PREVALENCE OF AND RISK FACTORS FOR BODY FATNESS AND NUTRITIONAL STATUS OF URBAN AND RURAL PRIMARY SCHOOL CHILDREN BETWEEN THE AGES OF SIX AND NINE YEARS IN THE POLOKWANE LOCAL MUNICIPALITY, LIMPOPO PROVINCE, SOUTH AFRICA

by

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DISSERTATION

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DECLARATION

I, Mamogobo Nelly Mokabane, declare that **"Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo Province, South Africa,"** hereby submitted to the University of Limpopo, in fulfilment of the requirements for the degree of Master of Science in Physiology, is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references, and that this work has not been submitted before for any other degree at any other institution.

____________________ __________________

Ms MN Mokabane **Date**

DEDICATION

This work is dedicated to the following people:

- **God**, thank you for helping me turn all my setbacks and failures into a stepping stone. You are my saving grace.
- **To my family**: my parents and brother for their prayers, emotional, financial, academic and moral support.

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ABSTRACT

Aim: The purpose of this study was to assess the prevalence and risk factors associated with malnutrition and nutritional status of rural and urban primary school children aged 6–9 years.

Literature background: Malnutrition is one of the leading causes of childhood morbidity and mortality in developing countries, affecting 10.9% of people globally, particularly in Southern Asian (15.7%) and sub-Saharan African (23.2%) countries undergoing urbanisation. Urbanisation affects diet, physical activity levels, body fatness, body composition and socio-economic factors. There is currently a shortage of information on the effect of urbanisation on nutritional status, especially in poor areas such as the Limpopo Province of South Africa. It is important to understand the effects that body fatness and associated risk factors have on stunting, wasting, underweight, and overweight/obesity in urban and rural children.

Subjects and design: This was a cross-sectional study including rural (n=106) and urban (n=68) primary school children aged 6–9 years. Anthropometric (weight and height) and skinfold measurements were taken and a 24-hour recall dietary assessment was conducted twice to include a week day and a weekend day. A questionnaire was used to gather demographic, health, dietary and physical activity information.

Results: The prevalence of stunting, wasting, underweight, and overweight/obese children in this population was 14%, 6%, 20%, and 26% respectively. Furthermore, the prevalence stunting, wasting, and underweight were higher in rural areas compared to urban areas. Meanwhile, the prevalence of overweight/obesity was higher in urban areas as compared to rural areas. Gender, area (urban/rural) (p=0.0001), birthweight, time spent on sedentary activities, monthly household income (p=0.0210), mode of transport to school, and breastfeeding (p=0.0560) were all found to be significantly associated with malnutrition. Weekday dietary intake of Vitamins A and D was significally associated with BF%, whereas weekend consumption of energy, protein, calcium, iron, phosphorus, and zinc were not significantly associated with BF%. The mean energy and calcium intake between the urban and rural population only differed significantly over weekends and not during the week, while vitamin D differed significantly between urban and rural populations during the week only.

Conclusions: The current study demonstrates that children in rural areas were significantly more wasted than those residing in urban areas, while those residing in urban areas were significantly more overweight/obese compared to rural areas. All indicators used for undernutrition were associated significantly with gender and the prevalence were higher males compared to females, but this significance disappeared for overnutrition. Families with a higher income tended to have children who were overweight or obese compared to families with a lower income. Children spending a lot of time on sedentary activities were more likely to be overweight or obese, and breastfeeding seemed to protect children from becoming overweight or obese, while low birth weight was associated with stunting. The weekaday and week-end diets indicate that school feeding schemes in the rural areas may be effective in increasing total energy intake in children and this should be further investigated. In this population, stunting, wasting, and underweight were not limited to rural areas, and should still be a health concern in urban areas, despite the fact that overweight/obesity is also prevalent in urban areas. Thus, overweight/obesity in this population can be prevented by promoting breastfeeding and physical activity, while at the same time discouraging children from partaking in too many sedentary activities.

Key words: Rural, urban, children, malnutrition, nutritional status, prevalence, urbanisation, stunting, wasting, underweight, overweight/obesity.

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LIST OF ABBREVIATIONS

Abbreviation	Description
BF%	Body fat percentage
BMI	Body mass index
BMR	Basal metabolic rate
Ca	Calcium
CCK	Cholecystokinin
CDLs	Chronic diseases of lifestyle
Cu	Copper
DHHS	Department of Health and Human Services
FAO	Food and Agriculture Organisation
FDA	Food and drug administration
Fe	Iron
HFA	Height-for-age
WFH	Weight for height
ISAK	International Society for the Advancement of Kinanthropometry
Kg	Kilogram
P	Phosphorus
PLM	Polokwane Local Municipality
POMC	Pro-opiomelanocortin
PUFA	Polyunsaturated fatty acids
PYY	Peptide YY
RDA	Recommended Daily Allowance
ROS	Reactive oxygen species
SA	South Africa
SAMRC	South African Medical Research Council
SD	Standard deviation
Se	Selenium
Vit A	Vitamin A
Vit D	Vitamin D
Vit E	Vitamin E
WFA	Weight-for-age
WHO	World Health Organization
Zn	Zinc

Chapter One: Introduction and background information

1 Introduction/background

Malnutrition is a major public health problem affecting 10.9% of people globally, particularly in Southern Asian (15.7%) and sub-Saharan African (23.2%) countries undergoing urbanisation (FAO, 2015). Urbanisation can be defined as a movement of individuals from rural to urban areas and the development of rural areas into urban areas (Ojiambo *et al*., 2012). It has a huge effect on the lives of individuals and is associated with changes in, amongst other factors, diet, physical activity levels (Yamauchi *et al*., 2001), body fatness, body composition, and socio-economic factors (Dinsa *et al*., 2012). Currently South Africa (SA) is in the midst of a huge sector of the population moving from rural areas towards urban areas (Monyeki *et al*., 2015). To complicate matters, the rural areas themselves are becoming more and more urban due to developments such as tar roads, shops, hospitals and clinics in these areas (Tydeman-Edwards *et al*., 2018). This has a huge impact on the lifestyle of the population causing changes in their dietary intake, resulting in changes in body composition such as abnormal body fatness (You & Henneberg, 2016).

Abnormal body fatness and stunting are caused by a variety of factors such as diet, maternal age, body composition, and socio-economic status (Leddy *et al*., 2008). Body composition profiles such as stunting, wasting, underweight, overweight/obesity can result in poor growth, poor development, and negative health outcomes, such as type 2 diabetes mellitus and hypertension (Kimani- Murage *et al*., 2010). Stunting and abnormal body fatness also have negative effects on learning abilities in children (Caulfield *et al*., 2004).

Globally, over 22 million children are overweight (Musaiger, 2011). Childhood obesity is not only a problem in developed countries, but it is also becoming an increasing problem in countries undergoing epidemiological transition, such as SA; this is seen especially in girls (Puoane *et al*., 2002). Girls between the ages of four and fourteen from countries such as Ethiopia, SA, and Zimbabwe have higher mean body mass indices as compared to boys of the same ages (Mascie-Taylor & Goto, 2007). Childhood obesity in SA is a major public health problem and is on the increase (Karnik & Kanekar, 2012). The prevalence of overweight/obesity in children varies with age, gender, population group and level of urbanisation (Lobstein & Frelut, 2003).

Low birth weight is a risk factor for both overweight and stunting (Arifeen *et al*., 2000). Worldwide more than 20 million babies are born with low birth weight every year due to factors such as poor maternal nutrition (UNICEF, 2012). Developing and middle income country such as SA has a relatively higher levels of under-nutrition compared to other middle-income countries (Sunguya *et al*., 2014). Malnutrition is one of the leading causes of death in Limpopo Province (UNICEF, 2009). It is likely that SA (including Limpopo Province) has a high prevalence of low birth weight due to the high prevalence of malnutrition (Kleynhans *et al*., 2006). As far as the author could ascertain, this was the first study comparing body fatness and nutritional status in rural and urban children to have been conducted in the Polokwane Local Municipality (PLM), Capricorn District, Limpopo Province, SA.

In a developing country such as SA, where a large sector of the population is currently affected by urbanisation (Monyeki *et al*., 2015), it is possible that the changes in lifestyle associated with urbanisation negatively affects the body fatness and body composition of prepubertal children (between the ages of six and nine years). It is of the utmost importance to increase the knowledge on the effect that urbanisation has on the development of these conditions and on the co-occurrence of stunting and overweight, especially in low-income areas such as the Limpopo Province.

2 Research problem

Stunting, wasting, underweight, overweight and obesity are all common conditions in developing countries such as SA (Tydeman-Edwards *et al*., 2018) and their prevalence is increasing with increasing urbanisation and modernisation (Monyeki *et al*., 2015). Overweight and stunting can even co-occur in one child (Symington *et al*., 2016). All these conditions may have a negative impact on children later in life by increasing their risk for the development of other chronic diseases of lifestyle (CDL), including type 2 diabetes mellitus, hypertension, and stroke (Pulos *et al*., 2014). There currently is a shortage of information on the effect that urbanisation has on the development of these conditions and on the co-occurrence of stunting and overweight, especially in poor areas such as the Limpopo Province.

3 Significance of the research

The findings of this study will make a valuable contribution to knowledge of how urbanisation affects body fatness and nutritional status of primary school children. The Department of Health and the Department of Basic Education may be able to use the results to design effective programmes to prevent abnormal body fatness and stunting in children, especially those from rural environments. The results may also be used to ensure that children (and probably parents) are informed about practical ways to ensure that a prudent diet is followed. This study will also help in understanding the effects that body fat and diet have on the development and growth of the children.

4 Purpose of the study

4.1 Aim

The aim of this study was to assess the prevalence, risk factors associated with malnutrition and nutritional status of urban (n = 68) and rural (n = 106) primary school children aged 6–9 years in the PLM, Capricorn District, Limpopo Province, SA.

4.2 Objectives

The objectives of this study were to:

- gather demographic and health information with a questionnaire to compare the prevalence of stunting, wasting, underweight, overweight/obesity between rural and urban children;
- measure weight, height, and skinfolds in children between the ages of six and nine years to compare the prevalence of risk factors associated with stunting, wasting, underweight, overweight, and obesity in children; and
- perform a repeat 24-hour recall dietary assessment (one week-day and one weekend-day) on 32% of the study population to determine correlations between dietary intake and body fatness.

5 Scope and limitations of the study

5.1 Scope

Anthropometric measurements were taken using the standardized techniques of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al*., 2006). The following anthropometric measurements were taken: weight and height, and the following skinfolds: biceps, triceps, subscapular, and iliac crest.

A 24-hour recall test was used to analyse micronutrient and macronutrient intake of a randomly selected subgroup of the subject population (32% of the children). Recommended energy and nutrient intakes vary according to gender and age. Information from the 24-hour recall test was used to calculate total energy intake as well as the percentage energy that was contributed by each of the macronutrient groups and was compared to the recommended daily allowances (RDAs) for each individual. Similarly, all macronutrient and micronutrient intakes were calculated for each individual and compared to RDAs for that age and gender group. The test was done according to the guidelines in Wolmarans *et al*. (2009) and was repeated twice to include one week-day and one weekend day. The results were coded and analysed using the FoodFinder software developed by the South African Medical Research Council (SAMRC) (Wolmarans *et al*., 2009).

5.2 Limitations

This research project was subject to the following limitations:

- This research project was limited to the rural and urban primary schools of PLM, Capricorn District, Limpopo Province which were selected by the Senior District manager of the Capricorn District.
- The rural primary schools selected consisted of only black children, whereas the urban primary schools had white, coloured, Indian and black children.
- The study only included children from six to nine years of age.
- The fact that the study population was not randomly selected could have introduced bias to the study. The Department of Basic Education selected the schools that participated in the study and the first children in each age and gender group who brought back signed consent forms was selected to participate in the study.

- A 24-hour recall questionnaire tends to underestimate the amount of an individual's intake because of day to day variation; however, the selection of this method was justified based on a review of the existing literature, particularly on national studies, with consideration of the unique characteristics of the South African population, and on the basis that it is the best method to use on children (Oldewage-Theron *et al*., 2011).
- The young children between the ages of six and nine found it difficult to accurately recall the food that had been consumed in the previous 24 hours. In this regard, the parents were interviewed telephonically to verify intakes if the children were unsure about what they ate.

5.3 Permission to conduct the study

An official letter for authorization to undertake the study at the nominated schools was submitted to the Senior Manager of Primary schools at the Department of Education, Capricorn District, and principals of selected schools. The letter entailed permission to take anthropometric measurements and assess the nutritional status of the children using the 24-hour recall test. The letter from the circuit manager (Addendum B), as well as the letter from the Limpopo Department of Education (Addendum C), both served as permission to allow the principals to let us conduct the study at their schools.

5.4 Harm to respondents

The researcher ensured that the participants were protected from any harm. Participants would have been referred to social workers and psycologists for professional intervention if it was found that harm had been inflicted due to the nature of questions posed.

5.5 Informed consent

The purpose of the study, the extent of their involvement, and what will happen to their private information was explained to the participants and their parens/guardians in the letter that accompanied the informed consent form. Thus both the participants and parents knew what the procedures involved before they gave consent to participate in the study. Parents of participating children gave informed consent on behalf of the child to participate in the study. Before data collection on any child commenced, the child was asked for ascent. The participants were also informed that the research was voluntary and if any individual chose to withdraw from the research he/she could do so at any time. In case some questions to the participants might sound offensive and uncomfortable to respond to, they were informed not to respond.

5.6 Confidentiality and anonymity

Confidentiality was maintained regarding the information which was collected from participants. Each participant was given a subject number which was used to link the child's questionnaire and data sheet. The only people who had access to this information were the researcher and supervisors. The information was stored securely in the office of the Head of the Department of Physiology and Environmental Health.

5.7 Release or publication of the findings

The research results will be made available to the participating schools and Department of Basic Education through a report and publishable articles which allows the participants access to the results.

6 Structure of dissertation

The outline of the various chapters of this dissertation is as follows:

- Chapter two deals with the background and literature review relevant to the current research focus.
- Chapter three outlines the procedures that were followed, including the sampling method, study design, scope, and data collection processes.
- Chapter four deals specifically with the results of the study.
- Chapter five deals with comparing the results to other studies.
- Chapter six contains the conclusion and recommendations.

Chapter Two: Literature review

1 Overview of malnutrition

According to Christopher *et al*. (2008), 54% of child mortality worldwide is due to malnutrition. Malnutrition in children develops due to insufficient consumption of calories, proteins, iron (Fe), and other nutrients, as well as consumption of food high in saturated fats and sugars and reduced physical activity (Brabin & Goulter, 2003). Little information is available about the prevalence of malnutrition in children between the ages of 5-19 years. (World bank, 2015).

Malnutrition is broadly classified into undernutrition (which presents as stunting, wasting, and underweight) and overnutrition (which presents as overweight/obesity) (Tathiah *et al*., 2013). Undernutrition is characterised by protein energy malnutrition (growth failure) and micronutrient deficiency, whereas overnutrition is characterised by overconsumption of macronutrients and energy dense foods (Faber & Wenhold, 2007). Wasting is defined as low BMI-for-age (below-2 z-score/SD) (WHO, 2010), and is an indicator of acute nutrient depreviation due to recent food shortage (famine) or illness (Corsi *et al*., 2015). Stunting is defined as low HFA; (below -2 Z-score/SD) (WHO, 2010) and is usually a linear growth delay due to chronic insufficient food and nutrient intake and frequent infections (Das & Bose 2011). Underweight is characterized by low weight-for-age (WFA) and is a result of short-term and long-term malnutrition (Faber & Wenhold, 2007). Overweight is a situation where body's fat stores have increased above normal limits, but have not reached a level classified as obesity yet. Thus it is an intermediate position between normal weight (lean) and obese (Ogden & Flegal, 2010). Obesity is defined by the WHO as the excessive accumulation of fat in the body, resulting in adverse health effects such as the development of metabolic diseases (Osuji *et al*., 2010). Overweight and obesity are two separate classes, but because of the small number of overweight subjects in this study, it was combined into one group. For this reason, it is treated as a single group throughout the study, including the literature review.

In many developing and even some developed countries, the prevalence of overweight co-exists with stunting in children (Lee *et al*., 2012). This double burden of malnutrition is advancing to a severe level, especially in developing countries such as SA, China, and Russia (Monyeki *et al*., 2015).

Due to urbanisation, the diets of many South Africans are changing from a traditional African (prudent) diet to a Western diet (Jinabhai *et al*., 2003). As a result of this nutritional transition in SA there is a shift in trends where undernutrition and overnutrition overlap, resulting in the co-existence of stunting and overweight in the population and even in the same individual (Atsu *et al*., 2017). Therefore, a child can be both stunted and overweight at the same time (Jinabhai *et al*., 2003).

2 Overnutrition

2.1 Overview of overnutrition

Obesity develops when the total energy intake is greater than the total energy expended by the body (Bray & Bellanger, 2006). The development of overweight/obesity occurs through interactions of various factors, including genetics, (Badawi *et al*., 2013) environmental, cultural and behavioural factors (Doak *et al*., 2006). In certain cultures, an abundance of food may result in social meetings which cause overeating, while foods rich in fats and energy are associated with prestige in other cultures (Kruger *et al*., 2005). Genetic factors associated with overweight/obesity include deficiencies in leptin and growth hormone, which result in the rising prevalence of obesity. However, most cases of genetic predisposition only become visible or are expressed in the presence of behavioural and environmental factors associated with a positive energy balance (Badawi *et al*., 2013).

Diseases associated with obesity have became a major public health concern in both developed and developing countries (Crowther & Norris, 2012). Manifestations of obesity include abdominal obesity (presented as an increased waist circumference), which is associated with the metabolic syndrome (Ntyintyane *et al*., 2006). Lower body obesity is another form of obesity which tend to have an inverse relationship with cardiovascular diseases and type 2 diabetes mellitus (Karpe & Pinnick, 2015).

There are different terms, metrics, indices and cut-off values used to classify and calculate overweight/obesity (Flegal *et al*., 2006). The body mass index (BMI), also known as the “Quetelet index”, uses the variables weight and height, and is calculated by dividing weight in kilograms (Kg) by height in metres squared (Kg/m^2) (Chung, 2015). It is used to measure body fat stores, usually in adults rather than children, because the BMI of children changes as they grow older. BMI-for-age is useful for screening for overweight and obesity (WHO, 2008). Cole *et al*. (2000) determined age-specific BMI cut-off points for children between the ages of six and eighteen. Children are at high risk for overweight/obesity if their BMI is between the 85^{th} and 95^{th} percentile and higher than the 95^{th} percentile for age and gender respectively (Cole *et al*., 2000).

2.2 The prevalence of childhood overweight/obesity

2.2.1 The prevalence of childhood overweight/obesity among children globally

Childhood overweight/obesity are pandemic worldwide, but are most prevalent in developed countries (Rahman *et al*., 2014). Guo *et al*. (2015) found that globally, more than 4 billion children were overweight. Majority of these children were living in developed countries (Guo *et al*., 2015). In Portugal, a study of children between the ages of seven and nine years found that 20.3% of the children were overweight and 11.3% were obese (Padez *et al*., 2004). The prevalence of overweight/obesity are increasing drastically in central and eastern Europe and the Middle East (Jackson-Leach & Lobstein, 2006). The prevalence of overweight/obesity amongst six to nine-year-old children was 5.6% and 6.3% respectively in a study conducted by Mosha and Fungo (2010) of Dodoma and Kinondoni Municipalities, Tanzania. Badawi *et al*. (2013) undertook a study of six to nine-year-old Port Said City primary school children and the results indicated that 17.7% of the children were overweight and 13.5% were obese. Studies on overweight/obesity in developing countries show that obesity increased from 4% in 1990 to 6% in 2010, and these percentages are expected to increase to 9% in 2020 (Gupta *et al*., 2013). Thus, overweight/obesity are now also increasing in underdeveloped and developing countries (Koirala *et al*., 2015), especially those undergoing nutritional and economic transition.

2.2.2 The prevalence of childhood overweight/obesity in South Africa

South Africa is a developing country, in a high transition state (Rocco *et al*., 2014), and is experiencing a rapid increase in the prevalence of overweight/obesity (Griffiths *et al*., 2013). The prevalence of overweight/obesity differs between ethnic groups, genders and geographical areas (WHO, 2015). A study conducted by Jinabhai *et al*. (2001) amongst Kwazulu-Natal primary school children between the ages of eight and ten reported that 3.1% of the children were obese. Another study conducted in Kwazulu-Natal amongst children between the ages of eight to eleven, found that the prevalence of overweight varied between 0.4% and 13.3% and obesity between 0.1% and 3.7% according to WHO criteria (Jinabhai *et al*., 2003). Overweight/obesity are now showing a dramatic increase in the low- and middle-income population in SA (An *et al*., 2013). Studies also indicate that there is an increase in prevalence of obesity in the previously disadvantaged population (Guo *et al*., 2015). If actions are not taken against the high prevalence of overweight/obesity in SA, the mortality rate due to obesity related conditions or the complications associated with obesity is likely to increase (Flegal *et al*, 2012).

2.2.3 The prevalence of childhood overweight/obesity in urban and rural areas

In SA, high prevalences of overweight/obesity were found in rural communities of Limpopo, Kwazulu-Natal and Eastern Cape (Motadi *et al*., 2015), but studies report that the prevalence of overweight/obesity is increasing most rapidly in urban areas due to the reduction of physical activity, consumption of energy dense Western diets containing refined carbohydrates, and meals full of refined oil (Duh *et al*., 2016). In agreement with previous studies, Monyeki *et al*., (2015) also found a higher prevalence of overweight/obesity in South African children residing in urban areas than in rural areas. The South African black population constitutes the largest percentage in the country and large numbers of people reside in rural areas (Stats SA, 2018). However, currently the percentage of urban blacks is increasing with more black Africans starting to reside in urban settings (Arndt *et al*., 2018).

2.3 The risk factors associated with childhood overweight/obesity

Childhood overweight/obesity is complex and multifactorial. The major determinants of childhood overweight/obesity are urban residences, nutritional transition, higher socio-economic status, genetic predisposition, female children, and lack of physical activity (Han & Powell, 2013).

2.3.1 Age

The development of obesity is rapid during early life periods, childhood and adolescence (Dietz, 1994). Children and adolescents who become overweight or obese seldom lose the weight and rather tend to gain more weight as they grow older, thus becoming increasingly overweight and obese (Sutharsan *et al*., 2015). Thus the prevalence of overweight/obesity in any group of children is likely to increase as the children grows older rather than to decrease.

2.3.2 Transition

The increased prevalence of overweight/obesity in developing countries is due to changes in lifestyle, particularly in diet and physical activity that is associated with urbanisation (Navaneetham & Dharmalingam, 2013). Childhood obesity has also been a problem over the past few decades because people in developing countries believed that increased body fatness improves chances of survival during famine (Parizkova & Hills, 2001) and thus overweight/obese children are viewed as being healthy and happy (Motadi *et al*., 2015).

2.3.3 The socioeconomic and cultural factors

The socioeconomic status of a family is positively associated with overweight/obesity (Wang *et al*., 2012). Children from families with high incomes have a high prevalence of overweight/obesity (He *et al*., 2014). Socioeconomic factors that are associated with overweight/obesity include, amongst others, parents' level of education and occupation, household size and geographical region (Meko *et al*., 2015). Mchiza *et al*, (2015) reported that there is higher BMI in high socio-economic areas than in low socio-economic areas of SA (Mchiza *et al*, 2015). A study conducted by Meko *et al*. (2015) in Bloemfontein, SA, found that children whose parents were degree holders were more overweight and obese than those whose parents did not have degrees.

In the black population of SA residing in rural areas, being overweight is reflected as a sign of being wealthy and happy, therefore people have a fear of being lean (Motadi *et al*., 2015). However, black South Africans residing in urban areas believe that people who are not overweight are not at risk of developing CDLs, such as type 2 diabetes mellitus, cardiovascular diseases, and hypertension (Puoane *et al*., 2010).

2.3.4 The genetic contribution of obesity

Genetic predisposition is one of the three main causes of childhood obesity, the other two being lack of exercise and unhealthy diet (Chamieh *et al*., 2015). Monogenic obesity (obesity due to a specific genetic mutation) is very rare (Dubern *et al.*, 2007). Only a small percentage of childhood obesity is due to monogenic obesity (Sheikh *et al*., 2017).

However, mutations on one or more of a variety of genes (Farooqi & O'Rahilly, 2005) can affect factors such as basal metabolic rate (BMR) (Luczynski *et al*., 2016) or the mechanisms responsible for energy intake and expenditure (Nordang *et al*., 2017). This will then affect the degree of body fatness or the relative ease with which one gains weight (Luczynski *et al*., 2016). It is called polygenic obesity and is recognised as a CDL (Nordang *et al*., 2017). Various genes have been linked with polygenic obesity, including: leptin, leptin receptor and pro-opiomelanocortin (POMC) genes (Cummings & Schwartz, 2003). These genes stimulate hunger and satiety signals, are involved in the growth and differentiation of adipose cells and control the amount of energy expenditure (Farooqi, 2011). The Y chromosome is involved in the development of obesity in some males and thus increases the chances of males to be obese (Perusse *et al.*, 2005).

2.3.5 The link between obesity and family history

Due to the genetic contribution to obesity, the condition has a trace of family history (Chamieh *et al*., 2015). An overweight parent is at high risk of having a child with obesity (Bahreynian *et al*., 2017), especially if the mother is obese (Reilly *et al*., 2005). If one of the parents is obese, there is a high risk of the children to become obese, and if both the parents are obese, then the risk is two times higher (Lifshitz, 2008).

2.3.6 Intra-uterine environment and early life

The environment that a developing foetus is exposed to during pregnancy affects foetal development and this have an affect on the development of obesity after birth (Whitaker *et al*., 1997). Such babies are often small at birth (Williams *et al*., 2014). Birth weight of 2500 g or less for a full term baby, is regarded as the cut-off point for low birth weight (Hughes *et al*., 2017). Certain factors associated with pregnancy, such as age of the mother, causes sub-optimal foetal development, which can increase the chances for becoming obese later in life, especially when faced with an energy dense diet and high energy intake (Williams *et al*., 2014). Aras, 2013 found that females with low body weight before pregnancy and those with low body weight during pregnancy gave birth to infants with low birth weight. These findings suggest that there is a significant correlation between maternal nutrition and low birth weight. A decrease in maternal nutrition affects the development of the foetus, resulting in low birth weight, which is a risk factor for obesity and type 2 diabetes mellitus (Galtier-Dereure *et al*., 2000).

Gestational weight gain is the best predictor for early childhood obesity and overweight later in life (Oken & Gillman, 2003). Driul *et al*. (2008) found that females who gained weight before pregnancy and those who gained weight during pregnancy gave birth to overweight children. Mothers who are overweight are likely to give birth to big infants, who are then at high risk for the development of other health effects, such as obesity and type 2 diabetes mellitus (Li *et al*., 2009). These diseases are all associated with increased body fatness (Pulos *et al.,* 2014).

Mothers who tend to over-feed their children may cause a positive energy balance in the child, resulting in the onset of obesity during infancy (Williams *et al*., 2014). Weight gain and the method used to feed the infant are both predictors of developing obesity later in life (Baird *et al*., 2005). Breastfed children tend to have normal weight compared to those who are not breastfed, because a breastfed child is likely to stop feeding when full, unlike a bottle-fed child who might be encouraged to continue feeding until the bottle is empty (Pinheiro *et al*., 2015).

2.3.7 The effect of dietary energy intake on body fatness

Energy intake should equal energy expenditure to ensure a stable body weight (Müller & Geisler, 2017). If energy intake exceeds energy expenditure the individual will gain weight and is said to have a positive energy balance (Lillefosse *et al*., 2014). If energy expenditure exceeds energy intake the individual will lose weight and is said to have a negative energy balance (Müller & Geisler, 2017). Many factors influence energy intake, but the diet is probably the single most important modifiable risk factor for execessive energy intake. In the human diet carbohydrates, proteins and lipids contribute to energy intake. Lipids conain more energy per gram than carbohydreates and proteins, thus an increased intake of fat can easily result in a positive energy balance (You & Henneberg, 2016). The typical western diet followed in most developed and increasingly in developing countries is rich in refined carbohydrates, sugar, proteins (especially animal protein), and fat. The portion size also plays an important role in dietary intake, whereby the larger the portion size the higher the energy intake, which puts an individual at high risk of having a positive energy balance and developing overweight or obesity (Chen *et al*., 2012).

In individuals with a positive energy balance, fat cells increase in number (Whitney & Rolfes, 2002) and this is a major global contributor to the childhood obesity epidemic (You & Henneberg, 2016). A high-calorie diet such as high carbohydrate intake influences the fat storage in adipose tissues (Lillefosse *et al*., 2014).

2.3.8 The effects of physical activity on body weight

Physical activity is the body movements which causes muscle contraction and an increase in energy expenditure (Moore *et al.*, 2013). The high positive energy balance leads to the accumulation of calories as fat in the adipose tissues which lead to obesity (You & Henneberg, 2016). Even though there are many factors that affect energy expenditure, physical activity is probably the single most important modifiable factor that affects energy expenditure. Physical activity is associated with high benefits such as the reduction of weight gain and obesity (Wiklund, 2016).

Lack of exercise due to few sport activities and lack of awareness about the importance of physical activity at school and at home increases the development of obesity (Davies *et al.*, 1991). Urbanisation is associated with the decrease in the physical activity whereby children in urban areas have access to transport than in rural areas which make them having high positive energy balance (Amadou *et al.*, 2013). In urban environments, physical activities such as aerobics, skipping rope and riding bikes have been replaced by a sedentary lifestyle, characterised by a large amount of time being spent watching television, playing video games and being busy on cellular phones (Anrig, 2003). Anderson *et al.* (2008) reported that children between the ages of four to twelve years have a low physical activity due to living a sedentary lifestyle.

Physical activity is one of the major factors that lowers the risks of diabetes, high blood pressure, heart diseases, osteoporosis and certain related cancers (Luke and Cooper, 2013). Staying physically active increases the energy expenditure which helps in losing weight and maitaining a healthy body weight (Borodulin *et al*., 2015).

2.3.9 The effect of leptin on the development of obesity

Leptin is a hormone that regulates food intake, energy expenditure and energy balance in humans through interactions with the hypothalamus (Crujeiras *et al*., 2015). Leptin interacts with specific leptin receptors to inhibit excess feeding (Sainz *et al*., 2015). Obesity is therefore often thought to indicate a leptin resistant state (Shapiro *et al*., 2011). Leptin resistance in obese individuals is thought to arise due to a blunted response of leptin to caloric intake (Koch *et al*., 2013).

2.4 The causal mechanism associated with increased body fatness

Obesity is a neuroendocrine dysfunction characterized by abnormal adiposity (Kwon & Pessin, 2013). It has been implicated in the aetiological mechanisms of metabolic disorders such as diabetes mellitus, insulin resistance, dyslipidaemia, hypertension and atherosclerosis, mainly due to hypersecretion of intermediary signalling mediators, such as adipocytokines, by the adipocytes (Finkelstein *et al*., 2012). Adipocytokines are extensively involved in hormonal communication, and are not only limited to fuel metabolism. Consequently, dysregulation of these molecules results in organ dysfunction of the cardiac, pulmonary, muscular, gastrointestinal, immune and reproductive systems, in addition to glucose and lipid metabolism (Refer to **Figure 2.1**). Furthermore, apart from the previously studied endocrine functions, adipocytokines, especially the thrombotic-promoting and pro-inflammatory type, are strongly associated with inflammatory response of the adipocytes (Kang *et al*., 2016). As the adipocytes become progressively subdued with nutrient reserves, tissue hyperplasia and hypertrophy initiates the self-induced inflammation of the adipocytes and increases levels of reactive oxygen species (ROS) (Li *et al*., 2009). Exaggerated local and systemic inflammation triggers a cascade of related events which lead to excessive production of antherogenic pro-inflammatory cytokines including tumor necrosis factor-α (TNF- α), interleukins (IL-6 and 1β) (but not limited to) and chemokines (Li *et al*., 2009). These inflammatory modulators have deleterious effects on both fatty liver and pancreatic functioning that chronically cause the metabolic pathologies that are central to insulin resistance (Aouadi *et al*., 2013). Accummulation of adipocyte macrophages and adipokines synergistically contribute to the pathogenesis of various malignant tumours such as hepatocellular, oesophageal and colon cancers (Olesfsky & Glass, 2010). Therefore, insulin-induced obesity follows when the compensatory mechanisms from leptin and adiponectin, both of which regulate feeding and energy utilization, are surpassed by overproduction of adipokines (Yadav *et al*., 2012).

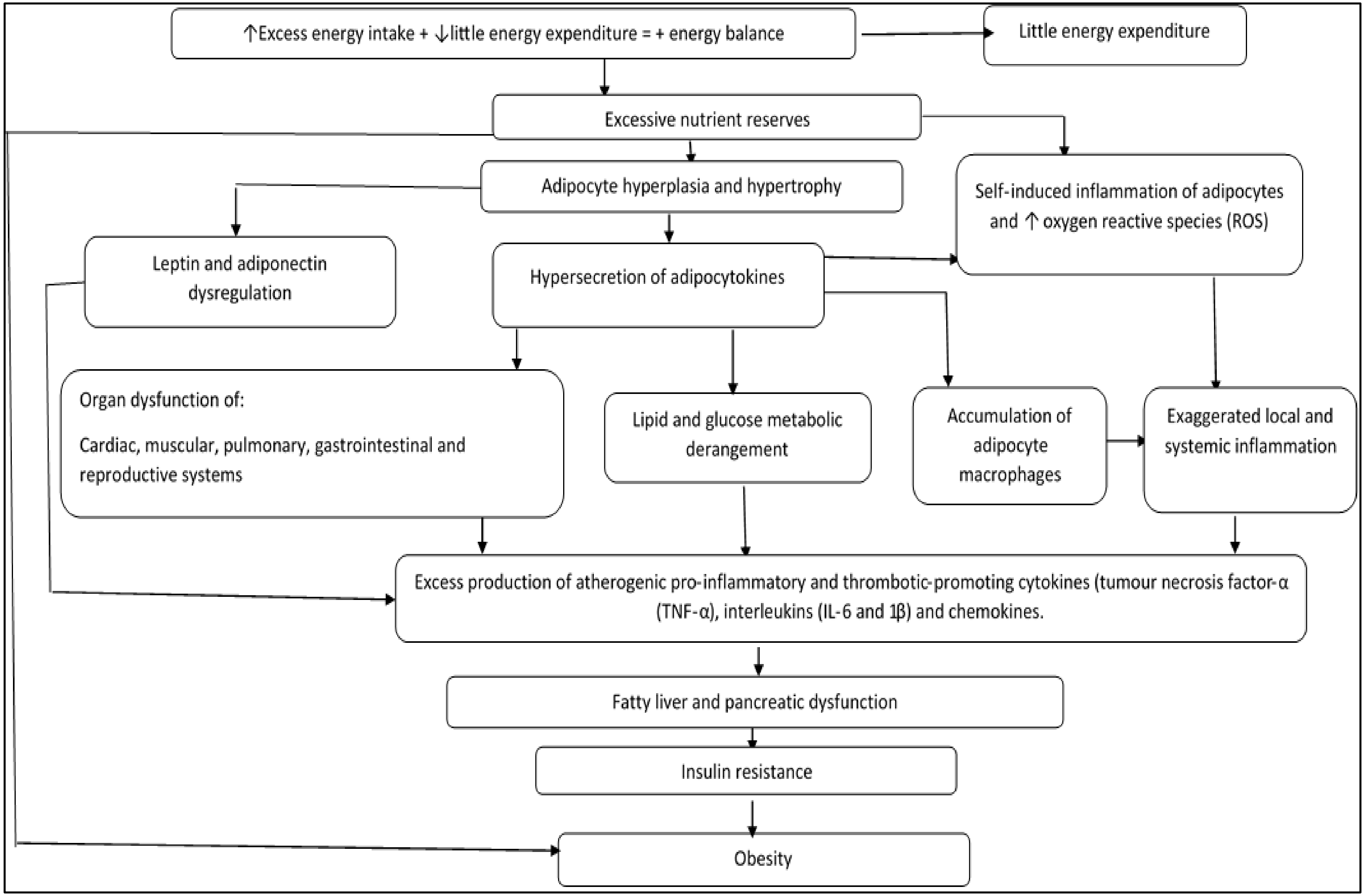

Figure 2.1: The causal mechanism associated with increased body fatness. (Constructed based on Kwon & Pessin, 2013, Finkelsten *et al*., 2012, Li *et al*., 2009, Aoudi *et al*., 2013, Olesfsky & Glass, 2010 and Yadav *et al*., 2012)

2.5 The complications associated with overweight/obesity

The Word Health Organization (WHO) classified childhood obesity as a major public health problem in both developed and developing countries globally (Anrig, 2003). Obesity is one of the leading causes of mortality and morbidity (Musaiger, 2011). Childhood obesity causes physical and psychological complications.

Physical complications include diabetes mellitus, ischaemic heart disease, and some types of cancer. Over 3.4 million deaths occur annually, of which overweight/obesity are the fifth major cause of mortality (Pulos *et al*., 2014). It is estimated that in 2020 a quarter of the deaths will be caused by CDLs associated with overweight/obesity (WHO, 2015). It is reported that globally 44% of deaths are caused by diabetes, 23% caused by ischaemic heart diseases and 41% caused by related cancers; these diseases are all associated with increased body fatness (Pulos *et al.,* 2014).

Psychological complications include low quality of life, depression, and low self-esteem (Pulos *et al*., 2014). Childhood is a stage where an individual is going through a lot of physical, behavioural and psychological changes which lead to the preparation of adulthood. In rural areas, obese individuals are often regarded as being affluent. On the other hand, many individuals, including children, regard being obese is as being less attractive (Zametkin *et al.*, 2004). As a result, obese children tend to isolate themselves from their peers (Mc Cullough *et al*., 2009). One out of every three obese children is antisocial and has few or no friends at all (Zeller *et al*., 2008). Bosch *et al.* (2004) indicated that some children call obese people inappropriate names such as lazy and ugly. Children as young as five years old engage in such stereotypical behaviour (Brylinsky *et al.*, 1994). These negative remarks can affect a child's self-esteem and confidence (Cornette, 2008). Within societies, it appears that only females suffer from image problems due to increased body fatness, as compared to males (O'Dea, 2005). However, limited research on males and body dissatisfaction suggests that males also experience body dissatisfaction, and that this trend is on the rise (Mitch, 2014).

3 Undernutrition

3.1 Overview of stunting

3.1.1 The prevalence of stunting globally

The global prevalence of stunting has been declining in the past decade (Black *et al*, 2013). Globally, one in four children is stunted (de Onis *et al*., 2012). However, there seems to be an increase in the prevalence of stunting in Africa due to a population increase in the past decade (Black *et al*., 2013). It has been estimated that with the rise in population outcomes (increased births) the prevalence of stunting in Africa will rise from 56 to 61 million (Black *et al*., 2013). Africa is still encountering challenges in reducing stunting by 40% in 2025; the reductions have been lagging behind, with reductions predicting 20% in 2025 with the current trend (Black *et al*., 2013). More than 178 million children in developing countries are stunted (Richard *et al*., 2012). Factors that may contribute to the development of stunting in developing countries include maternal education, accessibility to clean household water and sanitation facilities, and household income (Willey *et al*., 2009). Sub-Saharan Africa is one of the regions with the highest prevalence of stunting at 40%. Approximately 42% of children in sub–Saharan Africa are stunted (Kravdal & Kodzi, 2011). Malawi has the highest prevalence rates, ranging from 41–48% (Huey & Mehta, 2016).

3.1.2 The prevalence of stunting in South Africa

Stunting is a common disorder affecting children in SA (Berry *et al*., 2010). The prevalence of stunting in SA is currently at an estimated 20% (Kimani-Murage, 2010), and it is constantly increasing (Jinabhai *et al*., 2003). However, there are disparities in the prevalence of stunting in provinces, with rural Limpopo (34%) reported as the highest in the country and urbanised Gauteng (12%) with the lowest rate (Kleynhans *et al*., 2006).

3.1.3 The prevalence of stunting in urban and rural areas

Stunting is consistently higher in rural than urban areas (Jiang *et al*., 2015). Patil *et al*. (2016) reported that the prevalence of stunting in rural and urban India was 37% and 22% respectively. A study conducted in eastern India found that the prevalence of stunting was higher in boys (56%) compared to girls (47%), preterm born boys and those with low birthweight are more prone to be stunted than girls (Krishna *et al*., 2016). The study revealed that high birth order and educational status were independently associated with stunting (Biswas & Bose, 2010); thus it is possible that these factors are the mediators of stunting in rural areas. Low income level, poor socio-economic status and low education levels are associated with stunting (Biswas & Bose, 2010). A study conducted by Herrador *et al*. (2014) in rural and urban Ethopia found the prevalence of stunting to be 42.7% and 29.2% respectively. The THUSA BANA Study in the North-West province of SA reported that stunting is more prevalent in the rural areas (girls 23.7% and boys 26.7%) as compared with the urban areas (girls 11.6% and boys 17.1%) (Mukuddem-Petersen & Kruger, 2004).

3.2 Overview of wasting

3.2.1 The prevalence of wasting globally

The highest prevalence of children with severe wasting is found in central Africa and south-central Asia (Black *et al*., 2008). Globally in 2013, 8% of children suffered from moderate wasting and 3% of children were severely wasted, with the highest prevalence rates in Africa (28%) and Asia (71%).

3.2.2 The prevalence of wasting in South Africa

The prevalence of wasting in the South African provinces is high in the Northern Cape (19%), followed by the Western Cape (12%) (Berry *et al*., 2010). This might be because these provinces have large numbers of people living under poor socio-economic conditions, with increased risk of food insecurity. In Limpopo's Vhembe district, the prevalence of wasting is 0.4% in children (Motadi *et al*., 2015). There is not enough information about the prevalence of wasting in children in the Limpopo Province.

3.2.3 The prevalence of wasting in urban and rural areas

The prevalence of wasting is reported to be common in the rural areas (Berry *et al*., 2010). A study conducted by Herrador *et al*. (2014) reported a higher prevalence of wasting in rural area than urban area settings of Fogera and Libo Kemkem districts, Ethiopia.

3.3 Overview of underweight

3.3.1 The prevalence of underweight globally

The prevalence of underweight in Indonesian school aged children was reported to be 14.5% (Syahrul *et al*., 2016). A study conducted by Hasan *et al*. (2013) in higher primary schools in Azad Nagar and its surrounding area, Bangalore (Bengaluru), found that the prevalence of underweight amongst primary school children was 58.3%.

3.3.2 The prevalence of underweight in South Africa

Generally, the prevalence of underweight in SA is low (Berry *et al*., 2010), but reported prevalences vary between areas and studies. The reported prevalences may also be affected by the lack of studies in some areas. The prevalence of underweight in children between the ages of one and nine years was 9.3% (Berry *et al*., 2010) in 2005. A study conducted by Puckree *et al*. (2011) in Kwazulu-Natal amongst primary school children reported that the prevalence of underweight was 66%. A study conducted by Moselakgomo *et al*. (2015) in the Limpopo and Mpumalanga provinces of SA amongst primary school children reported that the prevalence of underweight was 74%. In contrast, the prevalence of underweight in Limpopo's Vhembe district is 0.3% in children (Motadi *et al*., 2015). This low prevalence of underweight in Vhembe district might be because of following a prudent diet due to agricultural practices which alleviates poverty.

3.3.3 The prevalence of underweight in urban and rural areas

The prevalence of underweight is common in rural areas (Herrador *et al*., 2014). A study conducted by Meshram *et al*. (2016) reported that the prevalence of underweight in urban and rural areas were 32% and 46% respectively. Monyeki *et al*. (2015) reported that the prevalence of underweight in rural and urban areas was 0.7%–66% and 3.1%–32.4% respectively.

3.4 The risk factors of undernutrition in children

3.4.1 The socio economic factors on undernutrition in children

Socio-economic factors associated with undernutrition include amongst others residing in an over-populated area, spending less money on food, and sharing a one roomed apartment (Kleynhans *et al*., 2006). Traditionally in Africa, child welfare is the responsibility of the mother; therefore, factors such as maternal employment may have both negative and positive nutrition outcomes in a child (Mesfin *et al*., 2015). In SA, Limpopo is one of the provinces with the highest rates of poverty and unemployment (STATSSA, 2016). Low socio-economic class is associated with undernutrition because of the few resources available to this society (Kleynhans *et al*., 2006).

3.4.2 The link between undernutrition and family history

Hereditary factotors play an important role in the predisposition of being underweight; however, environment in terms of physical activity, energy intake and socio-economic status also plays a role in family history as a risk factor for undernutrition (Kleynhans *et al*., 2006). A study conducted by (Fernald & Neufeld, 2007) found that European children with short mothers, were stunted. It is possible that the mothers themselves were stunted and the children may then also be stunted, both because of poor socio-economic conditions.

3.4.3 Gestation and maternal health

Van Stuijvenberg *et al*. (2005) suggested that factors associated with gestation and maternal nutrition are implicated in the prevalence of stunting. Gestation is one of the important processes that determine health and development outcomes of the child later in life. Nutritional challenges during pregnancy and failure to gain maternal weight may have long-term effects on child development (Popkin *et al*., 1996). Poor maternal nutrition results in inadequate foetal nutrition and thus in sub-optimal foetal development (Darton-Hill & Mkparu, 2015). Age and the nutritional status of the mother are associated with childhood undernutrition (Asafaw, 2015). Shrivastava and Shrivastava (2013) found that the prevalence of Indian children born with low birth weight was 45.6% among children born of teenage mothers. Factors such as short maternal stature, low pre-pregnancy weight, poor gestational nutrition outcomes and infections indirectly lead to higher risk of stunting (Krishna *et al*., 2016). A study conducted by Fernald and Neufeld (2007) found that European children with short mothers, were stunted.

3.4.4 Birthweight

There are four major stages of growth in children: (i) growth during the third trimester of pregnancy, (ii) during early infancy, (iii) between the ages of five to seven years (adipose rebound) and (iv) during adolescence (Popkin *et al*., 1996). The markers of stunting are reflected within the first 1000 days of life. Low birth weight is one of the markers associated with poor foetal conditions (Krishna *et al*., 2016). A study conducted by Kleynhans e*t al*. (2006) in poor areas of rural Limpopo and urban Gauteng found that there was a significant correlation between low birth weight and the child's current HFA.

3.4.5 Breastfeeding

Breast milk is a bio-active liquid with a multifaceted composition that varies within and between feedings to suit the unique nutritional and immunological requirements of an infant. It consists of macronutrients and micronutrients, with fat being the most varying nutrient; however, it provides half of the energy content in the milk (Lutter & Morrow, 2013). The hind milk is richer in fat as compared to the foremilk, and in essence the feeding process can occur eight to twelve times or more per day (Lutter & Morrow, 2013). Breast milk also constitutes bio-active substances such as immunoglobulins, hormones, growth factors and enzymes (Guo & Ahmad, 2014).

The nutritional requirements of an adult diet necessitate that it be composed of 55–60% carbohydrates; 10% proteins and 30% fats, varied according to polyunsaturated and saturated fats (Franz, 2003). The nutritional requirements of infants during the first six months ranges between 95 and 115 kcal/kg/day, with 40–60%, 8–12% and 50% derived from carbohydrates, proteins and fats respectively (Guo & Ahmad, 2014). In 100 ml of breast milk there is approximately 7 g of carbohydrates (with lactose being the main source), 0.9 g proteins, and 3.5 g fat. With the limited amount of protein in breast milk, it can easily be decreased during the process of pasteurisation, and therefore caution should be taken when giving infants donated breast milk to ensure that it is tailor-made for every infant's needs (Lutter & Morrow, 2013). On average an infant will gain approximately 25–40 g per day in the first three months and 15–20 g per day in the second three months (Guo & Ahmad, 2014).

Exclusive breastfeeding involves the feeding of an infant with only breast milk or expressed breast milk, with the exception of drops or syrups consisting of vitamins, mineral supplements, or medications, and therefore no other liquids or solids are given (Guo & Ahmad, 2014). It is recommended that with infants who cannot be exclusively breastfed by their own mothers, the next best alternative will be to receive donated pasteurized breastmilk (WHO, 2003). A study conducted in Limpopo's Vhembe district reported that breast milk decreases the risk of infectious diseases such as bacterial meningitis and diarrhoea, as well as stunted growth (Kyei *et al*, 2014). Children who are breastfed for more than one month have a lower risk of becoming overweight (Harder *et al*., 2005).

3.4.6 The effect of diet on undernutrition diet

Minerals are inorganic substances that are found in the food that the body needs for growth and health (van Stuijvenberg *et al*., 2015). Minerals are found in foods such as meat, cerelas, fish, milk and diary foods, vegetables, fruit and nuts (Motadi *et al*., 2015). Protein energy malnutrition is caused by inadequate intake of energy and protein, resulting in body muscles wasting (Voortman *et al*., 2017). Deficiencies in mineral nutrients causes diseases (Rooze *et al*., 2016). Deficiencies in Fe, iodine (I), Ca, vitamin A (Vit A), vitamin D (Vit D) and Zinc (Zn) are the most common micronutrient deficiencies in developing countries (Rooze *et al*., 2016). A study by van Stuijvenberg *et al*. (2015) focused on the dietary intake of South African children using a 24-hour recall test and found that deficiencies in Ca and Vit D were significantly associated with stunting. Since Ca is one of the main mineral components of bone tissue, it is essential for adequate bone formation, and considering that Vit D plays an important role in Ca metabolism, a diet with insufficient quantities of these nutrients can impact on the formation of the skeleton and on the process of growth and development (Rooze *et al*., 2016). Another study conducted in the Limpopo Province among pre-school children aged three to five years found that the Fe and Zn deficiencies were associated with poor growth and increased susceptibility to various infections (Motadi *et al*., 2015). Zn deficiency is prevalent in low income countries causing growth restriction, diarrhea, and other health issues (Shekhar, 2013). Stunting prevalence correlates with high risk of zinc insufficiency in young children leading to pneumonia, diarrhea and malaria (Shekhar, 2013). The prevalence of anemia is high in 18 months old children and drops as Fe requirements decreases (Black *et al*, 2008).

3.4.7 Infections

Poor socio-economic and environmentalfactors increase the risk of predisposition of children to infections and increase the risk for the development of stunting (Biswas & Bose, 2010). Complications associated with undernutrition include increased risk of mortality from infectious diseases such as diarrhoea, pneumonia, and measles (Black *et al*., 2013). South Africa has been listed among eight countries with a history of high occurrence of diarrhoea and malnutrition (Dillingham & Guerrant, 2004). Diarrhoea is a consequence of malnutrition (Prendergast & Humphreys, 2014). Infections increase the susceptibility of children to malnutrition, with Fe deficiency identified as a confounding factor associated with infection (Oliveira *et al*., 2015). There are two common pathogens involved in the pathogenesis of diarrhoea, *Cryptosporidium parvum* and *Giardia lamblia*, which affect the growth and nutritional status of children (Berkman *et al*., 2002). The high burden of diarrhoea and enteric infections correlates with impaired growth in children (Dillingham & Guerrant, 2004).

3.5 Causal mechanisms associated with undernutrition (stunting, wasting and underweight)

Causal pathways associated with stunting, wasting and underweight are still not well understood (Huey & Mehta, 2016). However, factors such as socio-economic and environmental factors, maternal, foetal and early nutrition, as well as physiological changes might lead to the development of undernutrion (Biswas & Bose, 2010). Improved socio-economic status of the mother, such as employment, might cause disruptions in the process of exclusive breastfeeding (refer to **Figure 2.2**). This will increase the risk of predisposition of children to infections and increase the risk for the development of stunting (Biswas & Bose, 2010).

When the body is invaded with infections, non-specific chronic activation of the immune system becomes activated. The immune system will respond by causing inflammation. The gradual inflammation will result in the accumulation of ROS, which will overwhelm the free radical scavenger activity of the body. This will be signified by deficiency such as Vit A, Vitamin E (Vit E), and essential minerals such as copper (Cu), Zn and some of the important fats such as glutatathione carotene and polyunsaturated fatty acid, and lead to the development of wasting (Aly *et al*., 2014).

Improved socio-economic status can further increase livelihood of the mother due to increased income and this may positively influence availability of food and food quality (NHANES, 2010). This will increase consumption of macronutrients and micronutrients. A high consumption of macronutrients and decreased physical activity levels will result in excess energy and increased adiposity, which causes the development of overweight/obesity (Chen *et al*., 2012).

The relationship between stunting and overweight is due to individual adaptability wherein stunted children did not have sustained better living conditions (Said-Mohamed *et al*., 2015). With emergence of the nutritional transition, it became apparent that children do not have control mechanisms towards adapting to the rapid change from a prudent to a Western diet; therefore, increased body fatness develops (Popkin *et al*., 1996).

Poor socio-economic status affects foetal and maternal nutrition (Darton-Hill & Mkparu, 2015). Poor feeding practices affect foetal development and result in lack of dietary control mechanisms. This will affect the sub-normal intake of macronutrients and micronutrients which will result in undernutrition or overnutrition (Emery, 2005).

During the gestation stage, poor feeding practices cause maternal and foetal hormonal changes and physiological responses (Darton-Hill & Mkparu, 2015). Breastfed children tend to have normal weight compared to those who are not breastfed, because a breastfed child is likely to stop feeding when full, unlike a bottle-fed child who might be encouraged to continue feeding until the bottle is empty (Pinheiro *et al*., 2015). Foetal hypothalamic programming alters appetite as a result of early chronic malnutrition. Chronic malnutrition results in slow growth, a shift in the BMR and changes in the gastrointestinal hormones such as ghrelin, Cholecystokinin (CCK) and peptide YY ($PYY_{3\text{-}36}$) (Emery, 2005). Slow growth, changes in BMR and changes in gastrointestinal tract (GIT) hormones cause a decreased intake of macronutrient and micronutrients, which results in the development of underweight (Emery, 2005). Inverserly, an increase or decrease in macronutrient and micronutrient intake causes changes in BMR (Emery, 2005).

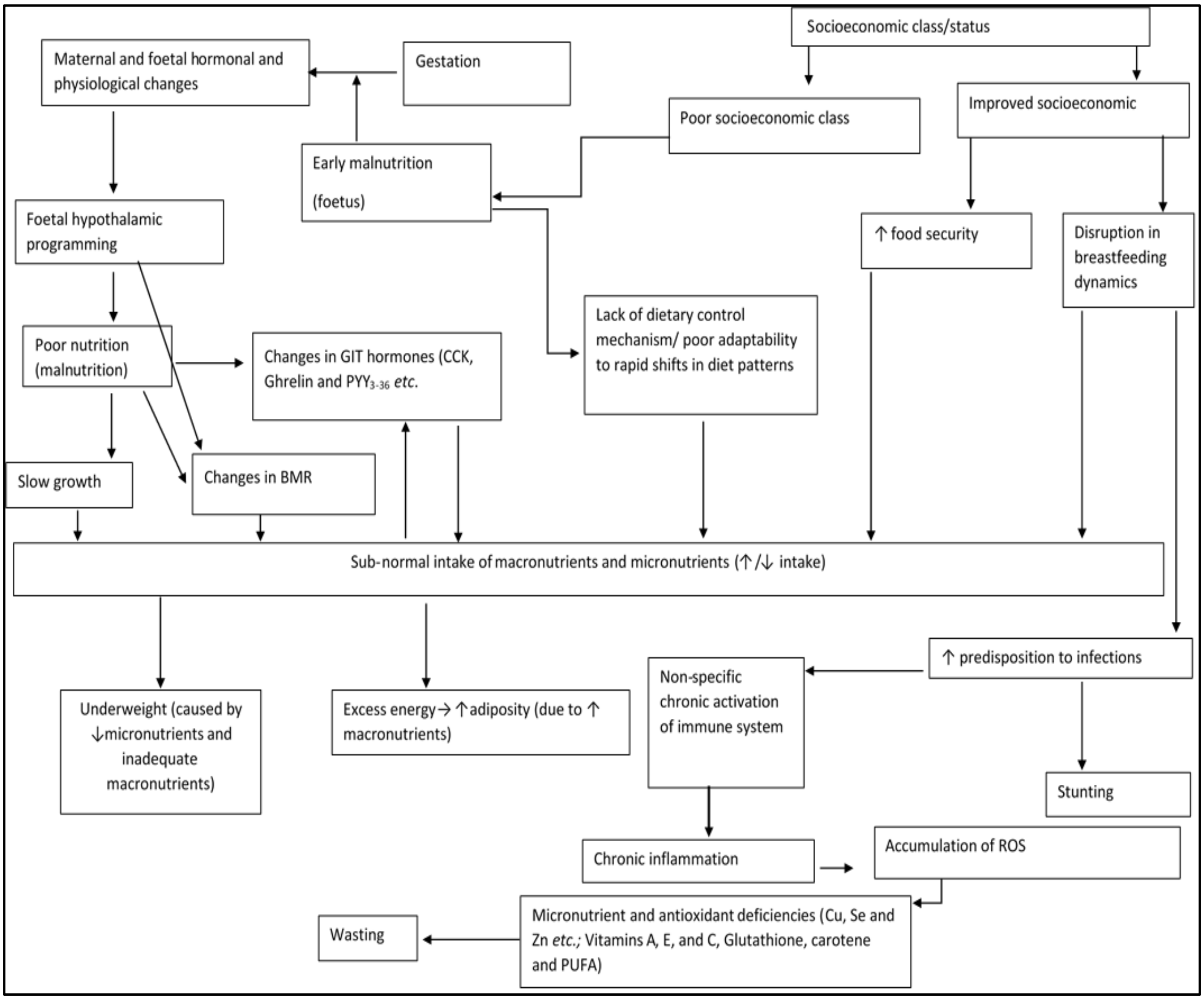

Figure 2.2: Causal mechanisms associated with undernutrition (stunting, wasting and underweight) (Constructed based on Huey & Mehta, 2016, Biswas & Bose, 2010, Aly *et al*., 2014, NHANES, 2010, Chen *et al*., 2012, Popkin *et al*., 1996, Darton-Hill & Mkparu, 2015 and Emery, 2005)

KEY: BMR = Basal metabolic rate, CCK = Cholecystokinin, PUFA = Polyunsaturated fatty acids, PYY_{3-36} = Peptide YY, ROS = Reactive oxygen species, Cu = Copper, Se = Selenium, Zn = Zinc

3.6 Complications associated with undernutrition

Complications associated with stunting, wasting and underweight include increased risk of mortality from infectious diseases such as diarrhoea, pneumonia, and measles (Black *et al*., 2013). Optimal growth and development in an infant is achieved between zero and six months through adequate dietary intake (Prendergast & Humphreys, 2014). Undernutrition is associated with increased likelihood of slow rate of developmental milestones and increases the risk of being overweight later in life (Bove *et al*., 2012). Complications associated with stunting before two to three years include poor cognitive and educational outcomes later in childhood and adolescence (Black *et al*., 2013). Stunting has been reported to be associated with poor education outcomes, especially in Africa and Asia, where it was reported that stunted children enrolled in school later than children of the same age (Murungi, 2012).

4 Summary

Malnutrition is an important public health concern in developing countries such as SA and is increasing alarmingly. The prevalence of malnutrition conditions (such as stunting, wasting, underweight, overweight/obesity) is increasing with urbanisation and modernisation. South African children are under a nutritional siege that stretches from stunting to obesity. However, the effect of urbanisation and modernisation on the development of these conditions and the co-occurance of stunting and overweight in South-African children, especially those residing in relatively poorer and rural provinces are not known.

Chapter Three: Research methodology

1 Introduction

Chapter Three outlines the methodology used to select the subjects, collect data and analyse the data for this cross-sectional study. The cut-off points for the different categories of malnutrition used during the analysis of data are also included.

2 Study area

This study included children from four primary schools in rural areas and four primary schools in urban areas of the PLM, Limpopo Province, SA. The selection of schools was done by the Limpopo Department of Basic Education and was based on the geographical areas in which the schools were located.

3 Study design

This cross-sectional study was conducted over a period of five months starting from May 2016. Anthropometric measurements and the questionnaire were only conducted once, but the 24-hour recall dietary assessment was conducted twice to include a week day and a weekend day.

4 Exclusion and inclusion criteria

The children with the following conditions were not included in the study population of the research:

- Children with cardiovascular conditions
- Children with respiratory complications such as asthma
- Children taking medications
- Children with some disabilities
- Children with injuries

Only children that met the following inclusion criteria were included in the study population of the research:

- Male and female children between the ages of six and nine years

- Children who brought back signed informed consent forms and completed questionnaires
- Children who gave ascent to participate in the study

5 Sample size and technique

The sample size for this study was calculated with the help of a qualified bio-statistician using Slovin's formula: $n = N / 1 + N(e)^2$ (Johnson & Christensen, 2012), where n is the sample size, N is the population size, and e is the level of precision (0.05). The population size of the primary school children was 433 and the sample size is 208, therefore $n = 208 / 1 + 208(0.05)^2$. Sampling was done by the researcher at the respective schools during school hours. A total of 208 randomly selected subjects were expected in this study, as described in **Table 3.1**. Four rural schools and four urban schools were included in the study. However, at one urban school the children between the ages of six to nine years did not bring back signed consent forms, therefore one urban school was excluded from the study. Furthermore, of all the seven schools that participated, only 174 consent forms came back signed by parents. Only children with signed consent forms were included in this study.

Table 3.1: Composition of the intended study population

Urban schools				**Rural schools**				**Total**
Gender	**Age**	**Per school**	**Total: 4 schools**	**Gender**	**Age**	**Per school**	**Total: 4 schools**	**8 schools**
Male	6-7	6	24	Male	6-7	6	24	48
	8-9	7	28		8-9	7	28	56
Female	6-7	6	24	Female	6-7	6	24	48
	8-9	7	28		8-9	7	28	56
Total		**26**	**104**			**26**	**104**	**208**

One urban school did not participate in the study.

6 Study population

Primary school children between the ages of six and nine were included in the study. Every effort was made to include an equal number of boys and girls across the study population, but it was not always possible. This is due to the fact that grade one learners include six and seven-year-old children, while puberty tends to start as early as the age of 10 years, therefore, children older than nine years were excluded to eliminate the effect of puberty-related hormone changes on the body composition of the children (Solorzano & Mc Cartney, 2010). Every effort was made to include 104 urban and 104 rural children in the study, but it was not possible. Only children with signed informed consent forms were allowed to participate in the study.

7 Research methodology

A cross-sectional study was conducted over a period of five months starting in May 2016. Anthropometric measurements and the questionnaire were only conducted once, but the 24-hour recall dietary assessment was conducted twice to include a week day and a weekend day. The sample size for this study was calculated with the help of a qualified bio-statistician using Slovin's formula: $n = N / 1 + N(e)^2$ (Johnson & Christensen, 2012), where n is the sample size, N is the population size, and e is the level of precision (0.05). The population size of the primary school children was 433 and the sample size is 208, therefore $n = 208 / 1 + 208(0.05)^2$. A total of 174 randomly selected subjects were included in this study. Sampling was done by the researcher at the respective schools during school hours. Weight and height measurements were used to calculate BMI, weight-for-height (WFH) and height-for-age (HFA) ratios (Mei *et al*., 2002). Skinfolds were used to calculate the body fat percentage (BF%) (Mei *et al*., 2002). The World Health Organisation's (WHO) 2007 cut-off points for BMI-for-age were used to classify wasting (thinness), overweight/obesity of the children. Criteria suggested by WHO (2007) were used to classify stunting and underweight. Z-scores were used to calculate undernutrition. All statistical analyses were performed using IBM SPSS Statistics version 23. Frequency distributions were calculated and checked for normal distribution. Any obviously incorrect outliers were checked against the questionnaires and data record sheets for correctness. Descriptive statistics were performed for all variables. Student's T-tests were used to compare rural and urban populations. Regression analyses were used to determine relationships between different variables, body fatness and nutritional status. Pearson correlatons were done to assess the relationship between BF% and nutrients, and a p-value of less than 0.05 was considered statistically significant.

8 Data collection

8.1 Organisational procedure

A formal letter for permission to conduct the study and a consent form was sent to the principals of the selected schools to give permission for the study to be conducted at the school (Addendum D). An appointment was made with the school to explain the study to the learners. Information letters and consent forms were sent to the parents to sign (Addendum E). The researcher distributed more consent forms than the number of participants wanted, to compensate for forms that may be lost or come back without the parent's signature. The researcher visited the school on a second occasion to collect the consent forms, conduct the first 24-hour recall assessment and take the anthropometric measurements. Each participating child received a questionnaire (Addendum F) to take home for the parents to complete as well as a feedback chart (Addendum G) with his/her results and their meaning. The researcher went to the school on a third occasion to collect the questionnaires and conduct the second 24-hour recall assessment. On some occasions, the researcher had to telephonically contact the primary care-giver of the child to clear up any uncertainties with regard to the dietary intake.

8.2 Questionnaire

Each participating child received a questionnaire (Addendum F) to take home with a request for the parents to complete. Parents were allowed to leave some questions unanswered, if they did not feel comfortable answering all the questions, especially those concerning family income and health status of the parents. The questionnaire also contained the contact details of the parents/guardians so that they could be contacted to verify the dietary intakes reported by the children. The questionnaire has been translated from English into Afrikaans and Sepedi (the native languages of most of the children in the geographic area) and backtranslated into English to ensure that the meaning of the questions remained the same throughout the translation process.

The questionnaire consists of the following sections:

- Section A: Demographic information
- Section B: Medical history
- Section C: Dietary information

- Section D: Physical activity information

8.3 Measuring malnutrition in children

8.3.1 Criteria for determining malnutrition in children

There are several anthropometric methods that can be used to measure malnutrition in children. In cases of a nutritional emergency, nutritional status is best measured with the following variables: gender, age, height, and weight. These variables are then used to calculate the different anthropometric indices, such as BMI-for-age, height-for–age (HFA), weight-for-height (WFH) and weight–for-age (WFA). In this study HFA, WFH, WFA and BMI for age were used to classify malnutrition. These methods are mostly used in literature because they are accurate and cost effective. Deficits in HFA are a sign of stunting and is usually a linear growth delay due to chronic insufficient food and nutrient intake and frequent infections (Das & Bose 2011); WFH index helps to identify children suffering from wasting and is an indicator of acute nutrient depreviation due to recent food shortage (famine) or illness (Corsi *et al*., 2015); and WFA index helps to identify the condition of being underweight for a specific age and is a result of short-term and long-term malnutrition (Faber & Wenhold, 2007). The index BMI for age is used to classify underweight, lean, overweight/obesity (Chung, 2015). Skinfolds are also used to calculate BF%, which can be used to classify overweight or obesity in children. Obesity is the excessive accumulation of fat in the body, resulting in adverse health effects such as the development of metabolic diseases (Osuji *et al*., 2010). The World Health Organisation (WHO) reference standards (WHO, 2007) were used to classify malnutrition in this study population. These criteria are summarised in **Table 3.2**.

Table 3.2: The criteria used to classify malnutrition in children aged six to nine years (WHO, 2007)

BMI for age	**SD-Z scores**
Severely thin and wasted	<-3 SD
Thin and wasted	≥-3 SD and < -2 SD
Normal weight	≥-2 SD and <+1 SD
Risk of overweight	≥+1 SD and <+2 SD
Overweight	+2 SD and < +3 SD
Obese	+3 SD
Height-for-age	**SD-Z scores**
Severely stunted	<-3 SD
Stunted	≥-3 SD and <-2 SD
Weight-for-age	**SD-Z scores**
Severely underweight	<-3 SD
Underweight	≥-3 SD and <-2 SD

8.3.2 Criteria for determining the recommended daily allowance of macronutrients and micronutrients in children.

The dietary reference intakes: recommended dietary allowance and adequates of micronutrients and macronutrients were used to classify malnutrition in this study population. These criteria are summarised in **Table 3.3.**

Table 3.3: The criteria used for determining recommended dietary allowance of micronutrients and macronutrients requirements for children between 4-13 years of age according to http://www.nap.edu/openbook.php?isbn=0309085373

Group	Vit A (µg/d)	Vit D (µg/d)	Ca (mg/d)	Fe (mg/d)	Zn (mg/d)	P (mg/d)	Protein (mg/d)	Carbohydrates (g/d)	Energy (kcal/d)
Children 4–8 years	400	15	1000	10	5	500	19	130	
Males 3–8 years									1.742
Females 3–8 years									1.642
Males 9–13 years	600	15	1300	8	8	1250	34	130	2.279
Females 9–13 years	600	15	1300	8	8	1250	34	130	2.071

Vit A = Vitamin A; Vit D = Vitamin D; Ca = Calcium; Fe = Iron; Zn = Zinc; P = Phosphorus;

8.3.3 Anthropometric measurements

Anthropometric measurements were taken by a trained staff using the standardized techniques of the ISAK (Marfell-Jones *et al*., 2006). The researcher in this study was trained to do anthropometric measurements. The following anthropometric measurements were taken: weight (kg) and height (cm), and the following skinfolds: triceps, subscapular, abdominal and suprailliac crest (all in mm). Weight was measured using an electronic scale, with subjects wearing minimal clothing. Height was taken using a portable stadiometer, with the head of the subject positioned in the Frankfort plane with the body standing upright. The children presented in minimal clothing for the skinfolds measurements. Prior to measuring the skin folds, landmarks were identified and marked, using a Lufkin Executive Thin line steel tape to measure the midpoints. A calibrated HaB Direct skinfold calliper was used to measure the skinfolds.

8.3.3.1 Anthropometric and nutritional status calculations

Body mass index was calculated by dividing mass (kg) into and height (m) squared (kg/m^2) and then used to calculate BMI-for-age, an indication of overweight/obesity (Chung, 2015). WFA index was calculated for each child to classify children as being underweight, overweight and obese for a specific age. HFA was calculated for each child to determine the prevalence of stunting. WFH was also calculated for each child as an indication of wasting. The equation of Brook (1971) was used to calculate and assess BF% from skinfold thickness, using the four skinfolds measured in this study.

These two Brook, (1971) equations were used to calculate density for males and females.

F: D = 1.2063–0.0999 (LOG sum of 4 skinfolds)

M: D = 1.1690–0.0788 (LOG sum of 4 skinfolds).

The following Lohman *et al* (1984) equation was used to calculate BF% for both males and females, the children were classified as as overweight or obese, M and F: Fat (%) = 530/D – 489.

8.4 Measuring dietary intake in children

There are different methods of assessing diet, such as diet records, diet history, weekly consumption of foods, 24-hour recall test, and food frequency questionnaires (Shim *et al*., 2014). It is extremely difficult to get accurate dietary information from children (Pérez-Rodrigo *et al*., 2015). Children tend to under- or over-report their nutrient intakes, the under-reporting of food intakes appears to be more common than over-reporting (Raina, 2013). However, parents can be contacted to verify food consumption.

The 24-hour recall test was used in this study in an effort to capture exactly what the children consumed immediately prior to a study visit, because it is cost effective and time efficient (Shim *et al*., 2014). Advantages of the 24-hour recall test are that it is quantifiable and does not alter eating behaviour (Shim *et al*., 2014). Compared to the food frequency questionnaire, the 24-hour recall test only requires children to recall a shorter time (one day) and it is therefore more accurate than the food frequency questionnaire (Shim *et al*., 2014). Accuracy can be further improved by contacting parents and/or caregivers to verify if the food reported by the child is correct. The disadvantages of the 24-hour recall test are that it relies on subject recall, requires multiple recalls, and it is a time consuming task to capture the data (Raina, 2013).

8.5 24-hour recall test

A 24-hour recall test was used to analyse the intake of macronutrients and micronutrients (minerals, vitamins and trace elements) in an individual. It requires subjects to report all foods and beverages consumed in the past 24 hours. This can be done via telephone or face-to-face interview. The test was done according to the guidelines in Wolmarans *et al*., (2009). It is best to repeat the 24-hour recall test at least twice to include one week-day and one week-end day. This is what was done in this study, each child was interviewed twice to report on a week day and a week-end day. Trained staff must conduct the interview to prompt for details, such as cooking methods and portion sizes. This researcher was trained to do a 24-hour recall. The data from the 24-hour recall test is usually coded and analysed using software such as the FoodFinder developed by the South Africa Medical Research Council (SAMRC) (Wolmarans *et al*., 2009).

Recommended energy and nutrient intakes vary according to gender and age. Information from the 24-hour recall test was used to calculate total energy intake as well as the percentage energy that was contributed by some of the macronutrient groups and was compared to the RDAs for each individual. Similarly, all macronutrient and micronutrient intakes were calculated for each individual and compared to RDAs for that age and gender group. The test was done according to the guidelines in Wolmarans *et al*., (2009) and the results from both the week day and week-end day were coded and analysed using the FoodFinder software developed by the SAMRC (Wolmarans *et al*., 2009).

9 Statistical analysis

All measurements have been expressed statistically using IBM SPSS Statistics version 23. The distribution of data was tested for normality using histograms and line graphs. Descriptive statistics were performed for the analyses of demographic and health information. Frequencies and percentages were used to interpret demographic and health information of the children, and to indicate the prevalence of malnutrition. The Student's T-test was used to compare rural and urban populations, and chi-square tests were performed and frequencies and percentages were presented for the comparison of the prevalence of stunting, wasting, underweight, overweight, and obesity between rural and urban children. A *p*-value of less than 0.05 was considered statistically significant.

To assess the prevalence of risk factors for the development of stunting, wasting, underweight, overweight/obesity in children, descriptive statistics was presented as means and standard deviation (±SD) and frequencies and percentages. Chi-square test was performed and a *p*-value of less than 0.05 was considered statistically significant.

Pearson correlatons were done to assess the relationship between BF% and nutrients, and a *p*-value of less than 0.05 was considered statistically significant.

10 Ethical considerations

This study was ethically approved by the University of Limpopo Ethics committee, project number (TREC/103/2017: PG) (Addendum A). Permission to collect data at the selected schools was granted by the Limpopo Department of Education and the Mankweng circuit offices respectively. The purpose of the study, the extent of their involvement, and what will happen to their private information was explained to the participants and their parens/guardians in the letter that accompanied the informed consent form. Thus both the participants and parents knew what the procedures involved before they gave consent to participate in the study. Parents of participating children gave informed consent on behalf of the child to participate in the study. Before data collection on any child commenced, the child was asked for ascent. The participants were also informed that the research was voluntary and if any individual chose to withdraw from the research he/she could do so at any time. In case some questions to the participants might sound offensive and uncomfortable to respond to, they were informed not to respond.

11 Reliability, viability and objectivity

For all anthropometric measurements, two values were taken and a third value was taken if the first two measurements differed too much the median was used. A BMI value larger than 60, Z-scores higher than 9.0 and Z-scores less than 0.9 were excluded as invalid.

12 Bias

The fact that the study population was not randomly selected could have introduced selection bias to the study. The Department of Basic Education selected the schools that participated in the study and the first children in each age and gender group who brought back signed consent forms was selected to participate in the study. The number of participants from the rural area was higher than the number of participants from the urban area (one of the schools in the urban area did not participate in the study because no signed informed consent forms were returned) and this could also have led to some bias. The same structured questionnaire was used for all the respondents to ensure consistency. For accurate results, two measurements were taken in each test and the average was used. There are many factors that affect and influence skinfold measurements such as tight skin, too much body fat, body lotion, and injuries. These factors may have affected the accuracy of the results.

Chapter Four: Presentation and interpretation of findings

1 Introduction

Chapter Three outlined the methodology used in this study. This chapter presents and interprets the results of the study. Tables and graphs are used to explain the results. The results are presented according to the sections of the questionnaire. Furthermore, the chapter is subdivided according to the objectives of the study, with the exception that the first section of the chapter is devoted to demographic and descriptive statistics to give an overview of the study population.

2 Demographic profile and medical history of the study participants

One hundred and seventy-four children participated in this study, giving a response rate of 84% (174/208). Every effort was made to include 104 urban and 104 rural children in the study, but only 174 children returned signed informed consent forms and this is dispite the fact that more than 208 forms were distributed. Of the 174 children in this study, 61% (106 children) were from the rural area and 39% (68 children) from the urban area. This is because there was a higher response rate from participants in rural areas than in urban areas.

2.1 Age distribution of the children

All the children were between the ages of six and nine years. The age distribution of the children is shown in **Figure 4.1**. The majority (40%) of the children were eight years old, followed by 28% aged seven years and 23% aged nine years. This was because this age group had the highest response rate and included children from grade 1–4. Few of the children were six years old (9%) because the majority of six-year-old children were still in pre-schools and have thus not been included in this study.

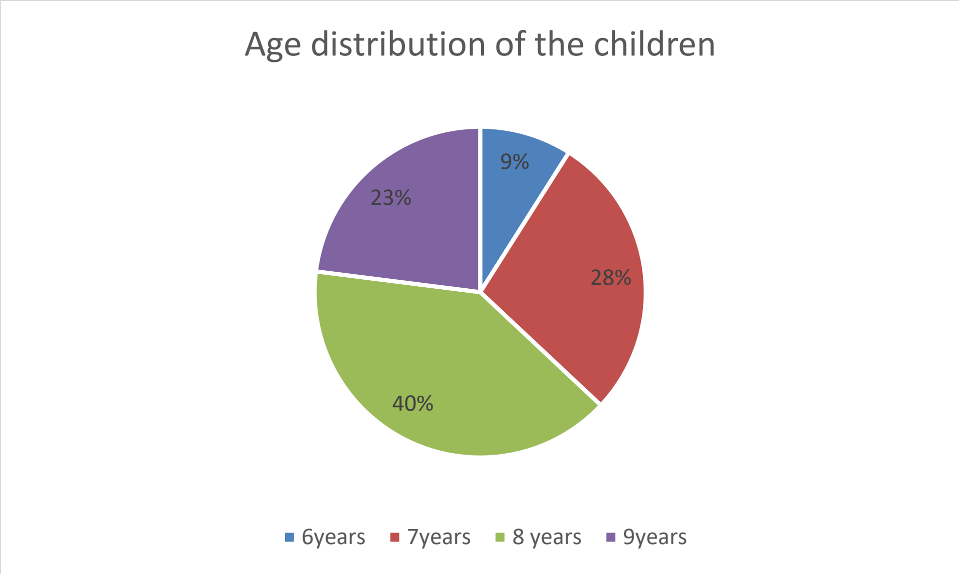

Figure 4.1: The age distribution of the children who participated in this study

2.1.1 The age distribution of the children in the rural versus the urban areas

The age distribution of children in the rural areas versus the urban areas is given in **Table 4.1**. From the table it is clear that for ages six and eight years there were more respondents from the rural areas, but for ages seven and nine years, there were more respondents from the urban areas. The reasons for this discrepancy are not clear, the response rate from the schools in the urban area was generally poor.

Table 4.1: The age distribution of children from urban versus rural areas

Area	Rural (n=106)		Urban (n=68)	
	Age (years)	Frequency (%)	Age (years)	Frequency (%)
	6	14.2	6	1.5
	7	23.6	7	33.8
	8	44.3	8	32.4
	9	17.9	9	32.4

2.1.2 The age distribution of the children between males and females

Table 4.2 below shows the age distribution of the children between males and females. Females of all ages had higher response rates than males. This is due to the fact that the response rate for females in the total population was higher (57%) than for males (43%).

Table 4.2: The age distribution of the children between males and females

Age (years)	Gender	
	Male	Female
	Frequency (%)	Frequency (%)
6	3.5	5.8
7	10.3	17.2
8	18.9	20.7
9	9.8	13.8

2.2 Gender distribution of the children

Every effort was made to include an equal number of females and males in the study; however, the response rate showed that more than half (57%) of the children were females, and only 43% were males. The rural population had 42.4% males and 57.6% females while the urban population had 42.6% males and 57.4% females. Thus, although they were not exactly equal, the gender proportions of the rural and urban populations compared well.

2.3 Age distribution of the parents/guardians

Mothers who are young have an increased risk of giving birth to children who have low birthweight (Aras, 2013). The age distribution of the participants' parents/guardians is shown in **Figure 4.2**. The largest proportion (40%) of the parents/guardians was in the age group 30–39 years, followed by those in the age group 40–49 years (21%). This shows that the majority of the children stayed with their parents or a guardian between the ages of 30 and 49 years. However, a few of the children clearly stayed with their grandparents (over the age of 60 years). In some cases, the parent/guardian was not willing to disclose his/her age, resulting in the "unspecified" group. Thus the majority of the children who participated in this study lived with parents who were clearly above the age of 20 years while being pregnant with these children.

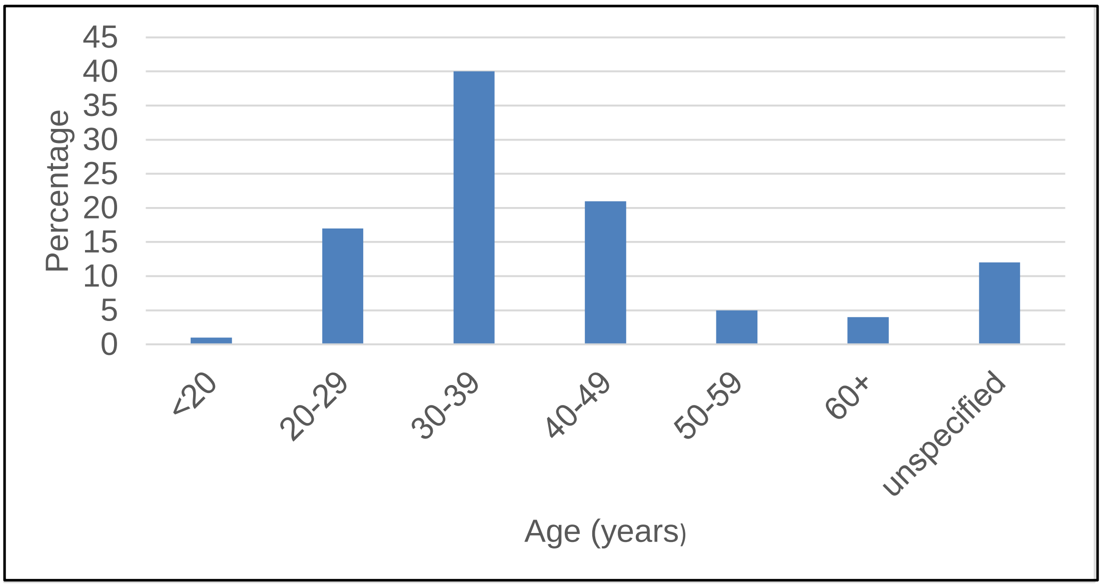

Figure 4.2: Age distribution of the parents/guardians

2.4 Monthly household income

Household monthy income is shown in **Table 4.3** below. Monthly income was grouped into three categories, namely: low-income (less than R1000), middle-income (R1000–R5000) and high-income (R5100–R10 000+) households. More than 20% of the families were in the low-income group with an income of less than R1000 per month and this means that the parents of the children may have been unemployed and depended on social grants or worked unskilled jobs which pay less. Nearly two-thirds (61%) of the parents reported that their monthly income was R5000 or less and only 39% reported an income of more than R5000. Thus the majority of participants in this study were from the middle-income group.

Table 4.3: Monthly household income

Income (per month)	Frequency (%)
< R1000	24.06
R1000–R5000	36.84
R5100–R10 000	13.53
R10 000+	25.56

2.5 Monthly household income between urban and rural population

A comparison of the monthy household income of the parents between urban and rural area is given in **Figure 4.3.** In the rural area 54.14% of respondents reported a monthly income of R5000 or less, compared to 6.77% respondents from urban areas. Approximately 1.5% rural parents reported that their monthly income was more than

R5000, while 37.29% urban parents reported that their monthly income was more than R5000. Thus, as expected the incomes in rural areas were less than that of families residing in urban areas. This will have an impact on the socio-economic status of the children who participated in the study.

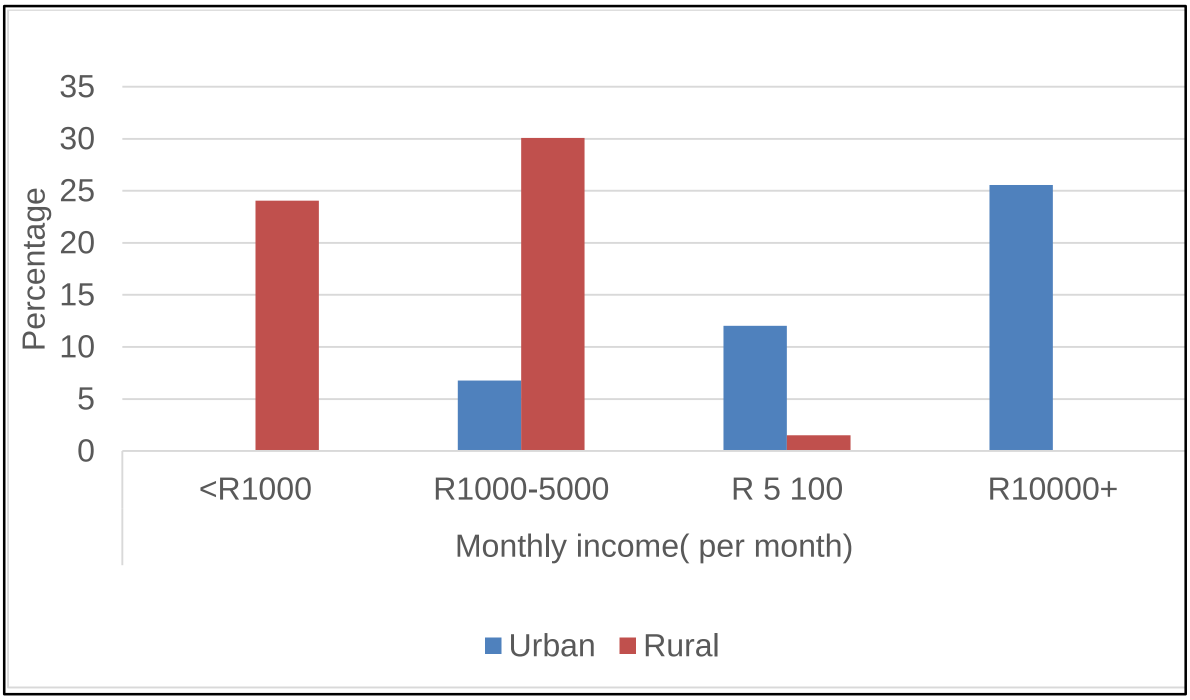

Figure 4.3: Monthy household income of urban and rural population

2.6 Availability of motor vehicle

Thirty-six percent of the parents/guardians reported that they own a motor vehicle, while 64% had no motor vehicle. This may be because the majority (54.14%) of parents were from rural areas with a low monthly income (R5000 or less) and cannot afford to buy a motor vehicle.

2.7 Parents medical history

Due to genetics and shared environmental risk factors, many CDL, including obesity runs in families (Chamieh *et al*., 2015) and this might increase the risk of the children to develop CDLs later in life. The medical history of the parents in this study is shown in **Figure 4.4.** Twenty per cent of the parents reported that they had diabetes mellitus, 16% hypertension, 9% stroke and 7% reported that they had high cholesterol. The majority (78%) of parents/guardians were between 20–49 years, this might be why they were still relatively healthy. In a few years' time this profile may look significantly different, because the prevalence of these diseases is known to increase with increasing age.

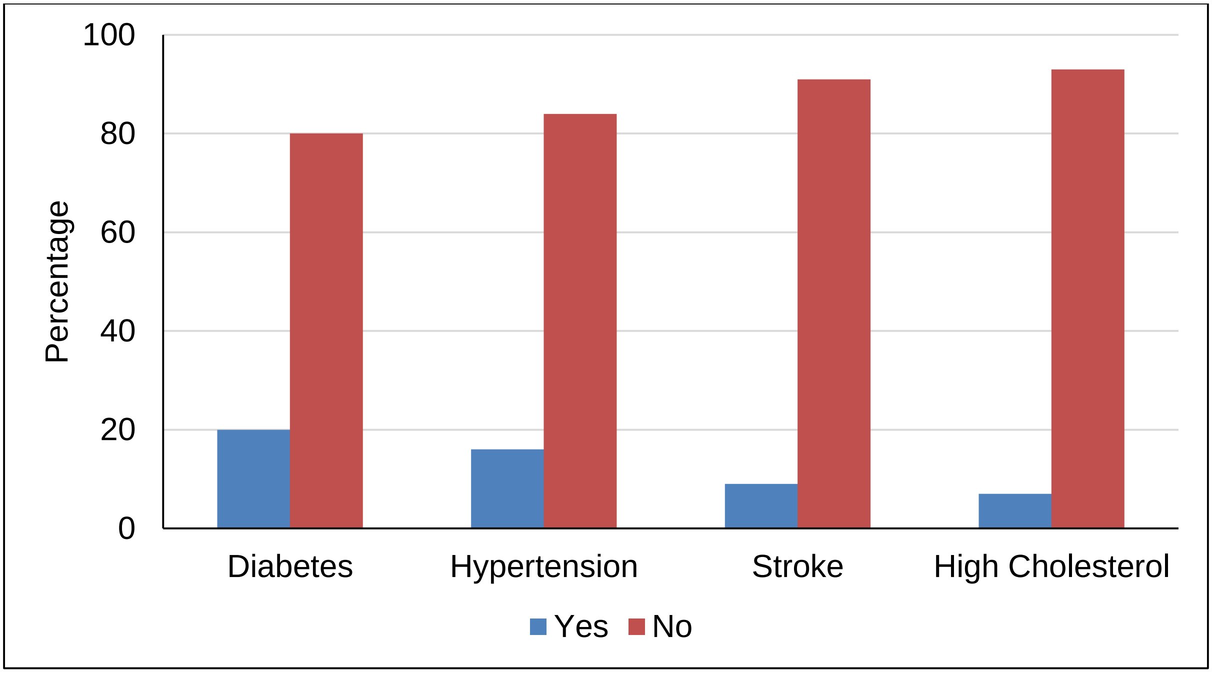

Figure 4.4: Medical history of selected non-communicable diseases in parents/guardians

3 Prevalence of malnutrition (stunting, wasting, underweight, overweight/obesity) in children between urban and rural areas

Table 4.4 below shows the descriptive statistics of anthropometric measurements between urban and rural population. Children in urban areas had significantly higher mean values of anthropometric measurements as compared to those in rural areas.

From **Table 4.4** it is clear that the HFA, WFH, WFA and BF% of the rural children were significantly lower than that of the urban children. This clearly indicates that the markers of undernutrition are significantly more pronounced in the rural compared to the urban population. On the other hand, since the mean BF% of the urban population was significantly higher than that of the rural population it indicates that the children living in urban environments have significantly more body fat than those living in rural environments.

Table 4.4: Descriptive statistics of anthropometric measurements and calculations used to determine nutritional status in the urban and rural population

Indices	Area		Total	P value
	Rural	Urban		
	Mean(±SD)	Mean (±SD)	Mean (±SD)	
Weight	24.78(5.28)	32.14(11.35)	27.98(8.84)	0.000
Height	1.24(0.08)	1.29(0.09)	1.26(0.09)	0.001
Age	7.66(0.94)	7.96(0.85)	7.78(0.91)	0.037
Height for age (stunting)	124.55(8.13)	128.69(8.92)	146(8.66)	0.002
Weight for height (wasting)	15.87(2.06)	18.89(4.87)	17.03(3.71)	0.000
Weight for age (underweight)	24.78(5.28)	32.14(11.35)	27.98(8.84)	0.000
Triceps	7.52(3.47)	12.89(8.23)	9.57(6.30)	0.000
Subscapular	5.22(2.29)	10.92(9.72)	7.39(6.82)	0.000
Abdominal	5.82(3.89)	13.93(12.53)	8.91(9.17)	0.000
Suprailliac crest	5.72(4.02)	13.61(12.56)	8.72(9.17)	0.000
Body fat percentage (overweight/obese)	12.13(5.02)	18.27(9.23)	14.49(7.54)	0.000

BMI = body mass index

Table 4.5 below shows the measurements/calculations used to measure the prevalence of stunting, wasting, underweight, overweight/obesity as an indication of malnutrition in children from urban and rural areas. Cut-off values used to classify children into each of the malnutrition categories were given in **Table 3.2** in Chapter 3. Overweight/obesity were considered as one entity because there were insufficient results of obese children.

In this study population, prevalence of stunting was 14%, wasting 6% and underweight 20% **(Table 4.5)**. A higher proportion of rural children were stunted, wasted and underweight as compared to urban children, however, the results for stunting and underweight were not statistically significant ($p > 0.05$). Thus despite the fact that the mean values for these indicators of undernutrition were significantly lower in the rural than in the urban population, the prevalence of two of the markers for under nutrion (stunting and underweight) were not significantly lower in the urban than in the rural population.

According to the WHO's BMI-for-age criteria, the prevalence of overweight/obesity was 26% in this study population. A significantly greater proportion of urban children were overweight and obese as compared to those in rural areas (p < 0.05). This is in accordance with the fact that the urban population had a significanty higher mean percentage body fat compared to the rural population.

Table 4.5: Prevalence of stunting, wasting, underweight, overweight/obesity

	n = 174	**Urban (n = 68)**	**Rural (n = 106)**	***p*-values**
		Number (%)	**Number (%)**	
Height for age:				
Stunting	24 (14%)	8 (12%)	16 (15%)	0.534
Weight for height:				
Wasting	11 (6%)	1 (2%)	10 (9%)	**0.035**
Weight for age:				
Underweight	35 (20%)	11 (16%)	24 (23%)	0.299
BMI for age:				
Overweight/obesity	45 (26%)	27 (40%)	18 (17%)	**0.001**

4 Prevalence of risk factors for stunting, wasting, underweight, overweight/obesity

Tables 4.6 to 4.9 display the same risk factors for the various types of malnutrition; these risk factors are: gender, child's age, birth weight, mother's age, gestational age at birth, monthly household income, area, sedentary time, mode of transport to school, breastfeeding, consumption of sweets, biscuits and /or cake, takeaways, cold drinks and fresh fruit.

4.1 Stunting

Table 4.6 displays the risk factors for stunting. It is clear that there was a significant relationship (p=0.0030) between gender and stunting, with males having had a higher prevalence of stunting than females. Furthermore, there was a significant relationship (p=0.0158) between stunting and birth weight, with the stunted children having lower birth weights compared to those who were not stunted. However, the mean birthweight of stunted children was within normal ranges, but at the lower limit of normal (normal being considered as 2.99kg). There were no significant relationships between any of the other risk factors and stunting.

Table 4.6: Risk factors for stunting

Risk factors	**n = 174**	**Stunted**		***p*-value**
		Yes, n (%)	**No, n (%)**	
Gender				
Male	74	17 (23)	57 (77)	**0.0030**
Female	100	7 (7)	93 (93)	
Child's age				
6	16	1 (6)	15 (94)	0.3710
7	48	10 (21)	38 (79)	
8	69	8 (12)	61 (88)	
9	41	5 (12)	36 (88)	
Birth weight (mean ± sd)	120	2.9 ± 0.6	3.3 ± 0.6	**0.0158**
Mother's age at pregnancy	146	28.1 ± 6.9	26.7 ± 5.9	0.3531
Gestational age (mean ± sd)	116	37.6 ± 2.6	37.9 ± 2.8	0.6313
Monthly income				
< R1000	32	5 (16)	27 (84)	0.9590
R1000–R5000	49	7 (14)	42 (86)	
R5100–R10 000	18	3 (17)	15 (83)	
R10 000+	34	4 (12)	30 (88)	
Area				
Rural	106	16 (15)	90 (85)	0.5340
Urban	68	8 (12)	60 (88)	
Sedentary hours (mean ± sd)		5.4 ± 6.6	7.3 ± 7.2	0.3146
Mode of transport to school				
Walk/run	79	8 (10)	71 (90)	0.7330
Bus/car	76	9 (12)	67 (88)	
Breastfeeding				
Yes	137	14 (10)	123 (90)	0.7200
No	14	2 (14)	12 (86)	
Don't know	5	1 (20)	4 (80)	
Times per week that sweets, biscuits and /or cake are consumed (mean ± sd)		2.9 ± 1.3	3.1 ± 1.9	0.7234
Times per week that take away meals are consumed (mean ± sd)		1.6 ± 1.8	1.6 ± 1.5	0.9910
Times per week that cold drinks are consumed (mean ± sd)		4.0 ± 1.9	4.5 ± 4.8	0.6531
Times per week that fresh fruit are consumed (mean ± sd)		4.5 ± 2.2	4.3 ± 2.7	0.7258

4.2 Wasting

Table 4.7 displays the risk factors for wasting in this study population.

Table 4.7: Risk factors for wasting

Risk factors	**n = 174**	**Wasted**		***p*-value**
		Yes, n (%)	**No, n (%)**	
Gender				
Male	74	20 (27)	54 (73)	**0.0500**
Female	100	15 (15)	85 (85)	
Child's age				
6	16	3 (19)	13 (81)	0.9790
7	48	10 (21)	38 (79)	
8	69	13 (19)	56 (81)	
9	41	9 (22)	32 (78)	
Birth weight (mean ± sd)	120	3.0 ± 0.44	3.2 ± 0.59	0.0734
Mother's age at pregnancy	146	26.6 ± 7.7	26.9 ± 5.8	0.8006
Gestational age (mean ± sd)	116	38.6 ± 2.2	37.8 ± 2.8	0.2300
Monthly income				
< R1000	32	8 (25)	24 (75)	0.2350
R1000–R5000	49	13 (27)	36 (73)	
R5100–R10 000	18	4 (22)	14 (78)	
R10 000+	34	3 (9)	31 (91)	
Area				
Rural	106	24 (23)	82 (77)	0.2990
Urban	68	11 (16)	57 (84)	
Sedentary hours (mean ± sd)		4.1 ± 2.2	7.7 ± 7.7	**0.0199**
Mode of transport to school				
Walk/run	79	22 (28)	54 (68)	0.4000
Bus/car	76	6 (8)	70 (92)	
Breastfeeding				
Yes	137	26 (19)	111 (81)	0.4460
No	14	2 (14)	12 (86)	
Don't know	5	2 (40)	3 (60)	
Times per week that sweets, biscuits and /or cake are consumed (mean ± sd)		3.3 ± 1.4	3.0 ± 1.9	0.4536
Times per week that take away meals are consumed (mean ± sd)		1.8 ± 2.1	1.6 ± 1.2	0.4452
Times per week that cold drinks are consumed (mean ± sd)		4.9 ± 3.5	4.3 ± 4.7	0.5536
Times per week that fresh fruit are consumed (mean ± sd)		4.5 ± 3.7	4.2 ± 2.4	0.5306

As for stunting there was a significant relationship (*p*=0.0500) between wasting and gender, with males having had a higher prevalence of wasting than females. There was also a significant relationship (*p*=0.0199) between wasting and time spent on sedentary activities. The mean time spent on sedentary activities per day was less for the wasted children than for those who were not wasted (4.1 hours and 7.7 hours respectively). Thus, wasted children may have been more active, resulting in a lower body weight than those who were not wasted. There was no significant relationship between any of the other risk factors and wasting. However, as in the case of stunting the mean birth weight of wasted children was less than that of the children who were not wasted (3.0kg and 3.2kg respectively), but in contrast with stunting, the relationship was not significant (*p*=0.0734).

4.3 Underweight

Table 4.8 displays the risk factors for underweight. There was a significant difference (*p*=0.0500) between gender and underweight, with the prevalence of underweight being higher in males than in females (27% and 15% respectively). The same was observed for stunting and wasting. There was no significant relationship between underweight and any of the other risk factors. However once again the mean birth weight for the stunted children was lower than that of the children who were not underweight (3.0kg and 3.2kg respectively). As was the case with wasting, this relationship was not significant.

Table 4.8: Risk factors for underweight

Risk factors	**n = 174**	**Underweight**		***p*-value**
		Yes, n (%)	**No, n (%)**	
Gender				
Male	74	20 (27)	54 (73)	**0.0500**
Female	100	15 (15)	85 (85)	
Child's age				
6	16	3 (19)	13 (81)	0.9790
7	48	10 (21)	38 (79)	
8	69	13 (19)	56 (81)	
9	41	9 (22)	32 (78)	
Birth weight (mean ± sd)	120	3.0 ± 0.45	3.2 ± 0.59	0.0734
Mother's age at pregnancy	146	26.5 ± 7.7	26.9 ± 5.8	0.8006
Gestational age (mean ± sd)	116	38.6 ± 2.2	37.8 ± 2.8	0.2300
Monthly income				
< R1000	32	8 (25)	24 (75)	0.2350
R1000–R5000	49	13 (27)	36 (73)	

Risk factors	n = 174	Underweight		p-value
		Yes, n (%)	No, n (%)	
R5100–R10 000	18	4 (22)	14 (78)	
R10 000+	34	3 (8.8)	31 (91.2)	
Area				
Rural	106	24 (23)	82 (77)	0.2990
Urban	68	11 (16)	57 (84)	
Sedentary hours (mean ± sd)	7.1±7.1	5.4 ± 6.5	7.2 ± 7.1	0.3146
Mode of transport to school				
Walk/run	79	17 (22)	62 (78)	0.2540
Bus/car	76	11 (14)	65 (85)	
Breastfeeding				
Yes	137	26 (19)	111 (81)	0.4460
No	14	2 (14)	12 (86)	
Don't know	5	2 (40)	3 (60)	
Times per week that sweets, biscuits and /or cake are consumed (mean ± sd)	3.1 ± 1.8	3.3 ± 1.4	3.0 ± 1.9	0.4536
Times per week that take away meals are consumed (mean ± sd)	1.6 ± 1.5	1.8 ± 2.1	1.6 ± 1.2	0.4452
Times per week that cold drinks are consumed (mean ± sd)	4.5 ± 3.5	4.9 ± 3.5	4.3 ± 4.7	0.5535
Times per week that fresh fruit are consumed (mean ± sd)	4.3 ± 2.7	4.6 ± 3.7	4.2 ± 2.4	0.5306

4.4 Overweight/obesity

Table 4.9 displays the risk factors for overweight/obesity. There was a significant association between overweight/obesity and monthly income (p=0.0210), area (p=0.0001), time spent on sedentary activities per day (p=0.0056), mode of transport to school (p=0.0320), as well as breastfeeding (p=0.0560). From the Table it is clear that the overweight/obese population tend to have a higher monthly household income than those who were not overweight/obese. Only 17% of the rural population were overweight/obese, while 40% of the urban population were overweight/obese, thus living in an urban environment seems to increase the risk for overweight/obesity in this population. The mean number of hours per day spent on sedentary activities was 9.6 hours for the overweight/obese population and only 6.1 hours per day for the non-overweight/-obese population. Of the children who walked or ran to school only 19% were overweight/obese, but 34% of those who were driven to school in a car or bus, were overweight/obese. Of the children who were breastfed only 26% were overweight/obese, while 50% of those who were not breastfed were overweight/obese.

Table 4.9: Risk factors for overweight/obesity

Risk factors	**n = 174**	**Overweight/Obese**		***p*-value**
		Yes, n (%)	**No, n (%)**	
Gender				
Male	74	17 (23)	57 (77)	0.4540
Female	100	28 (28)	72 (72)	
Child's age				
6	16	2 (13)	14 (87)	0.5980
7	48	12 (25)	36 (75)	
8	69	20 (29)	49 (71)	
9	41	11 (27)	30 (73)	
Birth weight (mean ± sd)	120	3.4 ± 0.7	3.2 ± 0.5	0.1010
Mother's age at pregnancy	146	26.9 ± 5.3	26.8 ± 6.4	0.9377
Gestational age (mean ± sd)	116	38.1 ± 2.2	37.9 ± 2.9	0.7471
Monthly income				
< R1000	32	7 (22)	25 (78)	**0.0210**
R1000–R5000	49	10 (20)	39 (80)	
R5100–R10 000	18	5 (28)	13 (72)	
R10 000+	34	17 (50)	17 (50)	
Area				
Urban	68	27 (40)	41 (60)	**0.0001**
Rural	106	18 (17)	88 (83)	
Sedentary hours (mean ± sd)		9.6 ± 9.2	6.1 ± 5.9	**0.0056**
Mode of transport to school				
Walk/run	79	15 (19)	64 (81)	**0.0320**
Bus/car	76	26 (34)	50 (66)	
Breastfeeding				
Yes	137	35 (26)	102 (74)	**0.0560**
No	14	7 (50)	7 (50)	
Don't know	5	-	5 (100)	
Times per week that sweets, biscuits and /or cake are consumed (mean ± sd)		3.2 ± 2.1	3.1 ± 1.7	9.7189
Times per week that take away meals are consumed (mean ± sd)		1.6 ± 1.2	1.6 ± 1.6	0.9182
Times per week that cold drinks are consumed (mean ± sd)		5.3 ± 7.6	4.1 ± 2.6	0.1515
Times per week that fresh fruit are consumed (mean ± sd)		4.4 ± 3.0	4.2 ± 2.6	0.6670

Thus it seems as if belonging to a lower socio-economic group, living in an urban area, spending more time on sedentary activities, being driven to school and not being breastfed as a baby, were associated with overweight/obesity in this study population. With regards to income, the middle and high income groups seem to have been more likely to be overweight/obese. Being breast fed was associated with not being overweight/obese, but despite this fact, 50% of children who were not breastfed were not overweight/obese. This may be because there are so many different risk factors that play a role in the development of overweight/obesity, and if a baby was not breastfed, but were not exposed to many of the other risk factors for overweight/obesity he/she will not necessarily develop the condition.

Table 4.10 below shows the descriptive statistics of the food consumption per week in the urban and rural population. It is clear that urban children consumed significantly more fresh fruit (p=0.027) and take away meals (p=0.017) than the rural children. The consumption of sweets, biscuits, cakes and cold drinks did not differ significantly between the two populations, but consumption of these products were higher in the urban than in the rural population. This is an indication that the urban population is following a more western, energy dense diet than the rural population. Take away meals are known to be rich in fat and refined carbohydrates and are therefore energy dense (You & Henneburg, 2016).

Table 4.10: Descriptive statistics for food consumed per week in the urban and rural population

Variables	**Area**		**P value**
	Rural	**Urban**	
	Mean(±SD)	**Mean (±SD)**	
Times per week that sweets, biscuits and /or cake are consumed	3.01(1.78)	3.25(1.91)	0.284
Times per week that cold drinks are consumed	4.00(1.41)	5.73(6.09)	0.583
Times per week that fresh fruit are consumed	4.00(2.65)	4.78(2.67)	**0.027**
Times per week that take away meals are consumed	2.84(1.90)	4.33(0.71)	**0.017**

5 Pearson correlation between weekday and weekend dietary intake and body fat percentage of the study population

Dietary analysis was done for 56 (32%) of the total study population, to investigate a possible correlation between weekday and weekend dietary intake and BF% in this study. Food finder was only able to calculate the micronutrients and macronutrients for children shown in **Table 4.11** and **Table 4.12** below.

Table 4.11: Descriptive statistics of weekday macronutrients and micronutrients between urban and rural population

	Area		Total	P value
Variables	Rural	Urban		
	Mean(±SD)	Mean (±SD)	Mean (±SD)	
Total energy	43.13(17.13)	43.99(19.73)	43.59(18.41)	0.863
Total protein	101.30(49.29)	86.29(37.91)	93.26(43.81)	0.204
Ca	38.33(31.38)	28.17(23.81)	32.89(27.84)	0.176
Fe	49.08(27.62)	48.83(26.02)	48.95(26.53)	0.973
P	63.51(37.20)	56.50(28.91)	59.76(32.91)	0.432
Zn	31.35(15.13)	32.45(15.32)	31.94(15.11)	0.788
Vit A	48.96(48.56)	34.01(48.09)	40.95(48.45)	0.253
Vit D	58.60(52.67)	16.41(22.63)	35.91(44.52)	**0.000**

Table 4.12: Descriptive statistics of weekend macronutrients and micronutrients between urban and rural population

	Area		Total	P value
Variables	Rural	Urban		
	Mean(±SD)	Mean (±SD)	Mean (±SD)	
Total energy	32.27(12.28)	40.81(27.24)	38.99(22.35)	**0.035**
Total protein	80.23(47.51)	85.44(38.93)	83.02(42.84)	0.654
Ca	12.41(8.04)	24.00(24.68)	18.66(16.90)	**0.027**
Fe	32.00(18.88)	45.20(41.84)	39.07(33.60)	0.144
P	37.35(14.75)	48.61(30.07)	43.43(24.66)	0.086
Zn	28.41(21.05)	28.90(17.94)	28.71(19.27)	0.937
Vit A	14.09(22.76)	27.82(48.55)	21.44(39.06)	0.192
Vit D	10.88(10.71)	17.74(17.19)	14.56(14.83)	0.085

All the children attending school in rural areas had the privIlege of getting lunch at school as part of the government feeding scheme, while only one of the urban schools had a feeding scheme for some of the children. From **Table 4.11** it can be seen that the nutrient consumption of children in rural and urban areas did not differ significantly, except for Vit D consumption which was significantly higher in the rural population. The reason for the higher Vit D intake in the rural population is not clear, but may perhaps be explained by the fact that all rural children ate lunch prepared at school as part of the feeding scheme, while only a small number of urban children received lunch at school. According to **Table 4.12** it is clear that during weekends when rural children do not have the benefit of the feeding scheme, the total energy intake and Ca intakes of the rural children were significantly lower than that of the urban children. The Vit D intake of the rural children over weekends was not significantly higher than that of the urban children (as during the week), in fact over weekends rural children consumed less Ca than urban children. These results clearly indicate the benefit of general school feeding schemes in rural areas.

Table 4.13: Pearson correlation between weekday dietary intake and body fat percentage of the study population

	Pearson correlation factor (*r*)	**Significance (*p*)**
Energy	-0.091	0.507
Protein	-0.185	0.171
Ca	-0.216	0.110
Fe	0.060	0.659
P	-0.169	0.214
Zn	-0.025	0.854
Vit A	-0.301	**0.024**
Vit D	-0.344	**0.009**

Ca = Calcium, Fe = Iron, P = Phosphorus, Zn = Zinc, Vit A = Vitamin A; Vit D = Vitamin D

Table 4.13 displays the results for the Pearson correlation between weekday dietary intake and BF%. There were statistically significant, but negative relationships between Vit A (p=0.024; r=-0.301) and Vit D (p=0.009; r=-0.344) intake and BF% however, there were no statistically significant associations between total energy intake, consumption of proteins, consumption of micronutrients (Ca, Fe, P, Zn) and BF%.

Table 4.14: Pearson correlation between weekend dietary intake and body fat percentage of the study population

	Pearson correlation factor (*r*)	Significance (*p*)
Energy	0.011	0.934
Protein	0.019	0.890
Ca	0.069	0.616
Fe	0.089	0.514
P	0.047	0.731
Zn	0.008	0.951
Vit A	0.033	0.809
Vit D	-0.119	0.383

Ca = Calcium, Fe = Iron, P = Phosphorus, Zn = Zinc, Vitamin A = Vit A; Vitamin D = Vit D

Table 4.14 displays the results for the Pearson correlation between weekend dietary intake and BF%. There were no statistically significant associations between total energy intake, consumption of proteins, consumption of micronutrients (Ca, Fe, P, Zn, Vit D and A) ($p > 0.05$) and BF%.

The absence of significant associations between energy intake and BF% may indicate that the nutritional data collected were not sufficiently accurate, but it may also indicate that there are numberous other factors that influence BF%, and mask the effect of energy intake.

Chapter Five: Discussion

1 Introduction

In Chapter Four, the results of the study were presented and interpreted. This chapter discusses the implication of the major findings as presented in Chapter Four. Furthermore, findings of the current study were compared with, and discussed in the light of previous studies. The objectives of this study were to: compare the prevalence of stunting, wasting, underweight, overweight/obesity between rural and urban children; compare the prevalence of risk factors associated with stunting, wasting, underweight, overweight/obesity in children; and to determine correlations between dietary intake and body fatness.

2 Prevalence of stunting, wasting, underweight, overweight/obesity in children between urban and rural areas.

2.1 Stunting

Reports on the prevalence of stunting in children living in SA vary considerably. The National Food Consumption Survey (NFCS) that was conducted in SA in 1999 and focused on children between the ages of one to nine years found that 23% of children were stunted (Labadarios *et al*., 2005). In the North-West province of SA, a study found that the prevalence of stunting was 4.2% among children in Grade 1 (Kruger *et al*., 2014). Said-Mohamed *et al*. (2015) reported that the prevalence of stunting in South African children has increased between 2005 and 2008, from 23.2% to 30%. Other African countries also report a considerable variation in the prevalence of stunting. A study conducted in Nigeria amongst children in the age group five to nineteen years reported that the prevalence of stunting was 17.4% (Senbanjo *et al*., 2011).

Finding studies on stunting in children between specifically six and nine years is difficult and as a result the studies used to compare the current study to included children younger than six years and/or children older than nine years. This fact could also in part explain the differences in stunting between this study population and the other study populations. In the present study, the prevalence of stunting in the total population (14%) was lower as compared to the Nigerian study and the NFCS, and higher as compared to the South African study in the North-West province. The higher prevalence of stunting in this study as compared to the North-West province study might be due to the delay of linear growth caused by chronic poor health and poor nutrition from areas which are more rural (de Onis & Branca, 2016). The low prevalence of stunting in this study, as compared to that in the Nigerian study, might be due to the different socio-economic groups. The study in Nigeria was conducted in an urban area with low socio-economic group where children attended public schools, while the current study was conducted not only in an urban area, but also in rural areas and subjects were not selected on the basis of socio-economic group. Thus in the present study not all participants are from low socio-economic groups, and as can be seen from **Figure 4.3** the urban population in this study reported higher household income than the rural population.

Labadarios *et al*. (2005) found that the prevalence of stunting amongst rural and urban South African children between the ages of one and nine was 27% and 17% respectively. Furthermore, the THUSA BANA Study in the North-West province of SA also reported that stunting is more prevalent in the rural areas (girls 23.7% and boys 26.7%) than in the urban areas (girls 11.6% and boys 17.1%) and the difference was not significant (Mukuddem-Petersen & Kruger, 2004). The same is true for other African countries. Herrador *et al*. (2014) indicated that the prevalence of stunting among rural and urban children in Ethopia was 42.7% and 29.2% respectively.

In agreement with the studies mentioned above, in the current study a greater proportion (15%) of rural children were stunted as compared to urban children (12%) and the result was not significant and although this was not significantly different the mean HFA in the rural population was significantly lower than in the urban population. This might be due to poor socio economic background in rural and low-middle income in rural families (Said-Mohamed *et al*., 2015).

The majority of the children in the current study are from low-middle income households in rural areas, as shown in **Figure 4.3**. Parents/guardians of the children in rural areas often do not have tertiary education, therefore, they are often unemployed, or they work on farms, as domestic workers and other forms of unskilled labour (Govender *et al*., 2017). Moreover, the parents of children in such areas often rely on child support grants, which do not allow them to afford nutritionally adequate diet, because food prices in SA have been steadily increasing (van Wyk & Dlamini, 2018). Therefore, children from poor families are more likely to be stunted than children from wealthy families.

The majority of the children stay with their parents or guardians who are 30–39 years old, as depicted by **Figure 4.2**. The women in rural areas are unable to meet their nutritional requirements during pregnancy due to poverty and high unemployment rates (Govender *et al*., 2017). These women are more likely to give birth to low birthweight infants who are at risk of illness and grow up to be stunted (Krishna *et al*., 2016). Unfortunately, the weight and dietary information of the mothers of the children in the current study were not available to researchers of the current study.

2.2 Wasting

The prevalence of wasting in children between the ages of one and nine was reported to be 19% in a study conducted by Berry *et al.* (2010) in Cape Town, SA. A study conducted in Burkina Faso amongst children in the age group seven to fourteen years found the prevalence of wasting to be 13.7% (Dabone *et al*., 2011). In contrast, the prevalence of wasting in this study was lower (6%) as compared to these two studies. This might be due to the implementation of the feeding schemes in South African primary rural school children (van Stuvjenberg *et al*., 2005). Moreover, the introduction of a child support grant with the aim of supporting children in the form of cash might also play a role in decreased prevalence of wasting (Triegaardt, 2005). In five of the schools that participated in this study there were feeding schemes, three schools did not have any feeding schemes.

In this study, the prevalence of wasting was significantly higher in rural children (9%) than urban children (2%), (p = 0.035) and the mean WFH in the rural population was significantly lower than in the urban population. Labadarios *et al*. (2005) found that the prevalence of wasting amongst rural and urban children between the ages of one and nine years in SA was 5% and 17% respectively. However, an Ethopian study found a higher prevalence rate of wasting in rural areas than in urban areas (Herrador *et al*., 2014). The higher prevalence of wasting in rural populations may be due to the majority of the children in this study being from rural families (61%) with low-to-middle-incomes (R5000 or less). Furthermore, there is availability of food in SA, however, food prices have been steadily increasing, making it less accessible to low and middle-income families (STATS SA, 2016). The feeding schemes introduced in South African rural primary schools 20 years ago might not contain food which have insufficient micronutrients and macronutrients (van Stuijvenberg, 2005).

2.3 Underweight

Twenty per cent of the children in the present study were underweight. The results of this study are in agreement with studies which found a prevalence rate of 14.5% amongst Indonesian children aged between 6 and 13 years (Syahru *et al*., 2016). In contrast, a study by Chirita-Emandi *et al*. (2016) of children between the ages of six and nine years, from eight Romanian countries, residing in urban and rural areas found the prevalence of underweight to be 5%. The high prevalence of underweight in this current study might be due to low income levels and high poverty rates (Govender *et al*., 2017)

Labadarios *et al*. (2005) found that the prevalence of underweight amongst rural and urban children between the ages of one and nine years in SA was 5% and 17% respectively. In contrast a study in India reported that the prevalence of underweight was 46% and 32% in rural and urban areas, respectively (Meshram *et al*., 2016). Similarly, in the present study the prevalence of underweight was higher in rural than urban areas and although this was not significantly different the mean weight for age in the rural population was significantly lower than in the urban population. This may be due to a high percentage of parents residing in rural areas where there is low income level, and high poverty rates (Govender *et al*., 2017).

2.4 Overweight/obesity

Labadarios *et al*. (2005) also found that the prevalence of overweight/obesity in children between the ages of one and nine years in SA was 10% and 4% respectively. Furthermore, the prevalence of overweight/obesity amongst 3-10-year-old children from Gauteng and Mpumalanga provinces was 12.0% and 3.7% respectively in a study conducted by Symington *et al*, (2016). In contrast, the prevalence of overweight/obesity amongst six to thirteen-year-old primary school children in SA was 31.1% and 8.1% respectively (Armstrong *et al*., 2006). The prevalence of overweight/obesity amongst six-to-nine-year-old children was 5.6% and 6.3%

respectively in a study conducted by Mosha and Fungo (2010) of Dodoma and Kinondoni Municipalities, Tanzania respectively. The combined prevalence of overweight/obesity in the current study was 26% which confirms findings of the study conducted by Armstrong *et al*. (2006). Worldwide there is a trend of increasing overweight/obesity in children that is caused by lifestyle changes associated with urbanisation and modernisation (van Zyl *et al*., 2012). SA, even the more rural parts such as the Limpopo province, is clearly no exception.

A South African study conducted by Labadarios *et al*. (2005) in children between the ages of one and nine years found that the prevalence rates amongst rural and urban were 12% and 13% respectively for overweight, and 4% and 6% respectively for obesity. In agreement with the previous study, Ahmed *et al*. (2016) also found higher prevalence rates of overweight/obesity in urban areas than rural. In China, a higher prevalence of overweight was found in urban areas than in rural areas among children in the age group seven to eighteen years (Zhang *et al*., 2016). The findings of the current study also confirm the results of previous studies. In the present study, the combined prevalence of overweight/obesity was also higher in urban children (40%) as compared to rural children (17%) and the mean BF% in the rural population was significantly lower than in the urban population. National Health and Nutrition Examination (NHANES), (2010) stated that overweight/obesity was more prevalent in high-income households for the past 32 years. Chen *et al*. (2012) reported that children in high-income households were more likely to follow a Western diet, which is high in fat and carbohydrates, and thus increase the body fat accumulation.

In the present study, monthly income was grouped into three categories, namely: low-income (less than R1000), middle-income (R1000-R5000) and high-income (more than R5100) households. It is clearly seen from **Figure 4.3** that the majority of the children belong to the low-middle-income households in the rural setting. This might be due to the fact that majority of the parents in rural setting works in Gauteng and send money to their families on a monthly basis (Govender *et al*., 2017). Based on our findings, overweight/obesity is more prevalent in the middle-income households compared to the low-income households. This might be because the middle-income households can afford to buy foods often found in Western diets, such as proteins (e.g. meat) and soft drinks compared to the low-income households (Chen *et al*., 2012). However, a few children belong to the high-income households in the rural setting, which might be due to the high unemployment rate of the area. Furthermore, the majority of the parents in the rural setting have poor education; therefore, they are usually only eligible to work on farms and as domestic workers (Govender *et al*., 2017).

The high combined prevalence of overweight/obesity in urban children might be due to children consuming large amounts of energy-dense food and decreased physical activity, whereas low prevalence of overweight in rural areas may be due to high levels of physical activity and following a prudent diet (Friedman, 2003). In the current study urban children consumed significantly more take away meals than rural children (**Table 4. 10**; p=0.017) while the children residing in rural areas consumed significantly more fruit than those residing in urban areas (**Table 4.10**; p=0.027). Take away meals are known to be energy dense as it contains large amounts of fat, refined carbohydrates and sugar (Lillefosse *et al*., 2015).

3 The prevalence of risk factors of stunting, wasting, underweight, overweight/obesity

3.1 Stunting

Monyeki *et al*. (2000) conducted a study in Lephalale (formerly known as Ellisras) in the Limpopo province of SA on children between the ages of seven and eight years. Their results indicated that 5.5% of males and 3.5% of females were stunted. Similarly, in this study 23% of the males and 7% of the females were stunted and there was a significant association between gender and stunting (p = 0.0030). This suggests that males in both these studies might be more vulnerable to frequent inappropriate feeding practices and poverty than female counterparts of the same age. In Tanzania, Abubakar *et al*. (2012) reported that child age (p = 0.001) and breastfeeding (p < 0.001) were significantly associated with stunting. The present study reported that child age and breastfeeding were not statistically associated with stunting (p = 0.3710 and p = 0.7200 respectively). In another study, child age was a risk factor associated with stunting in children (p < 0.001) living in rural Eastern Cape and Kwazulu-Natal, SA (Lesiapeto *et al*., 2010). A study conducted in rural Limpopo and urban Gauteng found a statistically significant association between low birth weight and stunting (Kleynhans *et al*., 2006). Kleynhans *et al*. (2006) conducted a study amongst children in rural Limpopo and urban Gauteng and also reported that low birth weight was a risk factor associated with stunting ($p = 0.0156$). In the present study, stunted children had a significantly lower birth weight than non-stunted children ($p = 0.0158$), however, the average birth weight of the stunted children was within normal ranges (2.9 kg ± 0.6). Thus it seems as if low birth weight is a risk factor for stunting in this population, similar to what has been reported in other studies. This is clearly demonstrated by the results of the studies, where birth weight was significantly associated with stunting (Kleynhans *et al*., 2006).

3.2 Wasting

Panigrahi and Das (2014) reported that monthly income and the mother's age at pregnancy were not statistically associated with wasting in a study conducted on children aged three to nine years residing in India. Similarly, in this study monthly income ($p = 0.207$) and the mother's age at pregnancy ($p = 0.9016$) were not associated with wasting. Children who reside in rural areas are more likely to be wasted because of poor environmental and socio–economic, factors, poverty and lack of proper feeding practices (Wolde *et al*., 2015). In the present study there was no significant association between area and wasting, thus living in a rural area does not seem to be a risk factor for wasting in this population. In fact, wasting was more prevalent in the urban population (23%) as compared to the rural population (16%). Similarly, a study conducted by Oninla *et al*. (2006) in Nigerian children reported that the prevalence of wasting was also higher in urban areas than in rural areas. This might be due to urbanisation which results in poor sanitation and a lower household income (Buttenheim, 2009). A study conducted by Harding *et al*. (2018) reported that mothers who reside in urban areas and gave birth more than twice were more likely to give birth to a wasted child than women who had given birth less freguently. Furthermore, working mothers were also likely to give birth to wasted children than mothers who were not working. In the present study, neither the number of births prior to the subject being born, nor whether the mother is working or not, has been measured.

Feeding practices and wasting in children were found to be statistically significant ($p < 0.05$) (Islam *et al*., 2015). In the present study, wasted children reported a higher frequency of consuming takeaways than children who were not wasted, but this was not significant. Takeaways might be deficient in nutrients that are needed by the body and thus result in wasting. Thus the result from the present study is in agreement with suggestions in literature that poor feeding practices and inadequate food (or nutrient) intake play a role in determining weight and height of a child (Angood *et al*., 2016).

3.3 Underweight

Underweight was statistically associated with male children (p = 0.021) in a study conducted by Lesiapeto *et al*. (2010) in rural districts of the Eastern Cape and KwaZulu-Natal provinces of SA. This is in accordance with the results of the present study where there was also a significant relationship (p=0.0500) between gender and underweight, with males having a higher prevalence of underweight than females (27% and 15% respectively). A possible explanation for this trend may be that males were more active than females (Telford *et al*., 2016). An increase in physical activity is often associated with a decrease in BMI (Curtner-Smith *et al*., 2007). A study conducted by Abubakar *et al*. (2012) in Tanzania among children reported that low birth weight was not statistically associated with underweight (p = 0.07). In agreement, the present study also showed that underweight and birth weight were not significantly associated (p = 0.0734). However, the current study revealed that for all markers for undernutrition (stunding, wasting and underweight), the undernourisched population had lower birth weights than the population who was not undernourished. This relationship was only significant in the case of stunting (p=0.0158), and not in the case of wasting (p=0.0734) and underweight (p=0.0734). Thus in this study population there is a trend that children who were undernourished also had lower birth weights.

In the present study, the prevalence of underweight was higher in rural than in the urban population (23% and 16% respectively). This is in contrast with the results from a study conducted by Oninla *et al*. (2006) in Nigerian children, where the prevalence of underweight was higher in an urban area than a rural area. The easy access and availability of food lacking proper nutrients, that are not approved by food and drug administration (FDA), might lead to development of underweight (Khan *et al*., 2018). Furthermore, children in this age group tend to under-feed themselves (Bryant-Waugh *et al*., 2010).

3.4 Overweight/obesity

A study conducted by Cort *et al*. (2013) in KwaZulu-Natal, SA, reported that socio-economic factors such as high monthly income have an influence on the accumulation of body fat. Cawley (2010) reported that high income promotes obesity, by enabling people to eat more calories and exert low physical activity due to sedentary pursuits. Therefore, households with high monthly income are more prone to overweight/obesity than households with low income. In this study, similar findings were reported, whereby the children from high monthly income households had a significantly higher prevalence of overweight/obesity (p = 0.0210) than children from low monthly income households. Speculations about these findings are that children from a household with a high monthly income engage in more sedentary activities, resulting in less energy expenditure. These findings are supported by **Table 4.9**, where there is an increase in sedentary time. Furthermore, accessibility of cars in a household with high income which decreases physical activity may result in a more sedentary lifestyle. In contrast, Jiang *et al*. (2006) found no association between overweight and monthly income (p = 0.56) in children two to six years residing in China. The results of the study conducted by Jiang *et al*. (2006) further indicated that there was no association between time spent playing video games and obesity. In contrast, the results of the current study reported a highly significant association between sedentary activities and overweight/obesity (p = 0.0056). Kyallo *et al*. (2013) conducted a study amongst public and private primary school children in Nairobi, Kenya, and reported an association between residential area and overweight/obesity (p = 0.028). Similarly, in the present study there was a highly significant association between area and overweight/obesity (p = 0.0001). In this study the majority of overweight/obese children lived in the urban area (40%) and not in the rural area (17%). Thus, in the present study, children residing in an urban area were at significantly higher risk for being overweight/obese. Chen *et al*. (2012) reported that children in high-income households were more likely to follow a Western diet, which is high in fat and carbohydrates, and thus increase the body fat accumulation. Furthermore, possible reasons for these findings might be that urban areas are modernised due to urbanisation (Monyeki *et al*., 2015), whereby children use a bus/car as a mode of transport, which decreases their physical activity levels; this is supported by the results in **Table 4.9** where there is a high prevalence of overweight and obese children who use car/bus as mode of transport to school and the association is significant (p = 0.0320). The children engage in more sedentary time and consume a diet rich in food containing saturated fats and carbohydrates (You & Hennesburg, 2016).

Yan *et al*. (2014) reported that breastfeeding was associated with a significantly reduced risk of overweight/obesity in children (p < 0.05). In contrast, Gopinath *et al*. (2012) reported that breastfeeding was significantly associated with the development of overweight/obesity in pre–school children (p = 0.002). In agreement, breastfeeding was significantly associated with overweight/obesity (p = 0.0560) in this study, However, of the children who were breastfed only 26% were overweight/obese, while 50% of those who were not breastfed were overweight/obese. Jing *et al*. (2014) further indicated that children who were breastfed for more than eleven months were more likely to be overweight and obese than those who were breastfed for only six to eleven months of their lives. Furthermore, Mamabolo *et al*. (2004) reported that mothers tend to introduce supplementary feeds and formula milk at an early age which causes excess feeding. In agreement, Stuebe (2009) reported that formula fed children are more likely to become obese later in life. However, Jing *et al*. (2014) reported that breastfeeding has beneficial effects, such as reducing the development of type 2 diabetes mellitus and obesity. This could be a possible explanation for the low prevalence of overweight and obese children who were both breastfed and formula fed in this study.

A South African study conducted by Labadarios *et al*. (2005) in children between the ages of one and nine years found that the prevalence rates amongst rural and urban were 12% and 13% respectively for overweight, and 4% and 6% respectively for obesity. In contrast, the prevalence of overweight/obesity in the present study was higher in rural areas than in urban areas. Modernisation and urbanisation might be the cause of this high prevalence of overweight/obesity in the rural areas. In the present study, overweight/obesity was more prevalent in the middle and higher income groups than in the lower income groups. This might result in easy access and availability of food that are not approved by FDA from shops. Furthermore, this might result in decreased physical activity levels, due to the fact that, in rural areas, the availability of excerise and sport facilities is low (Hoekman *et al*., 2013). Thus there is little opportunity for children to be active after school in sports and events, while unsafe conditions (due to crime) makes it impossible for the children to play outside (Senda, 2015). Furthermore, the use of mobile transport and the consumption of food rich in saturated fats also promote a positive energy balance (Lillefosse *et al*., 2014).

4 Pearson correlation between weekday and weekend dietary intake and BF% of the study population

Pearson correlations were conducted to investigate probable correlations between dietary intake, both during the week and over weekends, and BF%. The data analysis was done separately for week days and for weekend days to investigate probable differences in dietary intake between week days and weekend days.

A study in school children in Western Algeria showed that BF% was significantly associated with percentage of total energy intake (Saker *et al*., 2011). In contrast, the present study reported that there was no significant correlation between BF% and percentage of energy intake ($p > 0.05$) during either the week or over weekends. However, the correlation was negative for week days and positive over weekends. A possible reason could be that an increase in physical activity levels during childhood may have an influence on body fat levels whereby there is an increase in energy expenditure (Atkin & Davies, 2000). It is also possible that the collection of dietary intake data was not accurate or that there are various other factors that are masking the relationship.

You and Henneberg (2016) reported that protein is highly correlated with prevalence of obesity ($r = 0.666$, $p < 0.001$). However, the present study shows that there was a weak negative but not significant correlation between protein and BF% during weekdays ($r = -0.185$, $p = 0.171$) and a weak positive but not significant correlation over weekends ($r = 0.019$, $p = 0.890$). A similar result was found among five-to-twelve-year old Mexican obese children ($r = -0.07$, $p = 0.07$) (Moschonis *et al*., 2012). The negative association between protein intake and BF% during weekdays may be due to the fact that children conume a disproportionate amount of energy from fats and carbohydrates and do not consume sufficient proteins. The government feeding schemes probably provide food which are not rich in proteins, parents pack lunch boxes with less proteins, the portion size of proteins is not sufficient, or the children do not like consuming food rich in protein (Arsenault & Brown, 2017). Furthermore, in this study a large proportion (37%) of the households have a monthly income of R1000–R5000, as depicted in **Table 4.3**. This might result in purchasing food which is poor in protein as it is known that food rich in proteins is expensive. In populations where there is a low monthly income, a typical meal contains mostly starch-rich products, such as maize, as this is more affordable (Michaelsen *et al*., 2009). This low protein intake might therefore lead to increased body fat which might lead to the development of obesity. These results are supported by **Table 4.9**, where children who consume a high amount of sweets, biscuits and /or cake and cold drink per week are more likely to be overweight and obese, but the association is not significant (p > 0.05). Over weekends it is possible that the consumption of proteins increase, causing the positive relationship between protein intake and BF%.

A high intake of Ca was associated with low body fat in a study conducted by Carruth and Skinner (2009) in the United States. Similarly, Dixon *et al*. (2005) found an inverse correlation between Ca and BF% in US children. In contrast, the current study reported no significant correlation between Ca and BF% for weekdays (r = -0.216, p = 0.110) or weekend days (r = 0.069, p = 0.616). There was a significant but negative correlation of low Fe levels with BMI in a study conducted by Pinhas-Hamiel *et al*. (2000) in Israel. However, the current study shows that there was no significant correlation between Fe and BF% during the week (r = 0.060, p = 0.659) or over weekends (r = 0.089, p = 0.514). The present study found that Zn was not significantly associated with BF% during the week (r = -0.025, p = 0.854) or over weekends (r = 0.008, p = 0.951). The fortification of maize meal and wheat flour (used for bread) may have increased the consumption of micronutrients in children and therefore there may not have been correlations between BF% and some micronutrients. Furthermore, the school feeding schemes may also have significantly contributed to the consumption of micronutrients such as Ca and Fe.

Garcia *et al*. (2013) reported that Vit A in Mexican children was positively associated with BF%. In agreement, there was a significant but negative association between BF% and Vit A in the current study during the week (r = -0.301, p = 0.024); thus, the lower the Vit A intake, the higher the chances for a child to be overweight or obese (Yang *et al*., 2015). However, the association was positive but not significant over weekends (r = 0.033, p = 0.809). There was a significant but negative correlation between BF% and Vit D during the week (r = -0.301, p = 009) in the current study. Over weekends the association was negative but not significant (r = -0.119, p = 0.383) Furthermore, Lee *et al*. (2013) found that Vit D was also inversely associated with BF% in preadolescent children residing in Korea. Buyukinan *et al*. (2012) reported that deficiency in Vit D causes children to have excess body fat.

Thus, in this study population there were differences in food intake during the week compared to over weekends, as was expected. In general, the associations (whether significant or not) were negative during the week and positive over weekends. The school feeding schemes may have had an impact on the consumption of micronutrients by childer and have improved the micronutrient nutrition of the rural children, which were also generally in the lower socio-economic groups compared to the urban children.

Chapter Six: Conclusion and recommendations

1 Conclusion

The first objective of this study was to compare the prevalence of stunting, wasting, underweight (as indicators of undernutrition), and overweight/obesity (as an indicator of overnutrition) between rural and urban children. In this population, the indicators of undernutrion were more prevalent in rural than in urban areas, however this was only significant for wasting (p=0.035). On the other hand, the indicator of overnutrition was significantly more prevalent in the urban compared to the rural population (p=0.001). these results are in accordance with similar studies done in SA, Africa and in other countries. These results imply that the prevalence of malnutrition is increasing alarmingly and it indicates that this population is still facing a double burden of malnutrition (undernutrition as well as overnutrition). Socioeconomic factors, urbanisation, modernisation (FAO, 2015) and mothers' lack of knowledge about malnutrition are the most important causes of malnutrition among children (Saaka, 2014). With such a poor start in life, these children are likely to never reach their full potential as they might develop short- and long-term health consequences later on in life (Sahoo *et al*., 2015). Childhood obesity tends to continue and even increase into adulthood (Sahoo *et al*., 2015). Thus if 26% of these primary school children are already overweight or obese, the prevalence is likely to increase as the children grow older. This may have a far-reaching impact on their future health status, and this needs to be taken into account by health care services to ensure that there will be proper medical treatment available for them. It is also of the utmost importance to design effective prevention programmes in order to prevent further development of overweight/obesity in this population.

The second objective of this study was to investigate the association between malnutrition and some of its known risk factors. In the current study, children from both urban and rural areas suffered from malnutrition. This is in accordance with other studies done in SA, Africa and other countries. Malnutrition is not only due to lack of good nutrition, but are also often worsen by adverse socio-economic conditions, poor education, poverty, and infections (Leddy *et al*., 2008). Overweight/obesity seems to be increasing in the rural areas due to urbanisation and modernisation (Monyeki *et al*., 2015). In the current study gender was consistenly associated with undernutrition (males being more undernourished than females). This was not true for overnutrition. Birth weight tended to be lower in the undernourished children, with a significant association between birth weight and stunting (p=0.0030). Even though the association between birth weight and wasting as well as underweight was not significant (p=0.0734 in both cases) it shows a trend towards an association between birth weight and undernutrion. This is in accordance with literature and may be due to the poor socio-economic conditions of a large percentage of this study population. Mothers who are poor, often do not have proper nutrition during pregnancy resulting in low birth weight babies, who also will not have proper nutrition growing up, resulting in stunting, wasting and underweight (Aras, 2013).

In terms of overnutrition, the current study shows that there are a number of factors that increase the risk for overnutrition in this study population. These risk factors are middle to high household income, living in an urban area, having a sedentary lifestyle, being driven to school and not being breastfed. From these risk factors one can see that a western-type lifestyle, characterised by sedentary activities, motor vehicle transport, and a higher household income was associated with the development of overweight and obesity. Breastfeeding has been reported to protect against the development of overweight and obesity and this is in accordance with the results of the present study. Children who were breastfed had a lower prevalence of obesity compared to those who were not breastfed. However, many children who were not breastfed, were also not overweight/obese.

Table 6.1 below summarizes the risk factors associated with malnutrition in this population. It is clear that being a male is a risk factor for having a nutritional status below normal, while there are more risk factors for having a nutritional status above normal.

Table 6.1: The risk factors associated with malnutrition in this study population

Malnutrition category	Risk factors for this study population
Stunting	Male gender Low birth weight
Wasting	Male gender Not having a sedentary lifestyle
Underweight	Male gender
Overweight/obesity	Middle to high-income household Urban area Sedentary lifestyle Being driven to school Not being breastfed

In this study, low protein, Ca, Vit A and Vit D intake were associated with increased BF% (although not significant in all cases). Often these nutrients are found in food containing protiens. Proteins take a longer time to digest compared to carbohydrates and thus if children eat more protein they are likely to feel full for longer, making them less susceptible to snacking. Children replacing proteins with carbohydrates in their diets, may feel hungry relatively soon after a meal and will therefore be more likely to snack between meals. In low socio-economic settings such snacks often consists of refined carbohydrates and significant amounts of fat, which may, at least partly explain the association of these nutrients and BF%.

2 Limitations

- This was a cross-sectional baseline study; therefore, causality could not be determined.
- This research project was limited to the rural and urban primary schools of PLM, Capricorn District, Limpopo Province which were selected by the Senior District manager of the Capricorn District.
- The rural primary schools selected consisted of only black children, whereas the urban primary schools had white, coloured, Indian and black children.
- The study only included children from six to nine years of age.
- Although parents/gaurdians were requested to complete the questionnaire as truthfully as possible, there is no way of determining how “true” the answers to the questions were.
- Some of the questions were left unanswered, which may have affected the veracity of the responses.

- Schools in rural areas gave us a higher response rate compared to urban schools, which might have skewed the results.
- Despite a high response rate in our study (84%), children who were six years old showed a low response rate in comparison with other age groups.
- The fact that the study population was not randomly selected could have introduced bias to the study. The Department of Basic Education selected the schools that participated in the study and the first children in each age and gender group who brought back signed consent forms was selected to participate in the study.
- Recall bias may be reported due to the subjective nature of the dietary preferences in children.
- A 24-hour recall questionnaire tends to underestimate the amount of an individual's intake because of day to day variation; however, the selection of this method was justified based on a review of the existing literature, particularly on national studies, with consideration of the unique characteristics of the South African population, and on the basis that it is the best method to use on children (Oldewage-Theron *et al*., 2011).

  The young children between the ages of six and nine found it difficult to accurately recall the food that had been consumed in the previous 24 hours. In this regard, the parents were interviewed telephonically to verify intakes if the children were unsure about what they ate.

3 Recommendations

- Urbanisation in Limpopo is occurring rapidly. Designing context-specific interventions for these changing demographics is increasingly necessary, especially in terms of malnutrition.
- South Africa needs to focus on programs targeting the first 1000 days of life, especially taking into consideration the pre-conception period and expecting mothers with low BMIs, as this may improve the nutritional status of children.
- Policy makers and program designers should broaden their perspectives on nutrition interventions to address and change the environmental and behavioural factors. This can include promoting vegetable gardens at schools and in communities, introducing three meals per day in schools as a standard,

including a Physical Education time slot, as well as fun physical activities for children to partake in during school hours.

- Increasing education (of parents, children and educators), alleviating poverty, improving feeding practices, and preventing and treating infections are all required to assist in combating malnutrition in this province.
- Local communities must develop partnerships with schools, healthcare providers, local businesses and community groups, and strengthen the mission to create opportunities for healthy living and reducing malnutrition.
- Further investigation about feeding schemes should be done to check if it is reducing malnutrition and wether it should be extended to include weekends and holidays.

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ADDENDUM A: TREC CERTIFICATE

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING: **04 July 2017**

PROJECT NUMBER: **TREC/103/2017: PG**

PROJECT:

Title:	Differences in body fatness and nutritional status of urban and rural Primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo Province, South Africa
Researcher:	Ms MN Mokabane
Supervisor:	Dr M van Staden
Co-Supervisor:	Mr H Malan
School:	Molecular and Life Sciences
Degree:	Masters in Physiology

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:
i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**
ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding solutions for Africa

ADDENDUM B: LETTER FROM THE CIRCUIT MANAGER

LIMPOPO

PROVINCIAL GOVERNMENT

REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF

EDUCATION

CAPRICORN DISTRICT

DIMAMO CIRCUIT

Enq.: Kgopa M.S

CONTACT: 0828178889

TO : The Principal — 19 February 2016

Kokona Dikgale Primary School

Dimamo Circuit

PERMISSION TO CONDUCT RESEARCH IN DIMAMO CIRCUIT: UNIVERSITY OF LIMPOPO, DEPARTMENT OF PHYSIOLOGY AND ENVIRONMENTAL HEALTH AT YOUR SCHOOL

1. The above matter refers.
2. Kindly provide the necessary support and cooperation to the team as they conduct research at your institution.
3. Sufficient consultation to the Department has been done for this study to be conducted.
4. Herewith find documents that permit them to operate in the circuit.
5. The Department wishes you well and appreciates your interest on matters that would uplift the health standard in Education.

....

CIRCUIT MANAGER

ADDENDUM C: A LETTER FROM DEPARTMENT OF EDUCATION

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION
CAPRICORN POLOKWANE DISTRICT

Private Bag X 0711
POLOKWANE
0700
Tel: 015 285 7300
Fax: 015 285 7499

CONFIDENTIAL

Enq : Mphaphuli AJ
Tel No.: 015 285 7410
Email : MphaphuliAJ@edu.limpopo.gov.za
Date: 06 November 2015

To : **Dr M van Staden**
University of Limpopo
Department of Physiology and Environmental Health

SUBJECT: APPLICATION TO CONDUCT RESEARCH, PIETERSBURG CIRCUIT , MANKWENG CIRCUIT , MAMABOLO CIRCUIT, KGAKOTLOU CIRCUIT AND DIMAMO CIRCUIT .

Title: A non –invasive investigation into the prevalance and risk factor for malnutrition and its associated complications in children and adolescents In Limpopo Province, South Africa .

1. The about matter refers.
2. The Department wishes to inform you that your request to conduct a research has been approved.
3. The following conditions should be considered
   3.1 The research should not have any financial implication for Limpopo Department of Education.
   3.2 Arrangements should be made with both the circuit offices and school concerned.
   3.3 The conduct of research should not anyhow disrupt the academic programs at schools.

Cnr Blaauwberg & Yster Street, Ladanna

"We Belong, We Care, We Serve"

3.4 The research should not be conducted during the time examinations especially the fourth term.

3.5 During the study , the research ethics should be practiced, in particular the principle voluntary participation (the people involved should be respected)

3.6 Upon completion of research study, the researcher shall share the final product of the research with Department.

4. Furthermore you are expected to produce this letter at schools/offices where you intend conduct your research as evidence that you are permitted to conduct the research.

5. The department appreciates the contribution that you wish to make and wish you success in your research.

Name of Circuit	Name of Primary Schools	Name of Secondary Schools
Pietersburg Circuit	• Pietersburg Comprehensive School • Greenside Primary School • Laerskool Pietersburg • Ivy Park Primary School	• Westenburg Secondary School • Capricorn High School • Noorderland High School • Taxilla High School
Mankweng Circuit		• Mphetsebe Secondary School
Mamabolo Circuit	• Mamabolo Primary School	• Motlakaro Secondary School
Dimamo Circuit	• Kokona Dikgale Primary School	• Moruleng Secondary School
Kgakotlou Circuit	• Ntji Mothapho Primary School • Itireleng Primary School	• Mothimako Secondary School

Best wishes

09/11/2015

MR MOTHEMANE KD
ACTING DISTRICT SENIOR MANAGER

DATE

LIMPOPO PROVINCE
DEPARTMENT OF EDUCATION
POLOKWANE DISTRICT OFFICE
DSM OFFICE
2015 -11- 09
PRIVATE BAG X9711
POLOKWANE

Cnr Blaauwberg & Yster Street, Ladanna

"We Belong, We Care, We Serve"

ADDENDUM D: A FORMAL LETTER FOR PERMISSION TO CONDUCT THE STUDY

PROJECT TITLE: Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.

PROJECT LEADERS: Dr M van Staden (Promoter)
Mr H Malan (Co-promoter)

INFORMATION FOR PARTICIPANTS

1. Your school is invited to participate in the following research project/experiment: Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.
2. Participation in the project is completely voluntary and you are free to withdraw from the project/experiment (without providing any reasons) at any time. You are, however, requested not to withdraw without careful consideration since such action might negatively affect the project/experiment.
3. It is possible that you might not personally experience any advantages during the experiment/project, although the knowledge that may be accumulated through the project/experiment might prove advantageous to others.
4. You are encouraged to ask any questions that you might have in connection with this project/experiment at any stage. The project leader and her/his staff will gladly answer your question. They will also discuss the project/experiment in detail with you.
5. Your involvement in the project:

The study activities will include that you give the researcher permission to address learners in your school to inform them about the project and to invite them to participate, collect data from 50 children who return informed consent forms signed by the parents. The researcher will need to visit the school about three times to gather all information.

If you have any questions or queries regarding this research project, either now or in the future, please do not hesitate to contact either:

Dr. Marlise van Staden, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 2817, E-mail address: marlise.vanstaden@ul.ac.za,

OR

Mr H Malan, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 3005, E-mail address: henk.malan@ul.ac.za,

OR

Ms MN Mokabane, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 2209, E-mail address: donnah.mokabane@gmail.com.

PROCEDURES TO BE FOLLOWED

The researcher will explain the study to children and invite them to participate. All children will receive an information letter and consent form to take home. Only children who return signed consent forms may participate in the study. The researcher will visit participating children at the school during school hours (08:00 - 14:00). Each participating child will receive a questionnaire for parents/guardians to complete. The questionnaire contains questions on demography, medical history, and snacking behaviour. The researcher will weigh the child and measure his or her height, waist circumference, hip circumference and some skin folds. Twenty percent of the children will be interviewed to determine dietary intake. The researcher will return to the school on a second occasion to do another dietary intake interview with these children.

NATURE OF DISCOMFORT

To weigh the child all shoes and heavy clothing are removed and the child is asked to step onto a scale and to stand still and look straight ahead for the few seconds it takes to record the weight. Height is then also determined by asking the child (who is still barefoot) to stand with his/her back against a stadiometer. The child’s back is against the ruler part and the slider is pressed lightly onto the head of the child so that the correct height can be recorded. Both of these measurements are done fast and it should not be uncomfortable for the child. Skin folds are measured with a device called a “skin fold calliper” and it functions like a plier to determine the thickness of a skinfold. The researcher carefully pinches the skin of the child and pulls it away from the body to allow the calliper to fit over the skin fold. The calliper is then released and it measures the skin fold. This procedure is only slightly uncomfortable, but the measurement only takes a few seconds and is not painful.

ADVANTAGES THAT MAY BE EXPECTED FROM THE RESULTS OF THE EXPERIMENT

According to our knowledge data on body fatness, among urban and rural children in the Limpopo Province, South Africa is limited. Therefore, the importance of this research study is that its findings will shed more light on the current body fatness of children and some of the factors affecting their body fatness. It will also increase community awareness about the risks involved in being obese, overweight or underweight. Furthermore, detailed knowledge of these variables of children will assist the children’s parents, the school and the policy holders in further understanding, monitoring and minimizing the likelihood of serious health problems that continue in adulthood due to increased or decreased body fatness during childhood. The results of this study will also inform the need for intervention studies to prevent underweight and overweight or obesity in children.

Each participating child will receive a feedback form with his/her measurements as well as the normal values to take home. This will be accompanied by an information leaflet on healthy lifestyle. Each participating school will receive a short report on the body fatness of the participating children. No child’s name will be mentioned in this report so you can rest assure that all personal information will remain confidential at all times. The school will also receive some information on healthy lifestyle with suggestions to improve physical activity and healthy eating on the school grounds.

Yours sincerely,
Dr M van Staden

ADDENDUM E: A FORMAL LETTER TO REQUEST PERMISSION TO COLLECT DATA

PROJECT TITLE: Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.

PROJECT LEADERS: Dr M van Staden
Mr H Malan

INFORMATION FOR PARTICIPANTS

1. Your are invited to participate in the following research project/experiment: Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.
2. Participation in the project is completely voluntary and you are free to withdraw from the project/experiment (without providing any reasons) at any time. You are, however, requested not to withdraw without careful consideration since such action might negatively affect the project/experiment.
3. It is possible that you might not personally experience any advantages during the experiment/project, although the knowledge that may be accumulated through the project/experiment might prove advantageous to others.
4. You are encouraged to ask any questions that you might have in connection with this project/experiment at any stage. The project leader and her/his staff will gladly answer your question. They will also discuss the project/experiment in detail with you.
5. Your involvement in the project:

The study activities will include that you fill in a questionnaire to give some demographic and medical information about you and your child. Although we will prefer it if you complete the entire questionnaire, you may leave questions blank if you do not feel comfortable answering them. Furthermore, the researcher will assess your child’s body fatness by weighing and measuring him/her. Ten percent of the participating children.will be interviewed to determine dietary intake. The researcher may telephone you to clear up some uncertainties with regard to the dietary information provided by your child.

If you have any questions or queries regarding this research project, either now or in the future, please do not hesitate to contact either:

Ms MN Mokabane, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 2209, E-mail address: donnah.mokabane@gmail.com,

OR

Dr. Marlise van Staden, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 2817, E-mail address: marlise.vanstaden@ul.ac.za.

PROCEDURES TO BE FOLLOWED

The researcher will explain the study to children and invite them to participate. All children will receive an information letter and consent form to take home. Only children who return signed consent forms may participate in the study. The researcher will visit participating children at the school during school hours (08:00 - 14:00). Each participating child will receive a questionnaire for parents/guardians to complete. The questionnaire contains questions on demography, medical history, and snacking behaviour. The researcher will weigh the child and measure his or her height, waist circumference, hip circumference and some skin folds. Ten percent of the children will be interviewed to determine dietary intake. The researcher will return to the school on a second occasion to do another dietary intake interview with these children and to collect the questionnaires.

NATURE OF DISCOMFORT

To weigh the child all shoes and heavy clothing are removed and the child is asked to step onto a scale and to stand still and look straight ahead for the few seconds it takes to record the weight. Height is then also determined by asking the child (who is still barefoot) to stand with his/her back against a stadiometer. The child’s back is against the ruler part and the slider is pressed lightly onto the head of the child so that the correct height can be recorded. Both of these measurements are done fast and it should not be uncomfortable for the child. Skin folds are measured with a device called a "skin fold calliper" and it functions like a plier to determine the thickness of a skinfold. The researcher carefully pinches the skin of the child and pulls it away from the body to allow the calliper to fit over the skin fold. The calliper is then released and it measures the skin fold. This procedure is only slightly uncomfortable, but the measurement only takes a few seconds and is not painful.

ADVANTAGES THAT MAY BE EXPECTED FROM THE RESULTS OF THE EXPERIMENT

According to our knowledge data on body fatness, among urban and rural children in the Limpopo Province, South Africa is limited. Therefore, the importance of this research study is that its findings will shed more light on the current body fatness of children and the some of the factors affecting their body fatness. It will also increase community awareness about the risks involved in being obese, overweight or underweight. Furthermore, detailed knowledge of these variables of children will assist the children's parents, the school and the policy holders in further understanding, monitoring and minimizing the likelihood of serious health problems that continue in adulthood due to increased or decreased body fatness during childhood. The results of this study will also inform the need for intervention studies to prevent underweight and overweight or obesity in children.

Each participating child will receive a feedback form with his/her measurements as well as the normal values to take home. This will be accompanied by an information leaflet on healthy lifestyle. Each participating school will receive a short report on the body fatness of the participating children. No child's name will be mentioned in this report so you can rest assure that all personal information will remain confidential at all times. The school will also receive some information on healthy lifestyle with suggestions to improve physical activity and healthy eating on the school grounds.

Yours sincerely,
Dr M van Staden

ADDENDUM F: CONSENT FORMS (ENGLISH, SEPEDI AND AFRIKAANS)

UNIVERSITY OF LIMPOPO

ETHICS COMMITTEE

PROJECT TITLE: Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.

PROJECT LEADERS: Dr M van Staden
Mr H Malan

CONSENT FORM

I, hereby voluntarily consent to participate in the following project: Differences in body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.

I realise that:

1. The study deals with the assessment of children's body fatness and nutritional status of urban and rural primary school children between the ages of six and nine years in the Polokwane Local Municipality, Limpopo province, South Africa.
2. The procedure or treatment envisaged may hold some risk for me that cannot be foreseen at this stage;
3. The Ethics Committee of the University of Limpopo has approved that individuals may be approached to participate in the study;
4. The experimental protocol, i.e., the extent, aims and methods of the research, has been explained to me;
5. The protocol sets out the risks that can be reasonably expected as well as possible discomfort for persons participating in the research, an explanation of the anticipated advantages for myself or others that are reasonably expected from the research and alternative procedures that may be to my advantage;
6. I will be informed of any new information that may become available during the research that may influence my willingness to continue my participation;

7. Access to the records that pertain to my participation in the study will be restricted to persons directly involved in the research;
8. Any questions that I may have regarding the research, or related matters, will be answered by the researchers;
9. If I have any questions about, or problems regarding the study, or experience any undesirable effects, I may contact a member of the research team;
10. Participation in this research is voluntary and I can withdraw my participation at any stage;
11. If any medical problem is identified at any stage during the research, or when I am vetted for participation, such condition will be discussed with me in confidence by a qualified person and/or I will be referred to my doctor;
12. I indemnify the University of Limpopo and all persons involved with the above project from any liability that may arise from my participation in the above project or that may be related to it, for whatever reasons, including negligence on the part of the mentioned persons.

Signature of researched person Signature of witness

Signature of person that informed Signature of parent/guardian

Signed at this day of 2016

UNIVERSITY OF LIMPOPO

KOMITI YA MELAO

PROJECT TITLE: A non-invasive investigation into the prevalence of and risk factors for malnutrition and its associated complications in children and adolescents in Limpopo Province, South Africa

PROJECT LEADERS: Dr M van Staden (PhD Physiology)
Prof MJ Potgieter (PhD Botany)

CONSENT FORM

Nna,______________________________________ ke dumela go ithaopa go tšea karolo mo projekeng ye e latelago: A non-invasive investigation into the prevalence of and risk factors for malnutrition and its associated complications in children and adolescents in Limpopo Province, South Africa).

Ke lemoga gore:

1. Thuto ye ya dinyakišišo e šoma ka go lekola maemo a mahlahlo a ngwana sekolong le ka lapeng, le go lekola nako yeo ngwana ae fetšago a dutše a sa dire selo;
2. Tshepedišo goba mokgwa wa tswaro wo o letetšwego o ka ntšwarela dikotsi tše di sa bonelwego pele sebakeng se;
3. Komiti ya melao ya Unibesiti ya Limpopo e dumeletše gore batho ba ka latwa ka o tee o tee gore ba tšeye karolo ka mo gare ga thutonyakišišo ye;
4. Ke hlalosoditše melaoana ya teko, bjalo ka go naba maikemešetšo, le mekgwa ya nyakišišo;
5. Melaona ye e bea pepeneng dikotsi tšeo di ka lebelelwago gape le dikgonagalo tša maemo a go se thabiše go batho bao ba tšeago karolo ka gare ga nyakišišo,, tlaloso ya mehola yeo e ka letelwago go nna goba ba bangwe;
6. Ke tla tsebišwa ka tsebo yengwe le yengwe ye ntshwa yeo e ka bago gona bakong ya nyakišišo yeo e ka hlohleletšago boethaopo bjaka gore ke tswele pele ke tšea karolo;
7. Tumelelo ya direkoto tšeo di amanago le go tšea karolo ga ka mo thutonyakašišong ye e tla felela fela go bao ba lego karolong ya nyakišišo;
8. Dipotšišo di fe goba dife tšeo nka bago le tšona mabapi le nyakišišo ye, goba tše dingwe tšeo di amanago le yona, di tla arabjwa ke banyakišiši;

9. Ge ke nale dipotšišo tše dingwe le tše dingwe ka ga thuto, goba mathata mabapi le thutonyakišišo, goba go itemogela ditlamorago tsa go se kgahliše nka ikgokagantša le leloko le lengwe la sehlopa sa banyakišiši;
10. Go tšea karolo ka gare ga nyakišišo ye ke ka go ithaopa gomme nka gogela morago go tšea karolo ga ka nako ye ngwe le yengwe;
11. Ge bothata bja kalafi bo ka lemogwa nakong efe goba efe ya nyakišišo goba ge ke nyakollwa gore ke kgone go tšea karolo, boemo bo bjalo botlo sekwasekwa le nna ka sephiring le motho wa maleba gob aka romelwa ngakeng ya ka;
12. Ke tshepiša go lefela Unibesithi ya Limpopo le batho ka moka bao ba amegago mo projekeng ye ya ka godimo dikotlo ka moka tšeo di ka tšwelelago go tšwa go tšeyeng karolo ga ka mo projekeng ya ka godimo goba tšeo di ka amanago le yona ntle le go šetša mabaka, go akaretša le bošaedi legatong la batho bao ba boletšwego;

Mosaeno wa monyakišiši Mosaeno wa hlatse

Mosaeno wa motsebiši Mosaeno wa motswadi/ Mohlokomedi

E saenwe ka letšatši la _________ 2016

UNIVERSITY OF LIMPOPO
ETHICS COMMITTEE

PROJEK TITEL: ‘n Nie-ingrypende ondersoek na die voorkoms van en risikofaktore vir wanvoeding en die verwante komplikasies in kinders en adolesente in Limpopo Profinsie, Suid-Afrika

PROJEK LEIERS: Dr M van Staden (PhD Physiology)
Prof MJ Potgieter (PhD Botany)

TOESTEMMINGSVORM

Ek, gee hiermee vrywillig toestemming om aan die volgende projek deel te neem: ‘n Nie-ingrypende ondersoek na die voorkoms van en risikofaktore vir wanvoeding en die verwante komplikasies in kinders en adolesente in Limpopo Profinsie, Suid-Afrika.

Ek begryp dat:

1. Die studie verband hou met die meting van kinders se fisiese aktiwiteitsvlakke by die skool en by die huis en met die tyd wat kinders spandeer met sittende aktiwiteite;
2. Die prosedure of behandeling sekere risiko’s vir my mag inhou wat nie op hierdie stadium voorsien kan word nie;
3. Die Etiese Kommitee van die Universiteit van Limpop het goedgekeur dat individue genader mag word om aan die studie deel te neem;
4. Die eksperimentele protokol, m.a.w. die omvang, oogmerke, en metodes van die navorsing is aan my verduidelik;
5. Die protokol bevat ‘n uiteensetting van die risiko’s wat binne redelike perke verwag kan word, sowel as moontlike ongemak vir persone wat aan die navorsing deelneem, ‘n verduideliking van die verwagte voordele wat vir myself of ander uit die navorsing kan spruit en alternatiewe prosedures wat tot my voordeel kan strek;
6. Ek sal inkennis gestel word van enige nuwe inligting wat tydens die navorsing beskikbaar mag word, wat my voortgesette bereidwilligheid om aan die projek deel te neem kan beïnvloed;
7. Toegang tot die rekords wat verband hou met my deelname aan die studie sal tot individue wat direk by die studie betrokke is beperk word;

8. Enige vrae wat ek in verband met die navorsing, of verwante sake het, sal deur die navorsers beantwoord word;
9. Indien ek enige vrae oor, of probleme met die studie ondervind, of enige ongewenste gevolge ervaar, kan ek 'n lid van die navorsingspan kontak;
10. Deelname aan die navorsing is vrywillig en ek kan te enige tyd my deelname staak;
11. Indien enige mediese probleem op enige tydstip tydens die navorsing, of as ek vir die projek gewerf word, geïdentifiseer word, sal die toestand konfidensiëel met my bespreek word deur 'n gekwalifiseerde persoon en/of ek sal na my dokter verwys word;
12. Ek vrywaar die Universiteit van Limpopo en alle individue betrokke by bogenoemde projek van enige aanspreeklikheid wat uit my deelname aan bogenoemde projek mag spruit of wat daarmee verband mag hou, vir watter rede ook al, insluitende nalatigheid aan die kant van die genoemde individue.

Handtekening van deelnemer Handtekening van getuie

Handtekening van persoon wat ingelig het Handtekening van ouer/voog

Geteken te hierdie dag van 2016

ADDENDUM G: QUESTIONNAIRES (ENGLISH, SEPEDI AND AFRIKAANS)

Subject no:_______________

School name:_____________

Interviewer:_______________

Date:________

Questionnaire

Please complete the following questionnaire as accurately as possible. If you feel uncomfortable about answering some of the questions you may leave them blank.

SECTION A: DEMOGRAPHIC INFORMATION

1. Child's name and surname: ____________________________________
2. Child's date of birth: ____
3. Child's age ______ years and ______ months
4. Child's gender: male/female
5. You are the child's: Mother/Father/Guardian/Other (specify) ___________
6. Your age: ______ years and ______ months
7. In which area/suburb do you stay _________________________________
8. Do you own a motor vehicle? Yes/No
9. Including yourself, how many people aged 18 years and older live in your household?

Enter number_____________

10. How many children (including babies) under the age of 18 years live in your household?

Enter number__________

11. What is your monthly household income, net income after taxes and fringe benefit deductions? (Optional) (Choose only one option)

Less than R1000 R1000 to R2000 R2000 to R3000 R3000 to R4000 R4000 to R5000 R5000 to R6000 R6000 to R7000 R7000 to R8000 R8000 to R9000 R9000 to R10000 R10000 and more

SECTION B: MEDICAL HISTORY

1. What was your (or the child's mother's age) when giving birth to him/her? _____years.
2. How many weeks were you (or the child's mother) pregnant when you gave birth to this child? ______ weeks
3. What was the birth weight of this child (as indicated on the "road to health" chart)? _______kg
4. Does the child's father, mother, grandparents, brother or sister suffer from any of the following conditions?

a. Type 2 diabetes mellitus

b. Hypertension

c. Stroke

d. High cholesterol

5. How many people in the household smoke? ________

SECTION C: DIETARY INFORMATION

Please answer the following questions as accurately as possible.

1. How many times per week does the child eat sweets, biscuits or cake? _____
2. How many times per week does the child eat take-away foods? ______
3. How many times per week does the child drink cold drinks or fruit juice? ____
4. How many times per week does the child eat fresh fruit? ______

SECTION D: PHYSICAL ACTIVITY

(We want to know how much time your child spends doing different things each day. Please put an X in one box for each question to tell us the number of hours your child spends doing each activity)

1. In a typical week, how much time does your child usually spend watching television, DVD's or videos?

None Less than 1 hour 1–2 hours 3–5 hours 6–10 hours 11–14 hours 15–20 hours More than 20 hours

2. In a typical week, how much time does your child spend playing video games, cell phone games, or internet to e-mail or chat online? (Example: Nintendo, XBOX, PlayStation, WhatsApp, Mxit, etc).

None Less than 1 hour 1–2 hours 3–5 hours 6–10 hours 11–14 hours 15–20 hours More than 20 hours

3. In a typical week, how much time does your child spend reading outside of school? This includes reading books, magazines, newspapers, doing homework.

None Less than 1 hour 1–2 hours 3–5 hours 6–10 hours 11–14 hours 15–20 hours More than 20 hours

4. In comparison to your children how would you rate your physical activity level at present?

Less active/The same/More Active

5. When you were a child were you less or more physically active than your child?

Less active/The same/More Active

6. How do your children get to school?

Walk/Run/Bus/Car/Bicycle.

7. How did you get to school as a child?

Did not go/Walk/Run/Bus/Car/Bicycle.

Contact details:

Parent/Guardian's name (Please print your name in full) ______________________

Parent/Guardian's gender (please select your answer):Male/Female

Parent/Guardian's age: _______years(Mengwaga).

Landline Phone No__________Cellular Phone No ________

Name of your child (Please print child's name in full) ________________

Name of School your child attends _____________

Gender of your child (Please select your answer) Male /Female.

(**Thank you for completing this Questionnaire).**

Subject no: _______________

School name:_______________

Interviewer:_________________

Date:_______________________

SECTION A: DEMOGRAPHIC INFORMATION

SERIPA SA A : TSEBIšO

1. Child's name and surname

Leina la ngwana le sefane): ____________________________________

2. Child's date of birth

Letšatši la matswalo a ngwana: ________________________________

3. Child's age ______ years and _________months

Mengwaga ya ngwana______ le______ dikgwedi tše ________

4. Child's gender: male/female

Bong ba ngwana: monna/mosadi

5. You are the child's Mother/Father/Guardian/Other (specify) ___________

O tswala jwang le ngwana: Mma/papa/mohlokomedi (Ye ngwe hlalosa)_________

6. Your age: ______ years and ______ months

Mengwaga ya gago_____mengwaga le ________dikgwedi tše

7. In which area/suburb do you stay__________________

O dula tulong efe _________________________________

8. Do you own a motor vehicle?(O nale koloi)? Yes/No (Ee/Aowa)

9. Including yourself, how many people aged 18 years and older live in your household?

Enter number ______

O bala/akaretša le wena, ke batho ba ba kae ba go ba ka godimo ga mengwa ye 18 bao ba dulago ka ntlong y a gago?

Lokela nomoro ______

10. How many children (including babies) under the age of 18 years live in your household?

Enter number ______

Ke bana ba ba kae (go akaretša le masea) ba go ba ka fase ga mengwa ye 18 bao ba dulago ka ntlong ya gago?

Lokela nomoro______

11. What is your monthly household income, net income after taxes and fringe benefit deductions? (Optional)(Choose only one option)

Less than R1000 R1000 to R2000 R2000 to R3000 R3000 to R4000 R4000 to R5000 R5000 to R6000 R6000 to R7000 R7000 to R8000R8000 to R9000 R9000 to R10000 R10000 and more

Ke setšeka sefe se se tsenago ka lapeng la gago, ka morago ga motšhelo le go fokotšwa ga dikokeletšo) Kgetho) kgetha e tee fela)

Less than R1000 R1000 to R2000 R2000 to R3000 R3000 to R4000 R4000 to R5000 R5000 to R6000 R6000 to R7000 R7000 to R8000R8000 to R9000 R9000 to R10000 R10000 and more

SECTION B (SERIPA SA B): MEDICAL HISTORY(HISTORI YA TšA KALAFO)

7. What was your (or the child's mother's age) when giving birth to him/her? (Nna o be o nale (goba mengwaga ya mmago ngwana) mengwaga e me kae ge o be o belega ngwana o) _____years (Mengwaga).
8. How many weeks were you (or the child's mother) pregnant when you gave birth to this child? (O be o nale dibeke tše kae (goba mmago ngwana) o le mmeleng ge o belega ngwana o)? ______ weeks (dibeke)
9. What was the birth weight of this child (as indicated on the "road to health" chart)? (Nna ngwana o, o be a kala bokae (bjalo ka ge go laeditšwe godimo ga tšhate ya "road to health" _______kg
10. Does the child's father, mother, grandparents, brother or sister suffer from any of the following condition? (A e kaba papago, mmago, bomakgalo, buti goba sesi wa ngwana o nale bo bobongwe bja malwetši a a latelago)?

a. Type 2 diabetes mellitus
b. Hypertension
c. Stroke
d. High cholesterol

11. How many people in the household smoke? (Ke batho b aba kae bao ba kgogago motšoko ka mo lapeng)?________

SECTION C (SERIPA C): DIETARY INFORMATION (TSEBIšO YA MEKGWA YA GO JA)

Please answer the following questions as accurately as possible.

Ka kgopelo araba dipotšišo tše dilatelago ka go nepagala ka mokgwa o o ka kgonago ka gona.

1. How many times per week does the child eat sweets, biscuits or cake? _____

Kega kae mo bekeng mo ngwana a jago malekere. dikuku, dikhekhe?_______

2. How many times per week does the child eat take-away foods? ______

Kega kae mo bekeng mo ngwana a jago dijo tša go tšwelela diapeilwe? ______

3. How many times per week does the child drink cold drinks or fruit juice? ____

Kega kae mo bekeng mo ngwana a nwago dino tša go tonya goba metsanakodi a dikenya?____

4. How many times per week does the child eat fresh fruit? ______

Kega kae mo bekeng mo ngwana a jago dikenywa tša tša go sepone? ______

5. Was this child ever breastfed/fed breast milk?

Aa ngwana o o ile a fepšwa matutu?

a. Yes Ee

b. No Aowa

c. Don't know Ga ke tsebe

6. How long after birth was this child first breastfed?

O tšere nako ye kae ka morago ga go belegwa go nyantšhwa?

a. Immediately Semetseng

b. Less than one hour Pele ga iri ye tee

c. Less than 24 hours Pele ga iri tše 24

d. More than 24 hours Ka morago ga iri tše 24

e. I don't know Ga ke tsebe

7. How was this child breastfed for the first 6 months?

Naa kgwedi tše 6 tša pele ngwana o be a nyantšwa jwang?

a. Breastfeeding exclusively (Go nyantšhwa matutu feela a sa je goba go nwa selo ka ntle le matutu)

b. Both breastfeeding and formula milk / cow milk (O be a nyantšwa ebile a fepšwa maswi a go rekwa)

c. Other, specify Yengwe, hlalosa _________________________

8. How was expressed milk given?

Naa matutu a be a fiwa ngwana bjang?

a. Bottle with teat/nipple lepotlolo la go ba le hlogo

b. Cup Komiki

c. Spoon Lelepola

d. Other, specify Yengwe, hlalosa ______________________

e. I don't know Ga ke tsebe

9. For how long was this child breastfed / fed breast milk? _______ months

(Ngwana o nyantšhitšwe matutu nako ye kaakang?) _______ dikgwedi.

10. How old was this child when milk/food other than breast milk was given for the first time? _________ months

Ngwana o be a nale nako ye kaakang ge a be a fiwa maswi/dijo tše dingwe ntle le matutu la mathomo?_______ dikgwedi

11. What was the first drink other than breast milk that this child received?

Naa ke seno sefe ka ntle le matutu seo ngwana a se nwelego la mathomo?

a. Infant formula Maswi a bana a go rekwa

b. Water Metsee

c. Gripe water

d. Sugar water Meetse a sokiri

e. Other, specify Yenngwe, hlalosa _________________

SECTION D SERIPA SA D: PHYSICAL ACTIVITY (MEŠOMO YA MMELE)

(We want to know how much time your child spends doing different things each day. Please put an X in one box for each question to tell us the number of hours your child spends doing each activity)

Re nyaka go tseba gore ngwana wa gago o tšea nako ye kaakang a dira dilo tše go fapanafapana letšatši ka letšatši. Ka kgopelo bea le swayo le X ka gare ga lepokisi le lengwe le lengwe la potšišo gore botša nomoro ya diiri tšeo ngwana wag ago a di fetšago a dira mešongwana o mongwe le o mongwe

1. In a typical week, how much time does your child usually spend watching television, DVD's or videos?

Ke ga kae mo bekeng moo ngwana wa gago a fetšago nako a lebeletše Telebišene, DVD's or Bedio?

None Less than 1 hour 1–2 hours 3–5 hours 6–10 hours 11–14 hours 15–20 hours More than 20 hours

2. In a typical week, how much time does your child spend playing video games, cell phone games, or internet to e-mail or chat online? (Example: Nintendo, XBOX, PlayStation, WhatsApp, Mxit, etc).

Ke ga kae mo bekeng moo ngwana wa gago a fetšago nako raloka dithaloko tša Bedio, tša sellathekeng, goba internet go fihla go imeile

None Less than 1 hour 1–2 hours 3–5 hours 6–10 hours 11–14 hours 15–20 hours More than 20 hours

3. In a typical week, how much time does your child spend reading outside of school? This includes reading books, magazines, newspapers, doing homework.

Naa ngwana wag ago o tšea nako ye kae a bala a se ka sekolong? Se se akaretša go bala dipuku, magazines, dikuranta, le go dira mošomo wa gae?

None Less than 1 hour 1–2 hours 3–5 hours 6–10 hours 11–14 hours 15–20 hours More than 20 hours

4. In comparison to your children how would you rate your physical activity level at present?

Less active The same More Active

Ge o ke papetša le bana ba gago, o ka ke kala mahlahla a mmele wa gago bjang

A mmanyane A tekano A godimo

5. When you were a child were you less or more physically active than your child?

Less active The same More Active

Ge obe o le ngwana, naa o be o nale mahlahla a ka godimo goba ka fase ga a ngwana wag ago?

A mmanyane A tekano A godimo

6. How do your children get to school

Walk Run Bus Car Bicycle

? Naa ban aba gago ba fihla jwang sekolong?

Ba sepela Ba kitima Ka pese Ka koloi Ka paesekela

7. How did you get to school as a child?

Did not go Walk Run Bus Car Bicycle

Naa wena o be o fihla bjang sekolong?

Ga se ke tsene sekolo Ka go sepela Ka go kitima Ka paesekela Ka koloi Ka paesekela

Contact details:

Parent/Guardian's name (Please print your name in full) ____________________

Leina la motswadi/ mohlokomedi (Ngwala leina la gago ka botlalo) ______________________

Guardian's gender (please select your answer) Male/Female

Bong ba motswasi/mohlokomedi (kgetha karabo ya gago) Monna/Mosadi

Parent/Guardian's age: _______years.

Mengwaga ya motswadi/mohlokomedi: _______mengwaga.

Landline Phone No__________Cellular Phone No (Nomoro ya mogala)________

Nomoro ya mogala________

Name of your child (Please print child's name in full) ________________

Leina la ngwana wa gago (Ngwala leina la ngwana ka botlalo) ________________

Name of School your child attends _____________

Leina la sekolo seo ngwana wa gago a se tsenago _____________

Gender of your child (Please select your answer) Male/Female

Bong ba ngwana wa gago (Kgetha karabo ya gago) Monna/Female

Parent/Guardian's signature (Mosaeni wa motswadi/mohlokomedi) _________________Date _________

Mosaeni wa motswadi/mohlokomedi__________________Letšatši_________

Thank you for completing this Questionnaire

Re a leboga ge o kgonne go tlatša lenaeopotšišo le.

Subject no:__________________________

School name:________________________

Interviewer:__________________________

Date:_______________________________

SECTION A: DEMOGRAPHIC INFORMATION

AFDELING A: DEMOGRAFIESE INLIGTING

1. Child's name and surname: ___________________________________

Kind se naam en van:

2. Child's date of birth: ____

Kind se geboortedatum:

3. Child's age ______ years and ______ months

Kind se ouderdom ______ jaar en ______ maande

4. Child's gender: male/female

Kind se geslag: manlike/vroulik

5. You are the child's: Mother/Father/Guardian/Other (specify) ___________

U is die kind se: Moeder/Vader/Voog/Ander (spesifiseer)

6. Your age: ______ years and ______ months

U ouderdom: ______ jaar en ______ maande

7. In which area/suburb do you stay? ________________________________

In watter area/woongebied woon u?

8. Do you own a motor vehicle? Yes/No

Besit u 'n voertuig? Ja/Nee

9. Including yourself, how many people aged 18 years and older live in your household?

Enter number_______

Insluitende u, hoeveel individue van 18 jaar of ouer woon in u huishouding? ______

10. How many children (including babies) under the age of 18 years live in your household?

Enter number________

Hoeveel kinders (insluitende babas) onder die ouderdom van 18 jaar woon in u huishouding? ______

11. What is your monthly household income, net income after taxes and fringe benefit deductions? (Optional) (Choose only one option)

Wat is u huishouding se maandelikse inkomste, die netto inkomste na all aftrekkings, insluitende belasting? (Opsioneel) (Kies slegs een opsie)

Less than / minder as R1000 R1000 to / na R2000 R2000 to / na R3000 R3000 to / na R4000 R4000 to / na R5000 R5000 to/ na R6000R6000 to / na R7000 R7000 to / na R8000 R8000 to / na R9000R9000 to / na R10000 R10000 and more / en meer

SECTION B: MEDICAL HISTORY / AFDELING B: MEDIESE GESKIEDENIS

1. What was your (or the child's mother's age) when giving birth to him/her? ______years.

Hoe oud was u (of die kind se moeder) toe u aan hom/haar geboorte geskenk het? ______ jaar.

2. How many weeks were you (or the child's mother) pregnant when you gave birth to this child? ______ weeks

Hoeveel weke was u (of die kind se moeder) swanger toe die kind gebore is? ______ weke

3. What was the birth weight of this child (as indicated on the "road to health" chart)? _______kg

Wat was die geboortegewig van die kind (soos op die "road to health" kaart aangetoon)? ______kg

4. Does the child's father, mother, grandparents, brother or sister suffer from any of the following conditions?

Ly die kind se vader, moeder, grootouers, broer of suster aan enige van die volgende toestande?

a. Type 2 diabetes mellitus / Tipe 2 diabetes mellitus

b. Hypertension / Hipertensie

c. Stroke / Beroerte

d. High cholesterol / Verhoogde kolesterol

5. How many people in the household smoke? ________

Hoeveel mense in u huishouding rook? _______

SECTION C: DIETARY INFORMATION / AFDELING C: DIEËET INLIGTING

Please answer the following questions as accurately as possible.

Beantwoord asseblief die volgende vrae so akkuraat as moontlik.

1. How many times per week does the child eat sweets, biscuits or cake? _____

Hoeveel keer per week eet die kind lekkergoed, koekies of koek?

2. How many times per week does the child eat take-away foods? ______

Hoeveel keer per week eet die kind wegneem kos?

3. How many times per week does the child drink cold drinks or fruit juice? ____

Hoeveel keer per week eet die kind koeldrank of vrugtesap?

4. How many times per week does the child eat fresh fruit? ______

Hoeveel keer per week eet die kind vars vrugte?

4. Was this child ever breastfed/fed breast milk?

Is die kind ooit geborsvoed / moedersmelk gevoer?______

a. Yes / ja

b. No / nee

c. Don't know / weet nie

5. How long after birth was this child first breastfed?

Hoe lank na geboorte is die kind die eerste keer geborsvoed?_______

a. Immediately / onmiddellik

b. Less than one hour / minder as een uur

c. Less than 24 hours / minder as 24 uur

d. More than 24 hours / meer as 24 uur

e. I don't know / weet nie

6. How was this child breastfed for the first six months?

Hoe is die kind vir die eerste ses maande geborsvoed

a. Breastfeeding exclusively / slegs borsvoeding

b. Both breastfeeing and formula milk / cow milk / beide moedersmelk en beesmelk

c. Other, specify / ander, spesifiseer _________________________

7. How was expressed milk given?

Hoe is uitgedrukte borsmelk gegee?

a. Bottle with teat/nipple / bottel met tiet

b. Cup / beker

c. Spoon / lepel

d. Other, specify / ander, spesifiseer ________________________

e. I don't know / weet nie

8. For how long was this child breastfed / fed breast milk? _______ months.

Hoe lank is die kind geborsvoed / moedersmelk gegee? ______ maande.

9. How old was this child when milk/food other than breast milk were given for the first time? ________________ months

Hoe oud was die kind toe melk/kos buiten moedersmelk vir die eerste keer gegee is? ______ maande

10. What was the first drink other than breast milk that this child received?

Wat was die eerste vloeistof, buiten moedersmelk wat die kind ontvang het?

a. Infant formula / baba formule

b. Water

c. Gripe water / krampwater

d. Sugar water / suikerwater

e. Other, specify / ander, spesifiseer___________________

SECTION D: PHYSICAL ACTIVITY / AFDELING D: FISIESE AKTIWITEIT

(We want to know how much time your child spends doing different things each day. Please put an X in one box for each question to tell us the number of hours your child spends doing each activity)

(Ons wil weet hoeveel tyd u kind aan verskillende aktiwiteite spandeer. Maak asseblief 'n X in een van die opsies vir elke vraag om aan te toon hoeveel uur u kind aan elke aktiwiteit spandeer)

1. In a typical week, how much time does your child usually spend watching television, DVD's or videos?

In 'n tipiese week, hoeveel tyd kyk u kind televisie, DVD's of videos?

None

Geen Less than 1 hour / minder as 1 uur 1 – 2 hours / ure 3 – 5 hours / ure 6 – 10 hours / ure 11 – 14 hours / ure 15 – 20 hours / ure More than 20 hours / meer as 20 ure

2. In a typical week, how much time does your child spend playing video games, cell phone games, or internet to e-mail or chat online? (Example: Nintendo, XBOX, PlayStation, WhatsApp, Mxit, etc).

In ‘n tipiese week, hoeveel tyd spandeer u kind aan die speel van videospeletjies, selfoonspeletjies, internet, e-pos of aanlyn gesels?

None

Geen Less than 1 hour / minder as 1 uur 1 – 2 hours / ure 3 – 5 hours / ure 6 – 10 hours / ure 11 – 14 hours / ure 15 – 20 hours / ure More than 20 hours / meer as 20 ure

3. In a typical week, how much time does your child spend reading outside of school? This includes reading books, magazines, newspapers, doing homework.

In ‘n tipiese week, hoeveel tyd spandeer u kind aan lees buite skool ure? Dit sluit in die lees van boeke, tydskrifte, koerante en die doen van huiswerk.

None

Geen Less than 1 hour / minder as 1 uur 1 – 2 hours / ure 3 – 5 hours / ure 6 – 10 hours / ure 11 – 14 hours / ure 15 – 20 hours / ure More than 20 hours / meer as 20 ure

4. In comparison to your children how would you rate your physical activity level at present?

In vergelyking met u kinders, hoe sal u, u eie huidige fisiese aktiwiteitsvlak grader?

Less active / minder aktief The same / dieselfde More active / meer aktief

5. When you were a child were you less or more physically active than your child?

Toe u ‘n kind was, was u meer of minder aktief as u kind?

Less active / minder aktief The same / dieselfde More active / meer aktief

6. How do your children get to school?

Hoe kom u kinders by die skool?

Walk / loop Run / hardloop Bus / taxi Car / motor Bicycle / fiets

7. How did you get to school as a child?

Hoe het u as kind by die skool gekom?

Did not go / nie gegaan Walk / loop Run / hardloop Bus / taxi Car / motor Bicycle / fiets

Contact details:

Kontakbesonderhede

Parent/Guardian's name (Please print your name in full)

Naam van ouer/voog (Skryf u naam asseblief volledig)________________

Parent/Guardian's gender (please select your answer) Male/Female

Geslag van ouer/voog (kies die antwoord) Manlik/Vroulik

Parent/Guardian's age: ________years.

Ouer/voog se ouderdom ________jaar.

Landline Phone No__________Cellular Phone No_____________

Telefoonnommer ___________Sellulêre telefoonnommer _____________

Name of your child (Please print child's name in full)_______________________

Naam van die kind (Skryf die kind se naam asseblief volledig)

Name of School your child attends__________________________________

Naam van u kind se skool____

Gender of your child (Please select your answer) Male/Female

Geslag van u kind (Kies die antwoord) Manlik/Vroulik

Parent/Guardian's signature____________________Date___________________

Handtekening van ouer/voog Datum____________________

(Thank you for completing this Questionnaire / Dankie dat u die vraelys voltooi het).

ADDENDUM H: A FEEDBACK CHART

University of Limpopo

Private Bag X1106, Sovenga, 0727, South Africa

Tel: (015) 268 2817, Fax: (015) 268 2209, Email:Marlise.vanstaden@ul.ac.za

CHILD HEALTH PROJECT

Today your child ________________________________ aged _________ participated in the Child Health Project that you gave consent for. The results are attached below.

Body fatness

To measure body fatness we use a term called BMI. A high BMI indicates large body fatness and a low BMI indicates low body fatness. We all need to have some fat in our bodies; however having too much fat is unhealthy. Below is an indication of your child's body fatness. If your child does not have a healthy BMI, you may speak to a health practitioner who will be able to assist you to solve the problem.

BMI	**Body fatness**	**Your child's BMI**
Less than 18.5 kg/m^2	Thin	
18.5 – 24.9 kg/m^2	Healthy	
25 – 29.9 kg/m^2	Overweight	
30 kg/m^2 or more	Obese	

If you have any questions, please feel free to contact

Ms MN Mokabane, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 2209, E-mail address: donnah.mokabane@gmail.com,

OR

Dr. Marlise van Staden, Department of Physiology and Environmental Health, University of Limpopo, Q-Block, 1st floor, Phone Number: 015 268 2817, E-mail address: marlise.vanstaden@ul.ac.za,

Kind regards

Dr M van Staden (Head of Department: Physiology and Environmental Health)