semahlale tša Setho
Raad vir Geesteswetenskaplike Navorsing
Umkhandlu Wezokucwaninga Ngesayensi Yesintu
Ibhunga Lophando Ngenzulu-Lwazi Kantu

South African National Health and Nutrition Examination Survey

CONFIDENTIALITY AGREEMENT
For supply of confidential
South African National Health and Nutrition Examination

Survey data

Agreement between

THE HUMAN SCIENCES RESEARCH COUNCIL

A statutory body established in terms of the Human Sciences Research Council Act, No. 17of 2008
("the HSRC")

South African National Health and Nutrition Examination Survey (SANHANES)

and
The University of the Witwatersrand, Johannesburg,
and
Prof Laurel Baldwin-Ragaven,
and
Mr Siluleko Mkhize,
and
Prof Elena Libhaber

2. Visiting point (household) questionnaire

Visiting Point Questionnaire Number: _____

DFID health HSRC MRC

THE SOUTH AFRICAN NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY, 2011/2012

(SANHANES-1)

Visiting Point Questionnaire

A. Geographic Particulars

Province								
Enumerator area (EA)								
Visiting point (VP) number (taken from map)								
Visiting point (VP) address	C	O	D	E				

B. Number of Households at Visiting Point

Draw a diagram of the visiting point / stand. If more than one household is present, indicate how many separate households are resident at this visiting point. Allocate a number to each household and use the Kish grid to select only one household

Number of households at visiting point

The assigned 'number' of the selected household

C. Interview Details

	Year	Month		Day		Time code	Response code
First visit	2012						
Second visit	2012						
Third visit	2012						
Fourth visit	2012						
Fifth visit	2012						
						Final response code	

Time code
1 = Morning till 12h00
2 = 12h01-15h00
3 = 15h01-18h00
4 = 18h01-21h00
5 = 21h01 and later

Response code
1 = Interview completed
2 = Interview partly completed and another appointment made
3 = Appointment made for interview
4 = Not a valid visiting point
5 = No one living here (unoccupied)
6 = No one at home
7 = No one at home for duration of the survey
8 = Refusal by household head
9 = No one to consent (specify).....
10 = Incapacitated (specify).....
11 = Other (Specify).....

Fieldworker	Name							
	Staff number							
Interview starting time:				H	H	:	M	M

2.1 Childhood Hunger Identification Project (CCHIP Index)

SECTION B – 2	HUNGER SCALE		
NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
6a	Does your household ever run out of money to buy food?	Yes ..... 1 No 2	➢7a
6b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢7a
6c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
7a	Do you ever rely on a limited number of foods to feed your children because you are running out of money to buy food for a meal?	Yes ..... 1 No 2	➢8a
7b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢8a
7c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
8a	Do you ever cut the size of meals or skip meals because there is not enough money for food?	Yes ..... 1 No 2	➢9a
8b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢9a
8c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
9a	Do you ever eat less than you should because there is not enough money for food?	Yes ..... 1 No 2	➢10a
9b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢10a
9c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
10a	Do your children ever eat less than you feel they should because there is not enough money for food?	Yes ..... 1 No 2	➢11a
10b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢11a
10c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
11a	Do your children ever say they are hungry because there is not enough food in the house?	Yes ..... 1 No 2	➢12a
11b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢12a
11c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
12a	Do you ever cut the size of your children's meals or do they ever skip meals because there is not enough money to buy food?	Yes ..... 1 No 2	➢13a
12b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢13a
12c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	
13a	Do any of your children go to bed hungry because there is not enough money to buy food?	Yes ..... 1 No 2	➢14a
13b	Has it happened in the past 30 days?	Yes ..... 1 No 2	➢14a
13c	Has it happened 5 or more days in the past 30 days?	Yes ..... 1 No 2	

3. Child questionnaire

BARCODE

Individual Questionnaire Number: _____

DFID health HSRC SAMRC

THE SOUTH AFRICAN NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY, 2011/2012

(SANHANES-1)

Child Questionnaire: 0 - 14 years

(to be completed in an interview with the parent/ guardian)

1. Geographic and Interview Particulars	
Province	
Enumerator area (EA)	
Visiting point number (taken from the EA map)	
Visiting point questionnaire number	
Person number of participant	

2. Interview Details	Year	Month	Day	Time code	Response code
First visit	2012				
Second visit	2012				
Third visit	2012				
Fourth visit	2012				
			Final response code		

Time codes
1 = Morning till 12h00
2 = 12h01-15h00
3 = 15h01-18h00
4 = 18h01-21h00
5 = 21h01 and later

Response codes
1 = Interview completed and clinic appointment made
2 = Interview completed but NO clinic appointment made
3 = Partly completed
4 = Appointment made for interview
5 = Selected participant not at home
6 = Refusal by participant / parent / guardian
7 = Other (Specify) .....

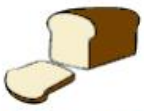
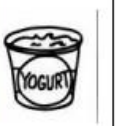
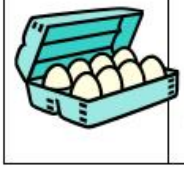
Fieldworker	**Name**	
	Staff number	
Interview starting time		H H : M M

1

3.1 Dietary knowledge questionnaire

Section J	DIETARY KNOWLEDGE (10-14 YEARS)	
	I am going to ask you questions about what you know about different foods and what you like to eat.	
1	Which food group do you think **Record a response for each question**	1. Should be included in most meals ☐ 2. Should be most restricted in meals ☐ 3. Contains foods with lots of fibre ☐ 4. Best provides the body with energy ☐ 5. Best builds the body's muscles ☐ 6. Protects the body against illnesses ☐

3.2 Food group display card

Meat, Chicken, Fish, Eggs	Brown Bread, Rice, Samp, Mealie meal	Vegetables	Fruit	Sugar, Sweets	Fats, oils	Milk, Maas, Yoghurt, Cheese
A	B	C	D	E	F	G
						
						
						
						

4. Child clinical examination form

Clinical Examination Form Number: C.....

THE SOUTH AFRICAN NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY, 2011/2012

(SANHANES-1)

Child Clinical Examination Form: 0 – 14 years

Examination Date | D | D | M | M | Y | Y | Y | Y |

Time of arrival | H | H | : | M | M |

Time of departure | H | H | : | M | M |

PASTE APPOINTMENT CARD HERE

Page | 1

4.1 Child anthropometric measurements

B. Examination Checklist			Completed		If No, Specify why not
Section A - E	Doctor	History and clinical examination	Y	N	
	Doctor	Blood pressure and pulse rate	Y	N	
Section F	Clinic Assistant	Weight	Y	N	
	Clinic Assistant	Height	Y	N	
	Clinic Assistant	Mid upper arm circumference	Y	N	
	Clinic Assistant	Head circumference	Y	N	
	Clinic Assistant	Waist circumference	Y	N	
	Clinic Assistant	Hip circumference	Y	N	
	Clinic Assistant	Triceps Skinfold	Y	N	
	Clinic Assistant	Sub scapular Skinfold	Y	N	
Section G	Nurse	Blood collection	Y	N	

5. Adult questionnaire

BARCODE

Individual Questionnaire Number: _____

DFID health HSRC MRC

THE SOUTH AFRICAN NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY, 2011/2012

(SANHANES-1)

Adult Questionnaire: 15 years and older

1. Geographic and Interview Particulars								
Province								
Enumerator area (EA)								
Visiting point Number (taken from the EA map)								
Visiting point questionnaire number								
Person number of respondent								

2. Interview Details	Year	Month		Day		Time code	Response code
First visit	2012						
Second visit	2012						
Third visit	2012						
Fourth visit	2012						
					Final response code		

Time codes	**Response codes**
1 = Morning till 12h00 2 = 12h01-15h00 3 = 15h01-18h00 4 = 18h01-21h00 5 = 21h01 and later	1 = Interview completed and clinic appointment made 2 = Interview completed but NO clinic appointment made 3 = Partly completed 4 = Appointment made for interview 5 = Selected respondent not at home 6 = Refusal by respondent / parent / guardian 7 = Other (Specify) .....

Fieldworker	**Name**							
	Staff number							
Interview starting time				H	H	:	M	M

5.1 Adult non-communicable diseases

SECTION B	NON COMMUNICABLE DISEASES

THE NEXT SET OF QUESTIONS DEAL WITH CHRONIC DISEASES OF LIFESTYLE

SECTION B-1	CARDIOVASCULAR DISEASE

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
2	Has a doctor or nurse or health worker at a clinic or hospital told you that you have or have had any of the following conditions:		
2a	High blood Pressure	Yes ..... 1 No ..... 2 Don't know 3	
2b	Stroke	Yes ..... 1 No ..... 2 Don't know 3	
2c	Heart disease	Yes ..... 1 No ..... 2 Don't know 3	

SECTION B-2	DIABETES

NO.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
4	Have you ever been told by a doctor or other health professional that you have high blood sugar or sugar diabetes?	Yes ..... 1 No ..... 2 Don't know 3	 ➢B-3 ➢B-3

6. Adult clinical examination form

Clinical Examination Form Number: A .....

DFID health HSRC SAMRC

THE SOUTH AFRICAN NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY, 2011/2012

(SANHANES-1)

Adult Clinical Examination Form: 15 years and older

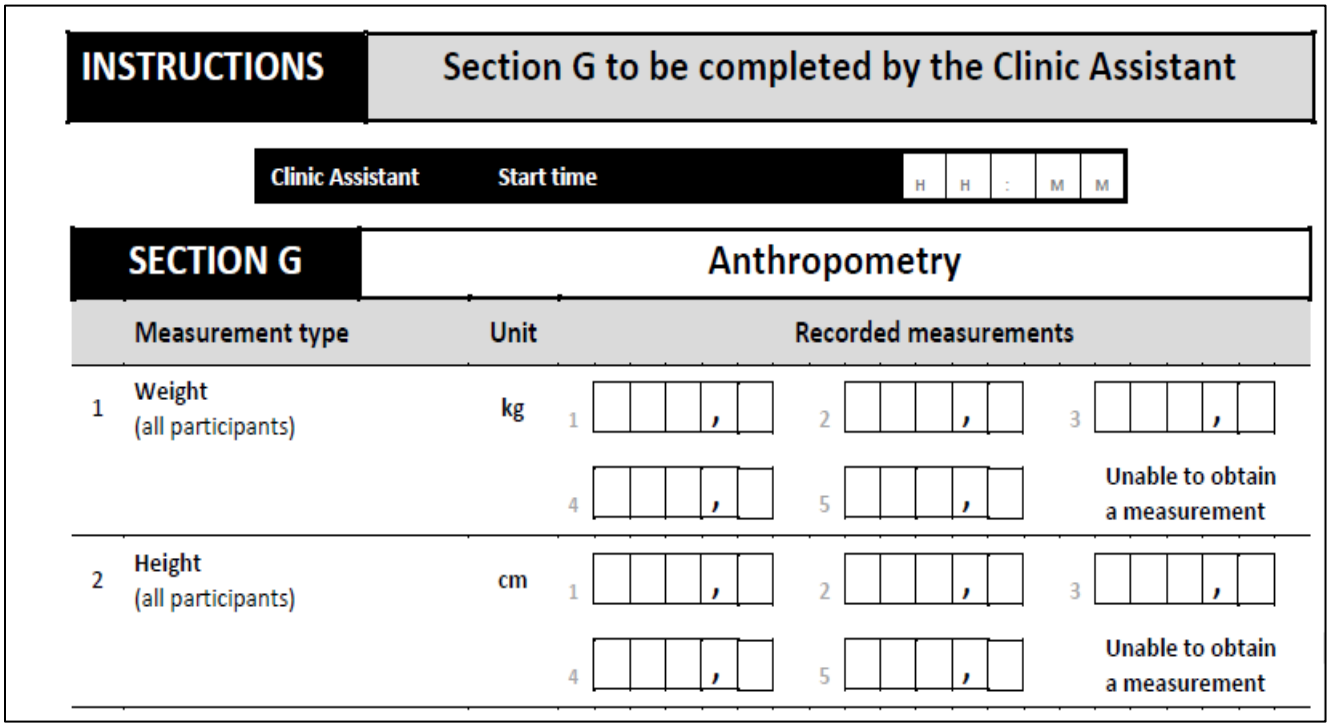
Examination Date D D M M Y Y Y Y

Time of arrival H H : M M

Time of departure H H : M M

PASTE APPOINTMENT CARD HERE

6.1 Adult anthropometric measurements



INSTRUCTIONS | Section G to be completed by the Clinic Assistant

Clinic Assistant | Start time | H H : M M

SECTION G | Anthropometry

	Measurement type	Unit	Recorded measurements
1	Weight (all participants)	kg	1 , 2 , 3 , 4 , 5 , Unable to obtain a measurement
2	Height (all participants)	cm	1 , 2 , 3 , 4 , 5 , Unable to obtain a measurement

7. First manuscript (submitted to PLOS ONE)

Childhood food insecurity in South Africa: a household-level analysis of hunger

Siluleko A. Mkhize[1], Elena Libhaber[2], Ronel Sewpaul[3], Priscilla Reddy[3,4] and Laurel Baldwin-Ragaven[1]

[1]Department of Family Medicine and Primary Care, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

[2]School of Clinical Medicine and Health Sciences Research Office, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

[3]Health and Wellbeing, Human and Social Capabilities, Human Sciences Research Council, Cape town, South Africa

[4]Faculty of Health Sciences, Nelson Mandela University, Port Elizabeth, South Africa

---

Corresponding author: Professor Laurel Baldwin-Ragaven, University of the Witwatersrand, 29 Princess of Wales Terrace, Parktown, Johannesburg, 2193

Telephone: 011 717 2058

Email: laurel.baldwin-ragaven@wits.ac.za

Acknowledgements

The authors acknowledge Dr Innocent Maposa for his assistance with data analysis. SM acknowledges the South African National Research Foundation for financial support of his postgraduate studies which enabled him to pursue this research.

Data availability statement

Access to the data was granted through a data sharing agreement with the Human Sciences Research Council (HSRC), the entity that conducted the SANHANES survey. The SANHANES adult data are available through registered access from the HSRC data repository at http://curation.hsrc.ac.za/Datasets-XKAHAA.phtml. The other data-subsets are under third

datasets can be obtained by contacting Ronel Sewpaul at rsewpaul@hsrc.ac.za. The final dataset used in this study is available upon request to the corresponding author.

Conflicts of interest

None declared

Contributions

SM, LBR and EL conceptualised the study and its design. SM, EL, LBR and RS conducted and interpreted the analyses. SM wrote the first draft of the manuscript; and, EL LBR and RS worked on subsequent iterations of the manuscript. RS and PR critically revised the manuscript for important intellectual content. All authors approved the final manuscript and take primary responsibility for its contents. The contents of the manuscript are solely the responsibility of the authors and do not necessarily represent the official views of the HSRC or the University of the Witwatersrand, Johannesburg, South Africa.

ORCID

Siluleko Mkhize https://orcid.org/ 0000-0002-8351-6891

Elena Libhaber https://orcid.org/ 0000-0002-7043-4002

Laurel Baldwin-Ragaven https://orcid.org/ 0000-0002-6744-3768

Ronel Sewpaul https://orcid.org/ 0000-0002-2523-1222

Priscilla Reddy https://orcid.org/ 0000-0002-0432-9060

Childhood food insecurity in South Africa: a household-level analysis of hunger

Abstract

Food insecurity impacts childhood nutritional status, physical and cognitive development, and increases lifetime risk for chronic disease. Previous South African studies have examined hunger at sub-national level without a specific focus on children. We therefore determined the national prevalence of childhood food insecurity and identified factors associated with hunger within the household. Individual and household-level data were extracted from the South African National Health and Nutrition Examination Survey (SANHANES-1). Prevalence of food insecurity was assessed using the Community Childhood Hunger Identification Project (CCHIP) index. Multinomial logistic regression analyses were conducted on all households (with and without children) to determine the predictors of food insecurity. Of 5 098 households surveyed, 68.6% had children (0-19 years). Of the households with children, 32.5% [95% CI (29.5 – 35.7)] were experiencing hunger and 26.3% [95% CI (23.9 – 28.8)] were at risk of hunger. Among all the households, significant associations for households experiencing hunger were the presence of children: AOR [95% CI]: 1.68 [1.12 – 2.53]; being female-headed: AOR [95% CI]: 1.53 [1.21 – 1.94] and informally-located; AOR [95% CI]: 1.61 [1.07 – 2.43]. Having a non-African household head, Coloured: AOR [95% CI]: 0.29 [0.19 – 0.44] and White/Indian/Asian: 0.12 [0.04 – 0.33] were protective against experiencing hunger and, as well as the household head having secondary/tertiary education being protective for experiencing hunger; AOR [95% CI]: 0.40 [0.28 – 0.56] and being at risk of hunger; AOR [95% CI]: 0.69 [0.52 – 0.92]. Receiving social grants or remittances more than doubled the risk of experiencing hunger; AOR [95% CI]: 2.15 [1.49 – 3.09]. In summary, only 41% of South African households with children were food secure. This indicates a critical need to bolster sustainable food systems for households with children whose heads are either female or African, informally located and dependent on social grants.

Keywords: children, household, food insecurity, hunger, CCHIP index, South Africa, SANHANES

8. Second manuscript (in preparation)

Food insecurity was independently associated with the double burden of malnutrition in South African households with children

Siluleko A. Mkhize[1], Laurel Baldwin-Ragaven[1], Ronel Sewpaul[3] and Priscilla Reddy[3,4] and Elena Libhaber[2]

[1]Department of Family Medicine and Primary Care, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

[2]School of Clinical Medicine and Health Sciences Research Office, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

[3]Health and Wellbeing, Human and Social Capabilities, Human Sciences Research Council, Cape town, South Africa

[4]Faculty of Health Sciences, Nelson Mandela University, Port Elizabeth, South Africa

---

Corresponding author: Professor Laurel Baldwin-Ragaven, University of the Witwatersrand, 29 Princess of Wales Terrace, Parktown, Johannesburg, 2193

Telephone: 011 717 2058

Email: laurel.baldwin-ragaven@wits.ac.za

Running title: Food insecurity and the double burden of malnutrition

Word count: 3274

Number of figures: 4

Number of tables: 4

Abstract

Background: Household food insecurity exerts differential effects in children compared to adults, especially women. Among women, food insecurity has been associated with overweight/obesity; conversely, food insecurity portends undernutrition in children. By corollary, it follows that food insecure households with children are faced with a double whammy of colliding nutritional outcomes; the double burden of malnutrition. However, factors contributing to this paradox have not been adequately elucidated. **Aim:** Therefore, we interrogated whether household food insecurity was independently associated with the double burden of malnutrition, beyond sociodemographic factors. **Methods:** From the first wave of the South African National Health and Nutrition Examination Survey (SANHANES-1, 2011/12), we extracted anthropometric and sociodemographic data of adults (n=4 214) and children (n=6 905) from (n=3 499) households. Using BMI, BMI-for-Age (BAZ) and Height-for-Age (HAZ) z-scores we defined households as either eutrophic, stunting/underweight, overweight/obese or double burdened. Categorical variables were compared with Chi-Square tests and continuous variables were compared using a Kruskal-Wallis test with Tukey *post hoc* procedure. Associations were computed using weighted univariable and multivariable multinomial logistic regression analyses. **Results:** In univariable analyses, stunting/underweight and overweight/obese was present in households that were at risk of hunger; OR [95% CI]: 2.02 [1.21-3.35, p=0.006] and OR [95% CI]: 1.53 [1.18-1.99, p=0.001], respectively. Experiencing hunger was associated with all levels of nutritional status, namely: stunting/underweight; OR [95% CI]: 2.99 [1.75-5.13, p<0.001], overweight/obese; OR [95% CI]: 1.64 [1.26-2.13, p<0.001] and double burden of malnutrition; OR [95% CI]: 2.65 [1.79-3.92, p<0.001]. In multivariable analyses adjusting for all sociodemographic characteristics of the heads of households; only overweight/obesity was persistently associated with households that were at risk of hunger; AOR [95% CI]: 1.37 [1.03-1.81, p=0.027]. Likewise, experiencing hunger was independently associated with the double burden of malnutrition; AOR [95% CI]: 1.65 [1.11-2.43, p=0.012]. **Conclusion:** Our findings emphasize the vulnerability of households with children to both food insecurity and its inevitable adverse health outcomes. More pertinently, our data suggests that food insecurity is an antecedent to contrasting forms of nutritional outcomes at the household level; and therefore, necessitates the adoption of double-duty actions to combat both under- and overnutrition simultaneously.

9. Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Mr Siluleko Mkhize et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180775

NAME: (Principal Investigator)	Mr Siluleko Mkhize et al
DEPARTMENT:	Family Medicine and Primary Care
PROJECT TITLE:	Food security, socioeconomic status, dietary knowledge and body mass index of children: a secondary analysis of the South African National Health and Nutrition Examination Survey (SANHANES-1)
DATE CONSIDERED:	27/07/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Laurel Baldwin-Ragaven
APPROVED BY:	Professor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	20/08/2018

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 on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized 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 the application 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 reviewed in July and will therefore be due in the month of July each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

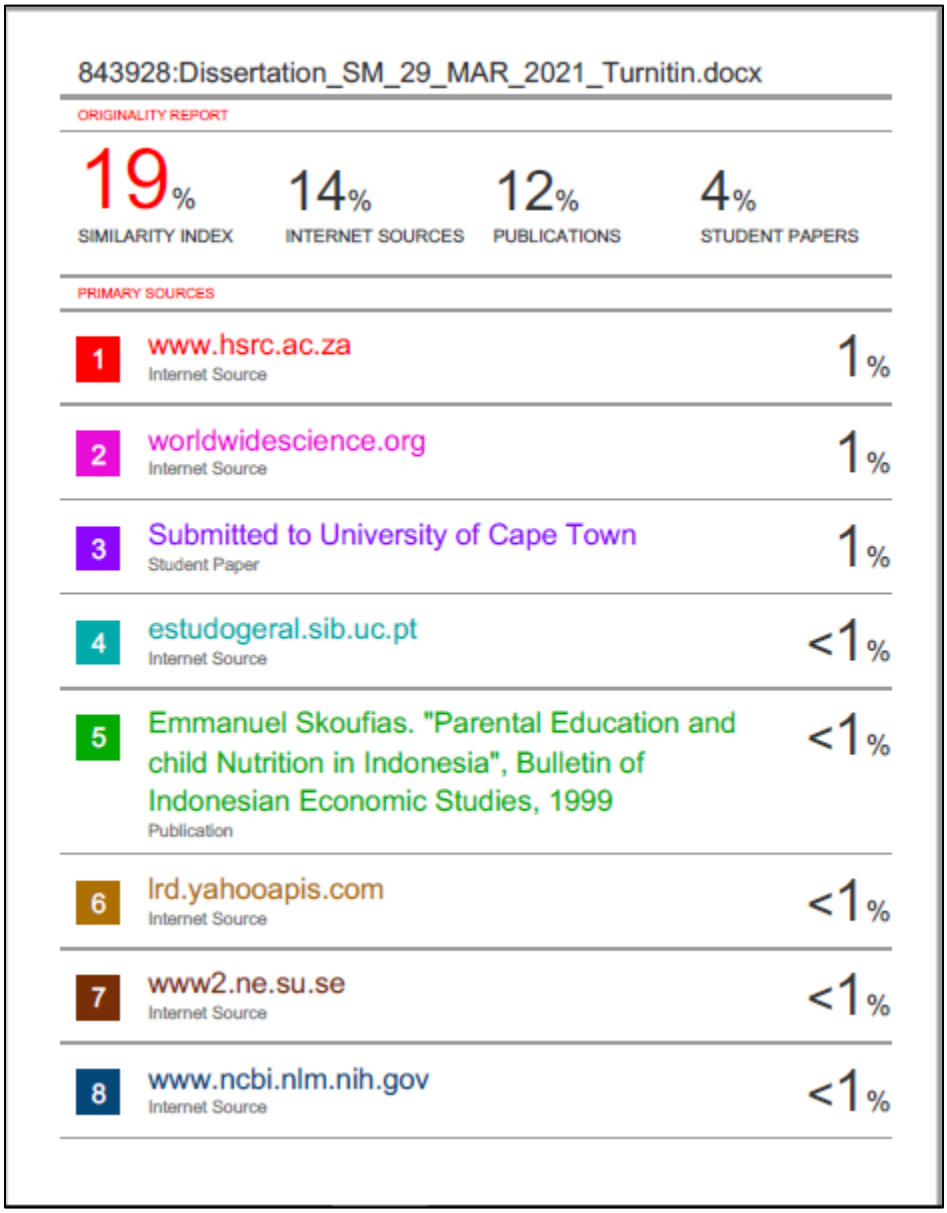
Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

10. Annotated code script

```
*************************************************************************************************************************************************************
                                                        //Computing child (0-19 years) Z-scores//
*************************************************************************************************************************************************************

egen Haz = zanthro(height_m, ha, WHO), xvar(ageyrs) gender(Sex) gencode(female=1, male=2) ageunit(year) //This code creates height for age Z-scores

gen bmi=weight_kg/(height_m/100)^2 //This formular calculates Body Mass Index (kg/m^2)

egen Baz = zanthro(bmi, ba, WHO), xvar(ageyrs) gender(Sex) gencode(female=1, male=2) ageunit(year) //This code creates BMI for age Z-scores using BMI calculated above


*************************************************************************************************************************************************************
                                                      //Running weighted analyses//
*************************************************************************************************************************************************************

svyset [pweight= INDV_WGT_ANSW_QSTN_BENCH_NEW ],strata(Province) psu(EA)  //When analysing interview questionnaire variables

svyset [pweight= INDV_WGT_ANSW_PHYS_BENCH_NEW ],strata(Province) psu(EA) //when analysing clinical/physical examination variables

svyset [pweight= vp_wgt],strata(Province) psu(EA) //For household level analyses

*Enumerator Area was used as primary sampling unit

*Province was used as strata (There are nine provinces in South Africa)

*************************************************************************************************************************************************************
                                                    //Retrieving missing observations//
*************************************************************************************************************************************************************

*In the case where some some household members had missing household level data, the respective variables (eg. food security) were copied from one individual onto all
* other members within that household.

sort vpno Food security //This code sorts the data (by vpno) in ascending order, starting with the individual with non-missing observations.

bysort vpno (Food security): replace Food security = Food security [_n-1] if ~missing(Food security [_n-1]) //This code copies the food security from the individual
*onto all the other individuals within the household.

*************************************************************************************************************************************************************
```

11. Plagiarism report



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