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The impact of an orange-fleshed sweet potato yoghurt on the nutritional status of pre-school children in Durban, South Africa

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Supervisor: **Date: 23 March 2022**

Co-supervisor: **Date: 23 March 2022**

Declaration

I, Onwaba Makanjana, hereby declare that the research work presented by this dissertation is my original work and all the materials used are appropriately acknowledged and explicitly reference. A reference list is attached to the thesis.

I also confirm that the thesis has not been submitted in any of its part or entirety for any degree in any other institution of higher learning internationally or locally.

I therefore give permission that my work be available for replication and/or for re-printing, for inter-library loan, and for the title and abstract of my dissertation to be made available to other educational institutions and students that might need it.

Onwaba Makanjana Date: 23 March 2022

Prof. Carin Napier Date: 23 March 2022

Dr Ashika Naicker Date: 23 March 2022

Dedication

This journey was far bigger than just achieving something for myself: I therefore dedicate this dissertation to every African student from a disadvantaged background who has a dream. Many of the challenges we go through in our academic journeys as those who have gone before you, are to set a path and to show you that it can be done. Walk on that path. Even better, run on it and go beyond it. With God, there are no limits!

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Abstract

Background: Malnutrition exists globally due to various factors including basic, underlying and immediate factors. Goal two of the global targets in the 2030 Agenda for Sustainable Development is to end hunger and ensure that even the poorest people have access to sufficient, nutritious and safe food all year round. The Department of Social Development (DSD) in South Africa identified Early Child Development (ECD) centres as an ideal platform for implementing strategies aimed at improving the wellbeing of children below five years of age. ECD centres are facilities designed to provide early childhood development services and programmes that include good health, proper nutrition and early learning, through a holistic approach in promoting a healthy environment that is conducive for learning and development.

Rationale and objectives: The health and nutritional status of young children is a global priority, as indicated in the 2030 Agenda for Sustainable Development. The arguments in favour of promoting the development of children at a very young age are clear and compelling. Effective interventions aimed at the vulnerable groups can make a positive contribution towards the achievement of Sustainable Development Goal (SDG) 2 which aims to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. Inadequate nutrition in young children not only affects physical growth and development, but mental functioning as well. The pre-school years are associated with a phase of rapid growth. Adequate nutrition during the pre-school years is critical as proper nutrition plays an essential role in preventing malnutrition and other childhood-related diseases.

Dietary diversification is one of the most effective strategies in preventing malnutrition and it is recommended that it is implemented during the stage of complementary feeding. Diets lacking dietary diversity lead to inadequate intake of vital nutrients such as vitamin A and iron, which may result in micronutrient deficiencies. Vitamin A and iron deficiencies are common among pre-school children in South Africa (SA) and the orange-fleshed sweet potato (OFSP) was identified as a potentially effective strategies to address vitamin A deficiency (VAD). The purpose of the study was to determine the nutrient intake, to develop and test the impact of an OFSP yoghurt on nutritional status of pre-school children in Durban, KwaZulu-Natal, SA, by determining the vitamin A and iron status of preschool children. The objectives of the study were to establish the socio-demographic profile of the children, to take anthropometric measurements (weight and height) to establish their nutritional status, to assess the dietary intake using a 24-hour recall questionnaire, (which was repeated three times) and a Food

Frequency Questionnaire (FFQ). Furthermore, the study also aimed to determine the levels of vitamin A and iron in the blood at the time of the study using the finger-prick dried blood spot method, develop a yoghurt using an OFSP, administer the yoghurt as an intervention for three consecutive months and thereafter test the impact of the yoghurt on the nutritional status of the participants.

Methodology: In this intervention trial, two ECD centres, an experimental group (EG) and control group (CG) comprising of 116 children aged 24–60 months were randomly selected. In each group, the participants were stratified according to age: 24–47 months and 48–60 months. At baseline, through the caregiver of the child participant, socio-demographic data was captured, and dietary intake was measured through three 24-hour dietary recall questionnaires, which were then analysed using Food Finder® software version 3.0 developed by the South African Medical Research Council (SAMRC). The food frequency questionnaire was used to calculate the food variety and food group diversity scores. Anthropometric measurements (weight and height) were taken and the World Health Organization (WHO) Anthro software® version 3.1 was used to convert these into nutritional data indices. Blood samples were collected through dried blood spot cards in order to determine serum retinol and haemoglobin (Hb) levels, which were assessed using the WHO indicators. A yoghurt with OFSP was developed following the steps of product development. The participants in the EG were given 100g of the developed OFSP yoghurt daily for three months, while the participants in the CG were given 100g of a peach flavoured yoghurt bought from the supermarket daily for three months, excluding weekends. The peach flavour was chosen for the CG as the colour was closest to the developed OFSP yoghurt. After the intervention period, anthropometric measurements were taken, dietary intake was assessed and blood samples were taken to assess impact on serum retinol and Hb levels.

Results: Regarding the socio-demographic profile, unemployment was high, as 45.6% (n=36) and 54.1% (n=20) of the participants in the EG and CG respectively, were unemployed. In terms of household characteristics, 45.6% (n=36) of the participants in the EG and 32.4% (n= 12) in the CG had a tap inside the house. Access to a flush/sewage toilet was very limited in both groups, as less than half of participants had a flush toilet (39.2%; n=31) and 40.5% (n=15) in EG and CG, respectively) and more than half of the participants had a pit latrine (60.8%; n=48) in the EG and 59.5% (n= 22) in the CG. At baseline, anthropometric results in the current study showed that 16.6% (n=2) of CG girls 48-60 months of age were stunted. Among boys,

10.5% (n=12) and 36.4% (n=4) of EG and CG boys 48-60 months of age respectively, were stunted. No change was noted among EG boys 24-47 months of age of age, as 4.8% (n=1) were severely stunted at baseline and at endline. At baseline, 8.7% (n=2) of EG girls 24-47 months of age were overweight. In the CG group, 28.6% (n=2) and 16.7% (n=2) of girls 24-47 months of age and 48-60 months of age, respectively, were overweight. Furthermore, 9.5% (n=2) of EG boys and 42.8% (n=3) of CG boys 24-47 months of age were overweight. The prevalence of overweight among boys 48-80 months of age was 10.5% (n=2) and 27.3% (n=3) in the EG and CG, respectively. The prevalence of the risk of overweight increased from 21.7% (n=5) among EG girls 24-47 months of age at baseline to 45.0% (n=9) at endline and from 14.3% (n=1) to 28.6% (n=2) in the CG group. In the CG, an increase in the prevalence of the risk of overweight was noted among boys 48-60 months of age from 36.3% (n=4) at baseline to 54.5% (n=6) at endline.

At baseline, the energy intake of girls and boys 24-47 months of age was more than the estimated energy requirement (EER) for both groups, whereas for the 48-60 month age group, it was less than the EER. The mean intake of fibre and calcium was lower than the recommended dietary allowance (RDA) for all groups and most participants consumed less than the RDA for fibre and calcium. The mean fruit and vegetable intake was less than the WHO recommendation of 320g to 480g per day for 24-47 month old children, and 400g to 480g for 48-60 month old children for all participants in the current study, and there was low variety in both groups. When comparing baseline with endline results between age groups within a group, there was a decrease in energy intake in all groups. Significant differences were found among EG girls 24-47 months of age ($p=0.008$) and CG girls ($p=0.003$ for 24-47 months and $p<0.001$ for 48-60 months) for energy intake. Furthermore, baseline results showed that 2.7% (n=2) and 14.3% (n=3) of participants had low serum retinol levels in the EG and CG, respectively. At endline, serum retinol increased in 5.5% (n=3) of participants in the EG and 4.5% (n=1) in the CG. Low Hb levels were found in 19.2% (n=14) of participants in the EG and 32.1% (n=9) in the CG. At endline, Hb levels increased in 3.7% (n=2) and 9.0% (n=2) of participants in the EG and CG, respectively.

Conclusion: Despite the numerous efforts to improve the nutritional status of children, a high prevalence of malnutrition still exists in South Africa. Consumption of the OFSP yoghurt made a small contribution to dietary vitamin A intake for some participants and iron intake levels did not increase from baseline to endline. The intervention period was too short to show an impact

on anthropometric measurements such as stunting. The socio-demographic profile indicated that participants were predominantly from low-income households, and deprived of some essential sanitation services. Other issues in the current study population included overcrowding and high unemployment, with some households running out of money to buy food. The diet of the participants, was sub-optimal for optimum growth. Malnutrition, presented through micronutrient deficiencies, stunting, overweight and obesity, co-exist in this vulnerable population.

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List of abbreviations

AMDR	Acceptable Macronutrient Distribution Range
ANOVA	Analysis of Variance
ARC	Agricultural Research Council
BFHI	Baby-Friendly Hospital Initiative
CCP	Critical Control Point
CDC	Centers for Disease Control and Prevention
CG	Control Group
CFU	Colony Forming Units
CHO	Carbohydrates
COVID	Corona virus
CP	Control Point
DAFF	Department of Agriculture, Forestry and Fisheries
DBE	Department of Basic Education
DBS	Dried Blood Spots
DSD	Department of Social Development
DUT	Durban University of Technology
ECD	Early Child Development
EAR	Estimated Average Requirement
EER	Estimated Energy Requirement
EG	Experimental Group
EMP	Embden-Meyerhof-Parnas
FAO	Food and Agriculture Organization
FFQ	Food Frequency Questionnaire
FGDs	Food Group Diversity Score
FRC	Faculty Research Committee
FVS	Food Variety Score
GHPs	Good Hygiene Practice
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis Critical Control Point
Hb	Haemoglobin
HF	Home Fortification
HPLC	High Performance Liquid Chromatography

IDA	Iron Deficiency Anaemia
IFAD	International Fund for Agriculture and Development
IP	Intensive Program
IREC	Institutional Research Ethics Committee
ISO	International Organization for Standardization
IYCF	Infant and Young Child Feeding
KZN	KwaZulu-Natal
LAB	Lactic acid bacteria
LB	Lactobacillus delbrueckii subsp. Balgaricus
MBFI	Mother-Baby Friendly Initiative
MDGs	Millennium Development Goals
MNP	Micronutrient Powders
MND	Micronutrient Deficiencies
MPI	Multi-dimensional Poverty Index
NAR	Nutrient Adequacy Ratio
NCDs	Non-Communicable Diseases
NIDS-CRAM	National Income Dynamics Study-Coronavirus Rapid Mobile
NFCS	National Food Consumption Survey
NFCS FB	National Food Consumption Survey Fortification Baseline
NPD	New Product Development
OFSP	Orange-fleshed Sweet Potato
PKF	Phosphoketolase
PRPs	Pre-requisite Programmes
RAE	Retinol Activity Equivalents
RDA	Recommended Dietary Allowance
RP	Reduced Program
SA	South Africa
SADHS	South African Demographic Health Survey
SAMRC	South African Medical Research Council
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
SANHANES	South African National Health and Examination Survey
SAVACG	South African Vitamin A Consultative Group
SD	Standard Deviation

SDGs	Sustainable Development Goals
SNF	Solid Non-Fat
SSA	Sub-Saharan Africa
ST	Streptococcus salivarius subsp. Thermophilus
TA	Titrable Acidity
UHT	Ultra-high Temperature
UL	Tolerable Uppper Intake Level
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
USA	United States of America
VAD	Vitamin A Deficiency
VRBL	Violet Red Bile Lactose
WASH	Water, Sanitation and Hygiene
WFP	World Food Programme
WFSP	White-fleshed Sweet Potato
WHO	World Health Organization
WPC	Whey Protein Concentrates
WPI	Whey Protein Isolates

List of symbols

%	Percent
°C	Degrees Celsius
<	Less than
>	Greater than
≤	Less than or Equal to
≥	Greater than or Equal to
g	Grams
kg	Kilograms
kJ	Kilojoule
L	Litre
mg	Milligram
ml	Millilitre
n	Number
P	Percentage
SD	Standard Deviation
Z	Z score

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CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 Introduction

The aim of this chapter is to introduce the reader to the context of the study by discussing the prevalence of hunger and malnutrition globally, in Africa and in South Africa (SA). The rationale for this study will be given and furthermore, the framework for the research study and the outline of the dissertation will be presented.

Hickson and Smith (2018: 19) define malnutrition as any condition caused by an imbalance (deficiency or excess) in the intake of energy, protein and other nutrients. Malnutrition manifests in various forms such as underweight (includes stunting and wasting), micronutrient-related malnutrition (includes deficiencies in micronutrients), overweight and obesity. A primary nutrient deficiency may occur as a result of insufficient dietary intake, whereas a secondary deficiency may be caused by an underlying disease or condition such as malabsorption. The most common micronutrient deficiencies in children under five years are vitamin A, zinc and iron deficiency [World Health Organization (WHO) 2020a: 1]. Nutritional deficiencies such as iron deficiency impair productivity and cognitive ability. Multiple micronutrient deficiencies cause irritability, aggression and a lack of energy. Clinical signs vary according to the type of nutrient lacking in the diet, and may include muscle wasting, restricted growth, increased risk of infections, delayed adaptation to the dark, night blindness, fatigue and spongy swollen or bleeding gums (Nagar *et al*. 2018: 312; Bharati *et al*. 2018: 236).

The WHO defines overweight in children below five years as weight for height above two standard deviation (SD) from the median of the WHO child growth standards for children below five years of age. Obesity in this age category is defined as weight for height greater than three SD above the WHO child growth standards median. Overweight in children increases the risk of non-communicable diseases (NCDs) later in life (WHO 2020b: 1). In recent years, the incidence of overweight and obesity in children has increased in low and middle-income countries in both rural and urban settings. The main cause of overweight and obesity in adults and children is an energy intake that exceeds energy expenditure. In young children, incorrect feeding practices are a major contributor to the high prevalence of overweight and obesity (WHO 2020b: 1).

1.2 The global prevalence of malnutrition

Malnutrition exists globally due to various factors such as poverty, food insecurity, poor food intake and poor socio-economic conditions. The United Nations Children's Emergency Fund (UNICEF), WHO and World Bank Group (2018: 1) mentioned that even though global and local strategies have been implemented to reduce hunger and eradicate poverty, the global under-five mortality rate is still high at 39 deaths per 1000 live births, and micronutrient deficiencies are widespread in various regions. In the fight against poverty and malnutrition, some improvement was made through the implementation of the Millennium Development Goals (MDGs) between 2000 and 2015 (United Nations 2015: 35). Subsequent to the implementation of the MDGs, malnutrition is still prevalent globally as most regions did not achieve the set targets by 2015. As a result, it was deemed necessary to create new targets and therefore, the Sustainable Development Goals (SDGs) were set by the United Nations General Assembly to address the persistent issues by 2030 (United Nations 2015: 35).

Goal two of the global goals in the 2030 Agenda for Sustainable Development is to end hunger and ensure that even the poorest people have access to sufficient, nutritious and safe food all year round (United Nations 2020a: 7). Food insecurity is one of the indicators of hunger. The State of Food Security and Nutrition in the World Report 2020 showed an increase in the prevalence of hunger globally. Data shows that approximately 8.9% of the global population is experiencing hunger, reflecting an increase of almost 60 million in the last five years (Food and Agricultural Organization (FAO), International Fund for Agriculture and Development (IFAD), UNICEF, World Food Programme and WHO 2020: 3). In 2019, approximately two billion people globally did not have continuous access to safe, nutritious and sufficient food and nearly 750 million people were exposed to severe food insecurity. The global target of achieving zero hunger by 2030 is therefore not on track, and it is anticipated that the levels of hunger will increase globally to 840 million (9.8%) by 2030 (FAO *et al*. 2020: 3). Similarly, the SDG 2020 Report also showed an upward trend in the population affected by moderate or severe food insecurity (United Nations 2020a: 26).

Moderate food insecurity reflects a state of not having access to sufficient and nutritious food on a regular basis, even though those affected may not be suffering from hunger. This leads to reduced diet quantity and quality, and therefore increases the risk of malnutrition. People with severe food insecurity are completely out of food and in some instances, may have had no food consumption in 24 hours or more (FAO *et al*. 2020: 19). Globally, the percentage of the

population experiencing moderate or severe food insecurity has increased from 22.4% in 2015 to 25.9% in 2019. An increase was noted in Asia (from 18.9% to 22.3%) and Latin America and the Caribbean (25.1% to 31.7% (FAO *et al*. 2020: 20).

Hunger affects long-term growth and development; another indicator of hunger is the prevalence of undernutrition (UNICEF 2019: 6). Global statistics show that the decline in the prevalence of undernutrition which was achieved in the last few years, has plateaued. Worldwide, 8.9% of the population was undernourished in 2015. There was a decline in 2017 (from 8.9% to 8.7%); however, 60 million more people were estimated to be undernourished in 2019, resulting in an increase to 8.9%. Africa has the highest level of undernutrition (19.1%), followed by Asia (8.3%) and the Latin America and the Caribbean (7.4%). The global average prevalence of undernutrition is 8.9%, and over half of undernourished people are from Asia. Southern Asia showed a decrease in the prevalence of undernutrition from 14.4% in 2015 to 13.4% in 2019; however, the rate increased in Western Asia from 10.7% to 11.2%. The rise of hunger in the latter region can be attributed to conflict and instability. Of significance is the civil war in the Syrian Arab Republic, which resulted in deterioration of the economy, infrastructure and the food system. Although progress has been noted in Southern Asia, the region is not on track for the 2030 target. The prevalence of undernutrition was 6.2% in Latin America and the Caribbean in 2015 and increased to 7.4% in 2019. Most sub-regions showed an increase in the prevalence of undernutrition, with central America moving from 7.9% to 9.3%, Latin America from 5.4% to 6.7% and South America from 4.4% to 5.6%. A decline in the prevalence of undernutrition was noted in the Caribbean, from 17.3% to 16.6%. This sub-region has the highest incidence partly as a result of drastic weather conditions like floods, droughts, earthquakes and the destruction of natural resources. Similar to Asia, it is unlikely that the Latin American and Caribbean region will achieve zero hunger by 2030 (FAO *et al.* 2020: 9).

Malnutrition results from consumption of diets of poor quality and quantity, as well as inadequate health care. Malnutrition manifests in various ways, including stunting, wasting, underweight, overweight and micronutrient deficiencies (International Food Policy Research Institute 2016: 2). The WHO stated that undernutrition is linked to 45% of child deaths worldwide (WHO 2020a: 1). The global nutrition targets also include a reduction of stunting and wasting in children under the age of five (by 40% and less than 5%, respectively), to achieve no increase in the prevalence of overweight in children in this age group by 2025 and to end all

forms of malnutrition by 2030. Statistics from the 2020 Global Nutrition Report show that inadequate progress has been made to meet the 2025 targets, as 149.0 million (21.9%) children are stunted, 49.5 million (7.3%) are wasted and 40.1 million children (5.9%) under five years are overweight (United Nations 2020b: 35).

Globally, more people were undernourished in 2020 compared to 2014. The increase can be attributed to a decline in economic conditions, resulting in increased poverty levels (FAO *et al*. 2020). Extreme weather and environmental conditions, which affect food production and distribution also contribute to the vicious cycle of poverty, resulting in undernutrition (Nhemachena *et al*. 2020: 2). Furthermore, the displacement of populations which is higher in low- and middle-income countries, leads to faster population growth and increased inability to meet healthcare and education requirements of the population. Even before the Corona virus (COVID-19) pandemic, the global goal to end poverty by 2030 was not on track (FAO *et al.* 2020: 3). The pandemic led to in an increase in global poverty levels, which will further deteriorate the nutritional status of children below five years (High Level Panel of Experts on Food Security and Nutrition 2020: 2).

1.3 Malnutrition in Africa and SA

Data published by the FAO *et al.* (2020: 20) shows that in 2019, 51.6% of people residing in Africa experienced moderate or severe food insecurity, the highest in the world. This is an increase from 46.5% in 2015. The increase indicates that Africa is not getting closer to achieving the nutrition targets, as an increase in food security impacts health and nutritional status negatively, resulting in different manifestations of malnutrition. The causes of food insecurity in this region include poverty, conflict, climate and unstable markets, among other (FAO *et al*. 2020: 20).

The African continent has the highest prevalence of undernutrition at 19.1% in 2019, which is more than double the global average of 8.9%. It is anticipated that it will increase further to 25.7% in 2030. Sub-Saharan Africa (SSA) has the highest statistics for undernutrition, with Middle Africa being the most severely affected region (29.8%), followed by Eastern Africa, Western Africa and Southern Africa (27.2%, 15.2% and 8.4%, respectively). In recent years, there has been a noted increase in the percentage of hungry people in this region. This region predominantly has poor infrastructure and limited access to health services. Both these factors pay a role in the elevated levels of malnutrition and food insecurity experienced by most of the

population in this continent. Africa has a population of approximately 800 million people with high rates of child morbidity and mortality (FAO *et al.* 2020: 8). Due to high food costs and unequal food distribution at household level, the diet of many people is not balanced and consists mainly of staple foods and insufficient amounts of animal protein and micronutrient-rich fruit and vegetables (French *et al.* 2019: 6).

Several surveys aimed at investigating the prevalence of malnutrition have been conducted in SA. The national surveys were cross-sectional and therefore a direct comparison is not possible however, certain trends can be observed. Findings indicate that SA has experienced nutritional issues for decades. Back in 1994, the South African Vitamin A Consultative Group (SAVACG) conducted a national survey to determine nutritional issues affecting the SA population. Results from this survey showed that one in three children had marginal vitamin A status, and over 35% of children between 36 to 47 months had less than 0.96 µmol /L levels of serum retinol. Biochemical vitamin A deficiency (VAD) was more prevalent in rural areas, as compared to urban areas. Iron deficiency was prevalent in children six to twenty-three months of age (SAVACG 1996:10).

In 1999, the National Food Consumption Survey (NFCS) which was conducted in SA by Labadarios *et al.* (2005: 536) showed that one in ten children between one and nine years of age were underweight and nearly one in five children were stunted. In 2005, the NFCS Fortification Baseline (NFCS-FB-1) was conducted in SA to evaluate the nutritional status of children and to determine progress made towards improving nutritional issues identified in surveys done prior to 2005. This survey showed that one in five children were stunted and one in ten children were underweight. Poor vitamin A status was found in two out of three children and one in seven children had iron deficiency. Furthermore, findings from this survey indicated that there was a noted increase in the prevalence of poor vitamin A status, when compared to the results from the SAVACG study (Labadarios *et al.* 2008: 255).

Close to a decade later, the SA National Health and Examination Survey (SANHANES-1) revealed that undernutrition is still prevalent in SA. Stunting was higher in younger children between zero and three years of age (26.9% of boys were stunted compared to 25.9% of girls). In children under five years, the mean serum retinol concentration was higher for females (0.79 µmol /L) compared to males (0.72 µmol/L). A lower mean retinol concentration was observed in black African children compared to any other racial group. Ten percent of the children were anaemic and the mean Hb concentration was 12.2 g/dL (Shisana *et al*. 2013: 18).

Compared to the NFCS-FB-1 conducted in 2005, the SANHANES-1 report showed an increase in the rate of stunting and severe stunting among children between one and three years (from 23.4% to 26.5% and 6.4% to 9.5%, respectively). This report further revealed that there was a significant improvement in the rate of wasting (from 5.1% to 2.2%) and underweight (from 11.0% to 6.1%) (Shisana *et al.* 2013: 211). In 2005, the NFCS-FB-1 indicated that 5.1% of children in this age group were wasted and 11.0% were underweight (Labadarios *et al*. 2008: 255). Compared to the NFCS-FB-1 (Labadarios *et al.* 2008), the SANHANES-1 report showed a 2.2% improvement in the rate of wasting and a decrease in the number of underweight children (Shisana *et al.* 2013: 211).

Furthermore, Shisana *et al.* (2013: 214) reported that at a national level, SA had a VAD prevalence of 43%, indicating a severe public health problem as per the WHO classification. Vitamin A status was noted to be poorer in black African children compared to coloured children, even though there were no statistical differences. Compared to the NFCS-FB-1 conducted in 2005 (Labadarios *et al*. 2008), the rate of stunting decreased from 16.4% to 11.9% in children between four to six years old. There was an overall improvement in the prevalence of stunting, wasting and underweight in this age group as the rate of severe stunting decreased from 5.1% to 2.2%, wasting from 5.0% to 2.0% and severe wasting from 1.8% to 0.8%. Moreover, the rate of underweight also reduced by 4.1% (from 8.6% to 4.5%). Zero-point six percent of children in this age group were severely underweight compared to 0.8% as indicated by the NFCS-FB-1 in 2005 (Labadarios *et al*. 2008). Undernutrition was more widespread in rural informal areas than urban areas. Looking at different age groups, ranging from one to three-years-old, four to six-years-old and seven to nine-years-old, there was a decrease in undernutrition, more so for wasting and underweight. For the slightly older children between six to nine years old, the SANHANES-1 study found that the mean BMI was relatively the same as the NFCS-FB-1 conducted in 2005 at 16.2kg/m² and 16.0 kg/m², respectively (Shisana *et al.* 2013: 209). The percentage of children who were underweight also remained almost the same at 89.0% and 89.9%, respectively. Similar trends of a significant reduction in various categories were evident in the seven to nine-years old age group. The prevalence of stunting decreased from 12.0% to 9.4%, with severe stunting from 3.4% to 1.7%. Furthermore, wasting and underweight also decreased from 3.0% to 1.9% and 7.6% to 6.6%, respectively. The percentage of children who were wasted and severely underweight remained the same in the NFCS-FB-1 2005 and SANHANES-1 at 0.5% and 0.9%, respectively (Labadarios *et al*. 2008; Shisana *et al.* 2013: 210).

Faber *et al.* (2015: 67) conducted a study in three provinces in SA in order to assess the vitamin A and anthropometric status of pre-school children. The results showed that the participants from KwaZulu-Natal (KZN) had a significantly lower serum retinol concentrations compared to those from the Northern Cape and Western Cape. Another study by Schoeman (2010: 25) also indicated that in KZN, 24% of children between 6 and 59 months were stunted, 11% were underweight and 5% were wasted. This study further indicated that stunting was higher among children aged 60-71 months (31%). Findings by Govender *et al.* (2021: 8) also showed similar nutritional issues among children between one to five years residing in selected rural communities in KZN. The authors reported that 20.5% of children were severely stunted, 5.1% were severely underweight and 7.7% were severely wasted (Govender *et al.* 2021: 8).

Over-nutrition is also a problem in SA. When comparing the nutritional status of South African children with other African countries, reports indicate that SA has high levels of overweight and obesity. Countries like Nigeria, Swaziland and Botswana have approximately 11% of obese or overweight children. In SA, the SANHANES-1 report found that there was a significant increase (from 10.6% to 18.1%) in the number of children who were overweight compared to the NFCS-FB-1 conducted in 2005. The prevalence of obesity on the other remained fairly constant (Shisana *et al.* 2013: 210).

1.4 Food security in SA

SA has a long-standing battle with food and nutrition security. Previous early research, by Lemke *et al.* (2003: 759) reported that in urban and rural areas of the North West province, 16% of the households were very food and nutrition insecure, 58% were insecure, 21% were relatively secure and 5% were secure. Progressively, a more recent report by Statistics SA (2018: para. 1 line 65-67), showed that household hunger decreased from 24.2% to 9.7% in 2018 in SA. However, the food security status of individual provinces differs vastly as in the same report, households in the North West province, Northern Cape, Mpumalanga, and Eastern Cape had a severe shortage of or inadequate access to food (Statistics SA 2018: para. 1 line 4). The COVID-19 pandemic has caused fluctuations in the employment and revenue sectors in SA. Research done by Statistics SA (2020: para. 1 line 10) disclosed that individuals receiving no income increased from 5.2% before the national lockdown to 15.4%. This report also showed that individuals experiencing hunger had increased from 4.3% to 7% since the first national lockdown. The National Income Dynamics Study-Coronavirus Rapid Mobile (NIDS-CRAM) survey investigated household food insecurity, child and household hunger through five waves

(May/ June 2020 and April/ May 2021). This survey reported that in wave one, 47% of households had run out of money, whereas only 35% of households ran out of money in wave five, however, household hunger was still prevalent as wave one showed 23% of households reported household hunger and waves three, four and five reported 17% to 18% of household hunger. The report also indicated that child hunger has not decreased as wave five showed 14% of child hunger in households (Van der Berg *et al.* 2021: 3).

1.5 Food-based micronutrient intervention studies

A number of food-based intervention studies have been conducted globally to address micronutrient deficiencies. Table 1.1 shows intervention studies conducted to address micronutrient deficiencies and provides a brief summary of the findings from each study.

Table 1.1: Intervention studies to address micronutrient deficiencies

Title of the study and author	Study population and location	Measuring instruments	Summarised results
Cassava Intake and Vitamin A Status among Women and Preschool Children in Akwa-Ibom, Nigeria (De Moura *et al.* 2015).	660 participants: pre-school children (6-59 months) and women of childbearing age 18-49 years. Location: Nigeria.	Anthropometry. 24-hour recall questionnaires. Blood samples were drawn from all participants by venipuncture. Hb was measured using Hemocue-Hb 201+. Serum retinol was assessed by a reversed-phase High Performance Liquid Chromatography (HPLC).	The frequency of daily consumption of cassava was high in both groups. There was a lower prevalence of VAD among women (3.4%) compared to children (16.9%). The prevalence of anaemia was higher among the children (75%), compared to women (55%).
Introduction of β-Carotene-Rich Orange Sweet Potato in Rural Uganda Resulted in Increased vitamin A intake among Children and Women and Improved vitamin A Status among Children (Hotz *et al.* 2012).	432 children from 6 months to 5 years and women. Location: Uganda.	Venous blood samples were collected from children 3-5 years and women. Normal-phase HPLC) was used to determine serum retinol concentration. 24-hour recall questionnaire. Anthropometric measurements (weight and height).	At baseline, the difference between the total intake of orange fleshed sweet potato (OFSP) in various groups was not significant. The OFSP intake contributed only 2-6% of total vitamin A intake in all groups (Intensive Program (IP), Reduced Program (RP) and control group (CG). Follow-up results showed a significant net increase in the intake of OFSP in the intensive program group and the reduced program

Table 1.1: Intervention studies to address micronutrient deficiencies

Title of the study and author	Study population and location	Measuring instruments	Summarised results
			group relative to the CG. Furthermore, the total contribution of OFSP to total vitamin A intake was 44-60% in the IP and RP groups, and 5-11% in the CG. The dietary intake of children and women increased significantly, resulting in a significantly lower prevalence of inadequate vitamin A status among women and non-breastfed children. Anthropometric results showed that low height for age was found in 35.7%, 40.6% and 42.3% of children between 6-35 months in the IP, RP and CG, respectively.
Daily Consumption of Orange-fleshed Sweet Potato Increased Plasma β-Carotene Concentration but did not increase Total Body Vitamin A Pool Size in Bangladeshi Women (Jamil *et al.* 2012).	Non-pregnant non-lactating women aged 18-45 years. Location: Bangladesh.	Anthropometric measurements: height, weight and mid-upper arm circumference. Pupillary threshold tests. Blood samples collected using antecubital venepuncture.	Plasma β-carotene increased after the intervention but not the total vitamin A.
Delivery of iron-fortified yoghurt, through a dairy value chain progamme, increases haemoglobin concentration among children 24 to 59 months old in Northern Senegal: A cluster-randomized control trial (Le Port *et al.* 2017).	321 children aged 24-59 months. Location: Senegal.	Questionnaires. Finger prick using a Hemocue device 201+.	Results showed a decrease in the prevalence of anaemia from 80% at baseline to 60% post intervention. There was a noted higher increase in haemoglobin in the intervention group compared to the CG.
A Food-Based Approach Introducing Orange-Fleshed Sweet Potatoes Increased vitamin A Intake and Serum Retinol Concentrations in Young Children in Rural Mozambique (Low *et al.* 2007).	827 households and children between four to 38 months. Location: Mozambique.	Blood samples were collected from all children in the households that participated. Serum retinol concentrations were assessed using HPLC. FFQs were used to assess the	The prevalence of stunting was 61% and did not differ between experimental group (EG) and CG. Some participants were wasted (six percent and three percent in the intervention and control groups respectively. The prevalence of underweight was higher in the

Table 1.1: Intervention studies to address micronutrient deficiencies

Title of the study and author	Study population and location	Measuring instruments	Summarised results
		consumption of vitamin A rich foods. 24-hour recall questionnaires were used to assess food intake. Anthropometry.	intervention group (34%) compared to the CG (24%). The intake of vitamin A was higher among the children in the intervention group. Baseline results showed no difference in the prevalence of low serum retinol concentration. After the intervention, the prevalence of low serum retinol decreased by 10%.
Triple-Fortified Rice containing vitamin A Reduced Marginal VAD and Increased vitamin A Liver Stores in School-Aged Thai Children (Pinkaew *et al.* 2014).	Children between Eight to twelve years (n=50). Location: Thailand.	Venous blood samples. Anthropometric measurements.	After two months of consuming the triple fortified rice, the total body reserves of vitamin A increased significantly among the children in the intervention group (from 153±66 µmol retinol to 269±148µmol retinol post intervention). Participants in the CG were given natural rice and no significant change was observed in the CG.
Double-blind cluster randomised controlled trial of wheat flour chapatti fortified with micronutrients on the status of vitamin A and iron in school-aged children in rural Bangladesh (Rahman *et al.* 2015).	352 children (203 in the intervention group and 149 in the CG). Location: Bangladesh.	Blood samples were collected by venepuncture.	Serum retinol concentration increased by 0.12 µmol L^{-1} at six months. After three months of intervention, the likelihood of VAD was significantly lower among children in the intervention group, odds ratio = 0.26 and 0.21 at six months. There was no evident effect of consuming the fortified chapattis on iron status.
Impact of micronutrient fortification of yoghurt on micronutrient status markers and growth – a randomized double-blind controlled trial among school children in Bangladesh (Sazawal *et al.* 2013).	1 010 six to nine-year-old primary school children. Location: Bangladesh.	Anthropometric measurements. Venous Blood samples. Urine samples.	The iron status did not improve; however, Hb levels improved significantly. Zinc status of the participants who consumed fortified yoghurt improved. Furthermore, the fortified yoghurt reduced the deterioration of vitamin A and iodine status.
β-Carotene-rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the	180 five to ten-year-old children. Location: SA.	Anthropometric measurements. Blood samples were obtained by	Anaemia was higher in the CG (37% compared to the treatment group).

Table 1.1: Intervention studies to address micronutrient deficiencies

Title of the study and author	Study population and location	Measuring instruments	Summarised results
modified-relative-dose-response test (Van Jaarsveld *et al.* 2005).		antecubital venipuncture and analysed using reverse-phase HPLC.	None of the children were underweight. The percentage of children with inadequate vitamin A liver stores was higher in treatment group (20%) compared to the CG (14%). In the treatment group, the percentage of children with adequate vitamin A liver stores increased significantly after the intervention (78% to 87%; P = 0.096), whereas there was no significant increase in the CG (86% to 82%; P = 0.267).

1.6 Early child development

Goal 4 of the global goals aims to ensure that all girls and boys have access to quality early childhood development, care and pre-primary education by 2030 (United Nations 2020a: 32). The WHO defines early childhood development (ECD) as the process of cognitive, physical, language, temperament, socioemotional and motor development of children commencing at conception until the age of eight years. Nurturing care is crucial for optimal development and it refers to a stable environment that is sensitive to the health and nutritional needs of children. Moreover, it includes components such as, opportunities for early learning, security and safety and response caregiving (WHO 2020a: 2).

The WHO, UNICEF and World Bank Group launched the nurturing care framework for early childhood development in 2018. The framework was developed based on evidence that timeous and appropriate interventions improve early child development. Lack of nurturing care negatively impacts the child's capacity to thrive and hinders growth and the ability to learn. Furthermore, learning and social skills are acquired at a young age therefore psycho-social and nutritional programmes implemented in the early years of life are of significant benefits and promote overall development (WHO and UNICEF 2018: 12).

In SA, the Department of Social Development (DSD) identified ECD centres as an ideal platform for implementing strategies aimed at reducing poverty in children below five years of age in SA (DSD and UNICEF 2007: 12). ECD centres are facilities designed to provide early childhood development services and programmes that include good health, proper nutrition and early learning through a holistic approach in promoting a healthy environment that is conducive for learning and development. ECDs in SA are non-profit organisations that are funded by the DSD and the Department of Education. There are approximately 14 205 registered partial facilities that operate as ECD centres and many others are unregistered as they do not comply with the requirements and standards set out in the Children's Act (DSD 2020: 1; DSD and UNICEF 2007: 24). Given the strong subscription of ECDs in SA, ECDs are the perfect platform to continue support for the first 1000 days of life (Makanjana and Naicker 2021: 2).

1.7 Rationale and motivation for the study

The health and nutritional status of young children is a global priority, as indicated in the 2030 Agenda for Sustainable Development (United Nations 2020b: 35). The arguments in favour of promoting the development of children at a very young age, are clear and compelling. It is evident from the information and statistics presented in this chapter that there is a necessity for various interventions to be implemented to address malnutrition, including micronutrient deficiencies in SA (Shisana *et al*. 2013: 210; Faber *et al*. 2015: 67; Govender *et al.* 2017: 5). Effective interventions aimed at the vulnerable groups can make a positive contribution towards the achievement of SDG 2. The goal in this era should not only be to strive for child survival but to also provide an environment that will enable children to thrive (UNICEF 2019: 14). Micronutrient deficiencies contribute to child morbidity and mortality. Inadequate nutrition not only affects physical growth and development but mental functioning as well. The preschool years are associated with a phase of rapid growth. Adequate nutrition is essential, as proper nutrition plays an essential role in preventing malnutrition and other childhood-related diseases (WHO 2020a: 1).

KZN is one of the provinces with a high prevalence of VAD and iron deficiency anaemia (IDA) (SAVACG 1996). The geographical area where the current study was conducted is a rural area characterized by high levels of unemployment and poverty. Various studies have reported that the prevalence of VAD and IDA tends to be higher among rural children compared to children residing in urban areas (Govender *et al.* 2017). The study reported in this dissertation

specifically focused on pre-school children as they have been identified as a vulnerable group that is mostly affected by VAD and IDA (WHO 2020a: 1).

This study offers insight into the food and nutrient intake of the participants in order to assess the adequacy of the participants' diet in relation to their estimated average requirement (EAR) for their age group. Incorrect feeding practices have been identified as one of the factors contributing to malnutrition in children (WHO 2020b: 1). During the pre-school years, children are still developing their food preferences therefore early interventions are important as they may contribute to the development of sound eating habits. Anthropometric measurements were taken in children to determine the level of stunting, wasting, underweight and overweight/obesity. During the pre-school years, it is imperative to monitor children's growth and identify any nutrition related issues for corrective measures to be taken while the child is still young, as untreated nutritional deficiencies may have detrimental effects on the child's life and hinder normal development (Nagar *et al*. 2018: 312). Reducing stunting is part of the 2030 Agenda for Sustainable Development (United Nations 2015: 35). Results obtained from this study will therefore give an indication of whether stunting is prevalent among the participants in this particular community. This will therefore give insight to researchers to better understand the nutritional situation of the participants, and is in alignment with global recommendations from the FAO *et al.* (2018: 19), which highlighted that it is imperative to monitor stunting to identify areas where it is still prevalent in higher numbers and prioritise contextualised interventions.

Dietary diversification is one of the most effective strategies for preventing malnutrition and it was recommended that it be implemented during the stage of complementary feeding (UNICEF 2020c: 12). The current study implemented a strategy known to be effective in the prevention of or in addressing VAD (Laurie *et al*. 2018: 77). These strategies are the enrichment of a widely consumed food item and the promotion of a nutrient rich crop to diversify the diet and enhance nutritional status. In the current study, a yoghurt sample was developed incorporating a nutrient rich crop and implemented in an attempt to improve nutritional status of pre-school children. Yoghurt was identified by the SA Department of Health (DOH) as one of the foods that can form part of a healthy breakfast (DOH 2018: 7). Fernandez *et al*. (2017: 492) mentioned that yoghurt provides children with a substantial amount of calcium, vitamin A, zinc, protein and vitamin B12 and it can be added to the diet as a healthy snack. Furthermore, the daily consumption of yoghurt is in alignment with the proposed SA Paediatric Food Based

Dietary Guidelines which recommend that children in this age group should consume milk, *maas* or yoghurt every day (Vorster *et al.* 2013: S9). Milk has been emphasised in these guidelines because of poor calcium intake by some children in SA, especially those from poor households (Vorster *et al.* 2013: S9).

As shown in the literature, the use of the OFSP to address micronutrient deficiencies is an international trend [Department of Agriculture, Forestry and Fisheries (DAFF) 2011]. The yoghurt was developed using the OFSP, as it is rich in β-carotene and it is easily grown in various regions in KZN (Motsa *et al.* 2015: 2). The use of the OFSP has also been investigated in various African countries such as Mozambique, Kenya and SA (Low *et al.* 2020: 1; Wanjuu *et al*. 2019: 616). Emphasis has been placed on promoting dietary diversification using β-carotene rich crops. The OFSP has been identified as an easy to cultivate and drought resistant crop that can be used to address VAD (Low *et al.* 2020: 3). In addition to its high β-carotene content and its versatility, the crop has been used in various ways to maximise the diversity of diets in different countries. In low-income countries, the OFSP has contributed significantly to increasing vitamin A intake and has been used as a solid strategy to reduce the prevalence of VAD (Low *et al.* 2020: 1; Wanjuu *et al.* 2019: 616).

Available literature supports the promotion of OFSP as a nutrient-rich crop that can be used in intervention studies to address micronutrient deficiencies in young children. Intervention studies implemented using OFSP to improve micronutrient deficiencies in Africa include the development of a vitamin A enriched bread, dried chips, OFSP flour, OFSP chutney, OFSP juice (Faber and Laurie 2011: 172) and complementary food for children (Khanyile 2016: 66). Leighton (2007) assessed acceptance of sweet potato varieties and reported that OFSP was the preferred variety. Findings by van Jaarsveld *et al.* (2005) showed that the OFSP improved the vitamin A status of pre-school children.

To the researcher's knowledge, no study in SA has been conducted using OFSP in yoghurt to address micronutrient deficiencies. Due to its β-carotene content (Leighton 2007: 61), it would be worthwhile to investigate various uses of this nutrient rich crop using a dairy product that can be used to provide much needed vitamin A required by pre-school children for growth and development.

Furthermore, the nutritional status of the children under five years in the current study community has not been extensively documented. Results from this study will provide insight

into the nutritional issues encountered by the participants and may be used to inform policy makers as well as any programmes that may be implemented regionally and nationally to improve the nutritional status of children.

1.8 Research aim and objectives

The purpose of the study was to develop and test the impact of an OFSP yoghurt on the nutritional status of pre-school children in Durban, KZN, SA by determining nutritional status of preschool children, developing the product, implementing it as an intervention and then assessing the nutritional status of the pre-school children to determine the impact of the OFSP yoghurt.

The specific objectives of the study are presented in phases 1-4, and intended to achieve the following:

Phase 1

- Establish the socio-demographic profile of the children (using a socio-demographic questionnaire, refer to Appendix A) to determine the purchasing habits, income and household profile.
- Assess nutritional status using anthropometric measurements to establish their nutritional status (refer to Appendix B).
- Assess the dietary intake of children using a 24-hour recall questionnaire, which was repeated three times (refer to Appendix C).
- Determine the frequency of the children's consumption of vitamin A and iron rich foods, using the Food Frequency Questionnaire (FFQ) (refer to Appendix D).
- Determine the levels of vitamin A and iron in the blood at the time of the study using the finger-prick dried blood spot method.

Phase 2

- Develop the yoghurt (using the OFSP, which is rich in β-carotene) in order to improve the nutritional status of the children.

Phase 3

- Conduct an intervention where the children consumed 100 g of the OFSP yoghurt five days a week, for three consecutive months.

Phase 4

- Assess nutritional status using anthropometric measurements to establish if the anthropometric status changed after the intervention phase.
- Determine the dietary intake patterns of the children by using the 24-hour recall questionnaire, repeated three times to establish if a change in food intake patterns may have influenced the nutritional status of the children.
- Determine the frequency of the children's consumption of vitamin A and iron rich foods after the intervention.
- Determine blood levels of vitamin A and iron to measure the impact of the OFSP yoghurt.

1.9 Framework of the study

Figure 1.1: Framework of the study

1.10 Structure of the dissertation

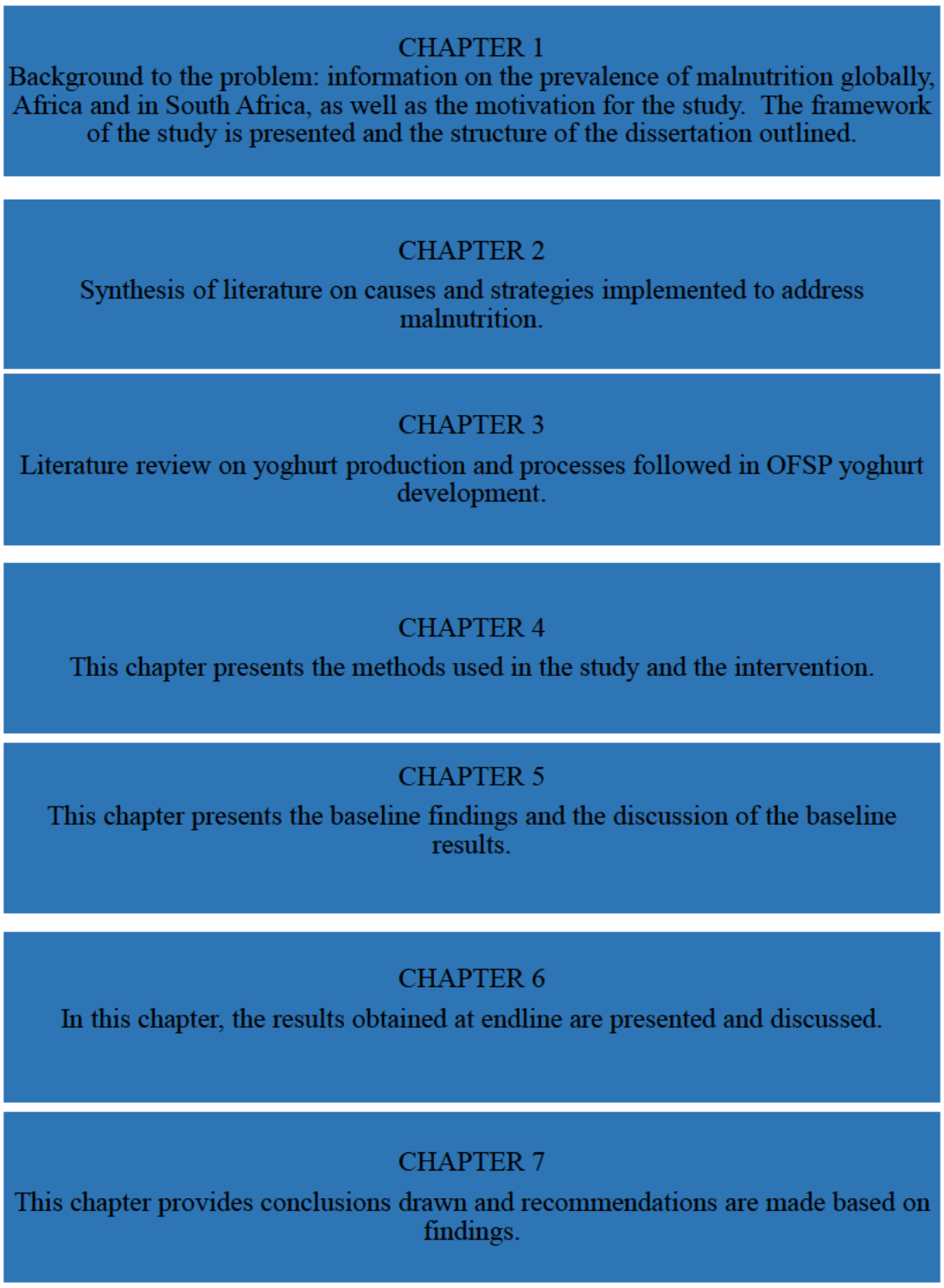

Figure 1.2: Structure of the dissertation

1.11 Conclusion

The effects of micronutrient deficiencies, specifically vitamin A and iron deficiency, are well documented. VAD is a major cause of avoidable visual impairment in children; it is the leading cause of night blindness in children and its high prevalence increases the rate of mortality and morbidity. The effects of VAD and IDA include poor growth and development, impaired motor development that may lead to reduced cognitive ability and poor school performance. Both these deficiencies make children more susceptible to infections, increase fatigue and weaken the immune system. VAD and IDA can be prevented by adequate nutrition while untreated malnutrition contributes to child mortality.

This chapter has highlighted the magnitude of malnutrition on a global scale and in SA. SA is one of the countries that was unable to achieve the two thirds reduction of mortality by 2015. In order to achieve the SDG 2 aimed at ending hunger, achieving food security and improved nutrition and sustainable agriculture by 2030, proactive measures need to be taken and interventions need to be implemented in various settings in order to address micronutrient deficiencies and food insecurity. In the current study, an OFSP yoghurt was developed and administered on weekdays for three consecutive months. The study therefore aimed to improve the nutritional status of the participants post intervention. Iron was not the primary focus in the study, however, it was included due to the association between VAD and iron levels. In the next chapter, the literature on malnutrition in young children will be reviewed.

CHAPTER 2: LITERATURE REVIEW ON MALNUTRITION

2.1 Introduction

In this chapter, available literature on the causes of malnutrition in children will be reviewed. The multifactorial determinants of child undernutrition will be discussed. Emphasis will be on VAD and IDA, as these are two of the prevalent micronutrient deficiencies affecting children under five years. This study focused on VAD and IDA as the NFCS-FB-1 survey reported that two out of three children had poor vitamin A status and one third of children had anaemia (Labadarios *et al*. 2008: 262). The SANHANES study also reported that nationally, VAD and anaemia prevalence in children below five years was 43.6% and 10.7%, respectively (Shisana *et al*. 2013: 212). Furthermore, various strategies to address malnutrition will also be presented and discussed.[1]

According to UNICEF (2019: 8), the triple burden of malnutrition refers to undernutrition, hidden hunger and overweight. Undernutrition manifests in the form of stunting and wasting and it has a negative impact on growth, as it increases the risk of infection and threatens survival and ability to thrive. Other effects include reduced cognitive abilities, poor school performance and reduced earning potential later in life. Micronutrient deficiencies affect tissue development and contribute to poor immunity, whereas overweight and obesity increase cardiovascular disease risk, poor self-esteem and various metabolic disorders (UNICEF 2019: 8).

The prevalence of undernutrition in Africa has increased between 2015 and 2019 from 18.3% to 19.1% (FAO *et al.* 2020: 9). The UNICEF conceptual framework shown in Figure 2.1 illustrates the determinants and outcomes of undernutrition. The UNICEF framework shows that short-term consequences of undernutrition include increased mortality, morbidity and disability in children. Long-term consequences not only affect the individual, but the economy as well. These include negative impacts on child height, decreased cognitive ability, reduced economic productivity and increased incidence of metabolic and cardiovascular disease

[1] Publication based on this chapter:
Makanjana, O. and Naicker, A. Nutritional Status of Children 24–60 Months Attending Early Child Development Centres in a Semi-Rural Community in South Africa. Int. J. Environ. Res. Public Health 2021, 18, 261. https://doi.org/10.3390/ijerph 18010261

(UNICEF 2015: 9). The immediate, underlying and basic causes of undernutrition are discussed in the next section.

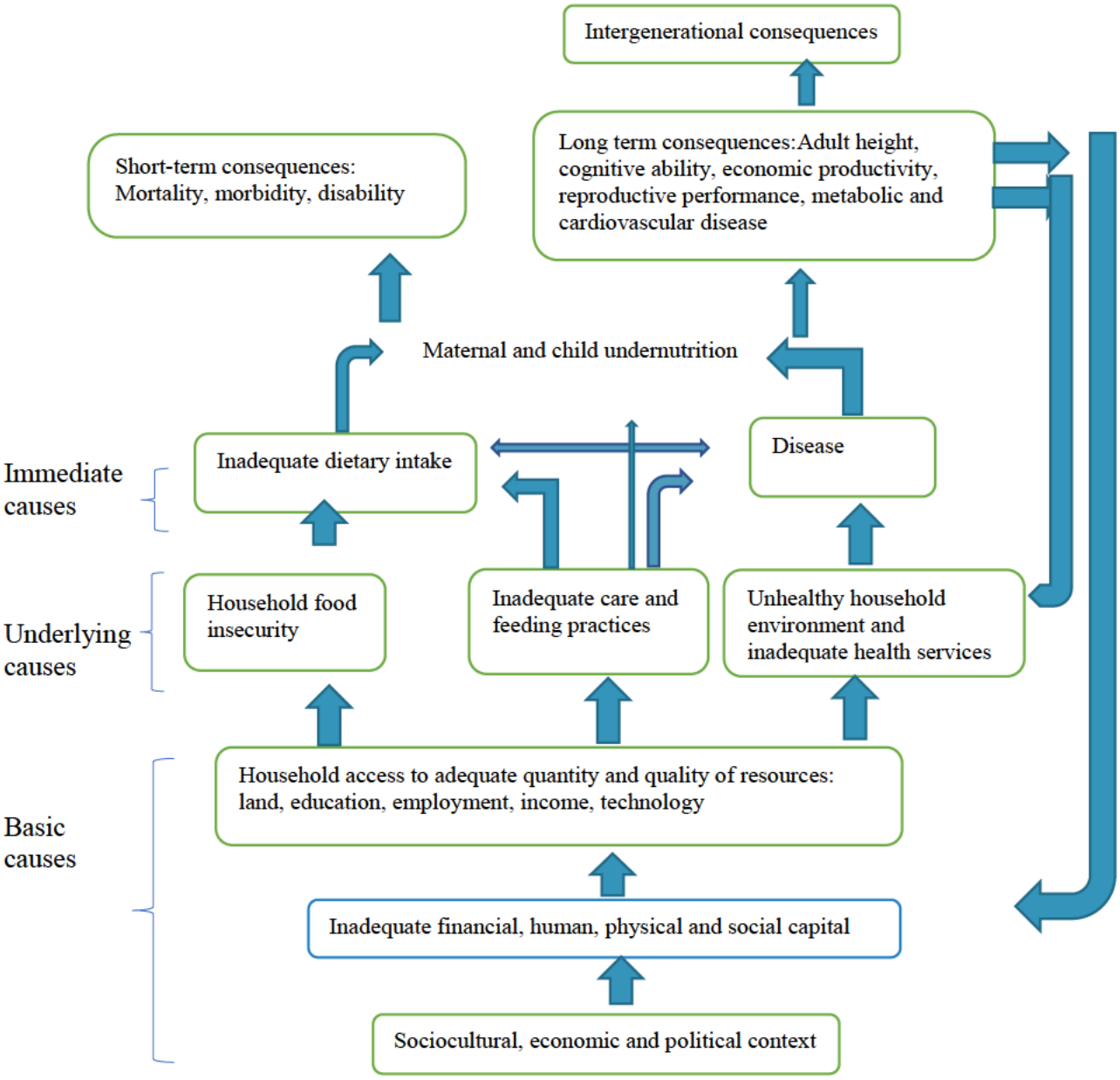

Figure 2.1: UNICEF conceptual framework of the determinants of child malnutrition (UNICEF 2015)

2.2 Causes of malnutrition

2.2.1 Basic causes

2.2.1.1 Household access to adequate resources

Poverty limits access to resources such as land, and proper education and it also contributes to low income in many households as a result of limited education (Statistics SA 2020). Statistics presented in the 2019 South African Child Gauge indicate that 30% of children lived in households with unemployment and 59% lived below the upper bound poverty line in 2018. Even though section 28 (1) (c) in the Bill of Rights in the South African Constitution stipulates that all children have the right to basic nutrition, shelter, basic healthcare services and social services, however, this right is not realised by all children (SA Department of Justice 1996). According to Statistics SA (2020), 62.1% of South African children are multidimensionally poor. Child poverty is higher among children residing in rural areas compared to those residing in metropolitan and urban areas (88.4%, 73.7% and 41.3%, respectively). Child poverty rates were reported to be higher in households with seven or more household members, in household where adults are not employed and in households where the head of the household has low or no education. Moreover, failure to register children's births was linked to higher levels of child poverty (Statistics SA 2020).

Hall et al. (2019: 6) stated that most South Africa children are born to unhealthy environments that decrease their likelihood of realising their full potential. Such environments typically do not have adequate access to maternal, new-born and child health services, social services and protection, nutritional support and quality early learning programmes. Access to basic services is one of the indicators of poverty. Due to socio-economic and racial inequalities, households from poorer communities are mostly affected by a lack of essential services. According to Van Dyk and White (2019: S1) public schools are ranked based on unemployment rate and the literacy rate of the community in which the school is located. Quintile one indicates an impoverished school, while quintile five indicates a wealthy school. Forty six percent of children from quintile one have no access to sufficient water and 29% have no access to adequate sanitation. Furthermore, 18% reside in overcrowded households and access to health care is limited for some children, as 29% do no live close to a clinic. South Africa has made improvement towards improving access to education, however, the quality of education offered still needs substantial improvement (Lake et al. 2019: 53).

2.2.1.2 Inadequate financial, human, physical and social capital

The link between poverty and malnutrition is well documented in a publication by Vorster (2010: 3; Figure 2.2). The author highlights that in SA, inequity between population groups is associated with high levels of poverty and malnutrition. Another factor that greatly contributes to basic causes of malnutrition in SA is inadequate human capital. Early infant and childhood malnutrition reduce mental capacity and lowers human capital development. Inability to grow optimally and poor socialisation are linked to reduced human capital. The figure below shows that the vicious cycle of poverty and malnutrition may affect an individual from conception to adulthood. Without effective suitable interventions, it leads to increased risk of diseases, reduced human potential and productivity.

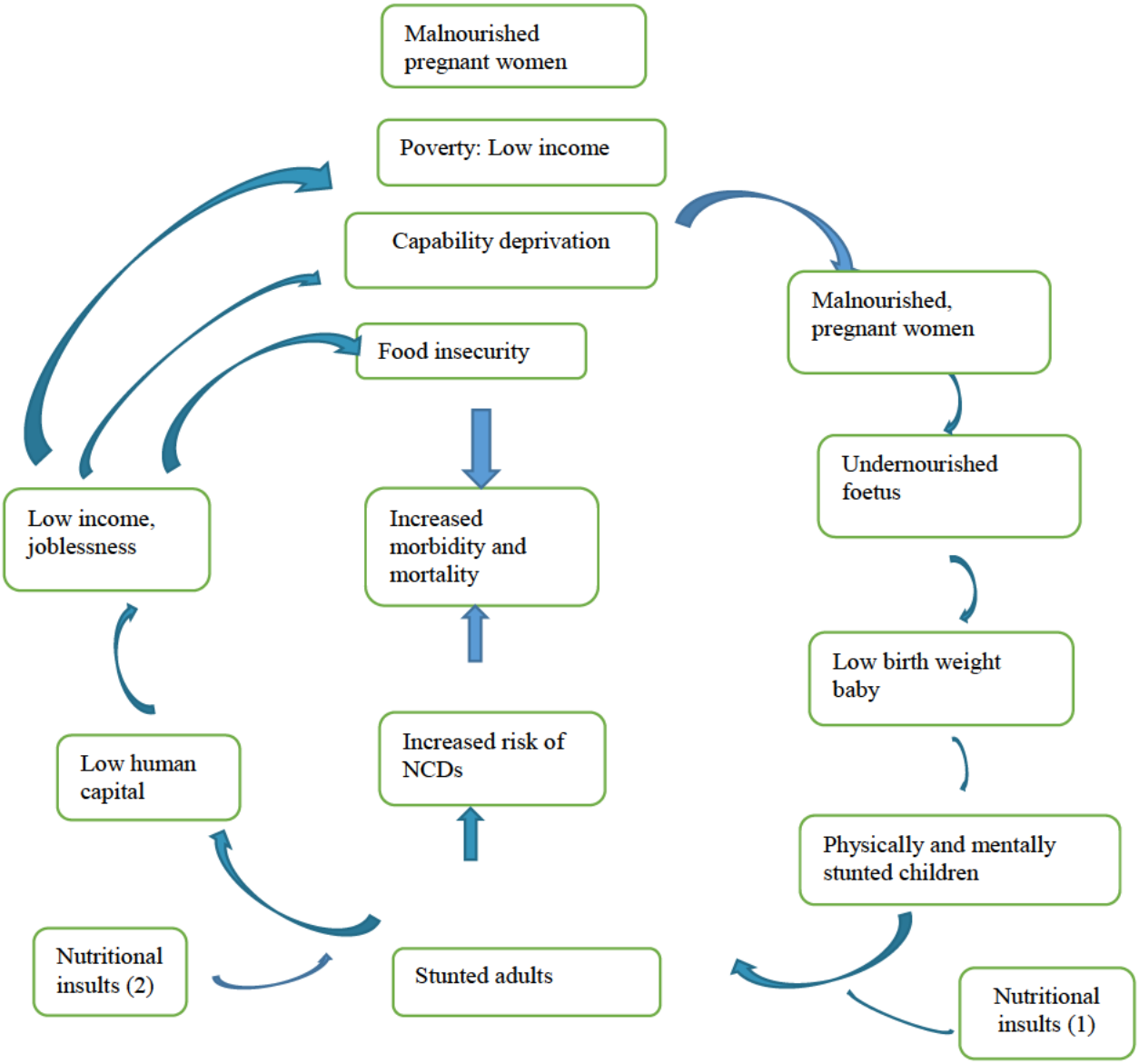

Figure 2.2: The vicious cycle of poverty and malnutrition (Vorster 2010)

2.2.1.3 Sociocultural, economic and political context

According to Mozaffarian *et al*. (2018: 3) government priorities and agricultural policies influence nutrition. Government policies and decisions influence the process of bringing healthy food to people and the cost of access to the food. The authors further emphasised the importance of governments prioritising good nutrition and the implementation of strategies to reduce social and racial disparities clustering from suboptimal diet habits and disease risk factors.

2.2.2 Underlying causes

2.2.2.1 Household food insecurity

The dietary intake of children, as well as their exposure to disease, is influenced by underlying factors such as household food insecurity, inadequate care and feeding practices, unhealthy environments and insufficient access to health care (UNICEF 2015: 9). Even though SA is reportedly food secure nationally, household food insecurity is experienced in many households in different provinces across the country (Van der Berg et al. 2021: 6). In 2017, the General Household Survey showed that 21.3% of households had limited access to food. Ten point four percent of households were vulnerable to hunger and 12.1% of individuals experienced hunger. In KZN in particular, 4.8% of households had severely inadequate access to food and 18.6% had inadequate access. In addition, 7.9% of households who did not have adequate access to food resided in the eThekwini Municipality (Statistics SA 2018: 56). The SANHANES-1 study showed that the percentage of households that were food insecure were higher in urban informal areas and rural formal areas, at 32.4% and 37%, respectively. Nationally, 28.3% of households were at risk of hunger and 26.0% were food insecure. KZN had the highest percentage of households at risk of hunger (34.4%) followed by the Eastern Cape (32.4%) and the Free State (31.9%). Food insecurity was higher in the Eastern Cape (36.2%), followed by Limpopo (30.8%), Free State (28.8%) and KZN (28.3%) (Shisana et al. 2013: 146).

The rising food prices contribute to food insecurity in poor households. Findings from a study conducted by Mkhawani et al. (2016: 71) indicated that 50% of the participants spent almost half of their household income on food due to increased food prices and 52% of the participants spent less than R500 on food per month, resulting in a reduction in the quality and quantity of food consumed. Coping strategies reported by 70% of the participants included a reduction in

portion sizes. Other participants indicated that they ate less preferred food and borrowed money to buy food. Furthermore, 17% of the participants indicated that they opted to eat indigenous foods that grew in the wild and some participants reported sending children to neighbours and relatives for them to have more meals. The authors suggested that for the poor to be able to afford adequate food, all food prices should be subsidised, not only the price of staple foods. Faber and Drimie (2016: 54) argue against food price subsidisation, stating that it is not a feasible strategy for the country. These authors advocate for a systematic approach that takes into consideration the symptoms of food price increase as part of the underlying causes of hunger within the food system. Furthermore, the authors are of the view that being dependant on purchased food only makes poor people more vulnerable to hunger and therefore access to food should be improved by the use of home gardens. They also point out that the link of smallholder farmers to the local food system should be strengthened in order to improve people's access to diverse foods (Faber and Drimie 2016: 54).

A study conducted in the Eastern Cape by Musemwa et al. (2015: 650) reported that 68% of households were severely food insecure. Household members in 1.9% of the households reported that they often spent a day and night without eating. There were reported instances of not having food of any kind in 12.7% of the households and 1.9% of households often went to sleep without any food. Walsh and van Rooyen (2015: 128) confirmed that the Free State is also one of the provinces with a high prevalence of food insecurity. Findings from this study showed that 73.2% of households in a rural area had a high risk of food insecurity compared to 87.4% of households in an urban area. More households in urban areas (88%) reported that they ran out of money to purchase food, compared to 73% of households in rural areas. Furthermore, a higher percentage of children reported hunger in more than half (59%) of households in the urban area, compared to 18% of children residing in rural areas (Walsh and van Rooyen 2015: 128).

Findings from a study conducted in uThungulu district showed that the majority of participants were involved in farming. Those involved in farming were mainly part of community gardens or had their own home gardens. Interestingly, the participants did not perceive their participation in agricultural activities to obtain economic support or for job creation and focused on farming for subsistence purposes. The participants' reasons for not farming for commercial purposes included inability to produce enough supply to meet the demands of the market and lack of support. Half of the study population reported that they did not receive seeds due to

political issues. Furthermore, some participants' perceived notion that livestock is a traditional asset also limited the ability to use livestock for commercial use (Masuku et al. 2017: 5). Household food insecurity is prevalent in other districts across KZN (Ngema et al. 2018: 19; Msaki and Hendriks 2014: 1; Mthethwa 2015: 47). Msaki and Hendriks (2014: 1) conducted a study in the Umbumbulu district of KZN. Results from this study showed that 35.4% of households were living below the poverty line. Seventy nine percent of the households purchased food and others produced food. Another study conducted in Umzimkhulu by Mthethwa (2015: 47) found that most participants were involved in agriculture, either having livestock, crop production or both. The households mainly relied on farming to supply food in the household as a result of low household income. The authors further stated that 31.3% of the households were food secure and were less vulnerable to food insecurity. However, chronic food insecurity affected 46.7% of the households and 11% of the households had transient food insecurity (Mthethwa 2015: 47).

The COVID-19 pandemic has further increased poor nutritional status and food insecurity among poor households. UNICEF (2020b: 1) highlighted that COVID-19 has disrupted nutritional services and has further increased the risk of death of malnourished children, particularly those who are wasted. For the children who survive malnutrition, the effects include poor growth and learning difficulties, therefore impacting the ability to thrive. McLaren et al. (2020: 517) emphasised that school closures and restrictions in trading as a result of country lockdowns due to COVID-19 have all had a negative impact on the production, distribution, transportation and sale of fresh, nutritious food, thereby contributing to the consumption of less nutritious diets in poor households. Yoshikawa et al. (2020: 191) and McLaren et al. (2020: 517) agree that worldwide, the development of children will be severely affected due to increased levels of food insecurity and poverty, death of caregivers and decreased healthcare due to the COVID-19 pandemic.

2.2.2.2 Inadequate care and feeding practices

Inadequate care and feeding practices also cause malnutrition in young children. The WHO (2019b) recommends exclusive breastfeeding for the first six months of life and that breastfeeding should continue until 24 months. Despite the numerous benefits of breastfeeding such as brain development, protection against infections and improved school performance, many mothers use breastmilk substitutes instead of breastfeeding. Factors that contribute to a lack of breastfeeding include cultural and social taboos, returning to work and a lack of support

for breastfeeding. Barriers to feeding babies that have started complementary feeding a diverse nutritious diet included financial constraints as mothers in different regions of the world indicated that they could not afford to buy a variety of foods. In some cases, a lack of access to healthy food was reported, as well as the child disliking healthier food options (UNICEF 2019: 29).

As stated by Jackson et al. (2019: 1), SA had one of the lowest rates of exclusive breastfeeding rates, ranging from 6.2% to 25.7% between 1998 and 2009. Post policy implementation to promote exclusive breastfeeding in 2011, there has been an improvement, as the 2016 South African Demographic Health Survey (SADHS) reported that 32% of infants below six months were exclusively breastfed (SA DOH et al. 2019: 181). However, this percentage is still lower than the post 2015 development agenda targets of achieving at least 50% of exclusive breastfeeding until the age of six months of age. Siziba et al. (2015: 173) investigated feeding practices of mothers with infants below six months of age in four provinces in South Africa. The results showed that the majority of the mothers (90%) commenced breastfeeding within an hour after delivery. Forty eight percent of the mothers exclusively breastfed their infants; however, this was not for the required duration of six months, as only 12% reached six months. Reasons for early cessation (as early as one month post-delivery) of exclusive breastfeeding included having to return to work or school (29% and 12%, respectively), the mother being sick (10%), sore breasts (9%), perceived insufficient milk production (7%), the mother preferred giving formula (4%) and anticipated starting complementary feeding (4%). Reasons for not breastfeeding the infants at all included the mother having the human immunodeficiency virus (HIV) and taking antiretroviral drugs (25%), mother's health was poor (19%) producing perceived insufficient milk (13%) and not wanting to breastfeed (9%). The infants who were not exclusively breastfed were given formula milk and liquids such as water or juice in addition to breastmilk (70%), formula only (19%), and breastmilk with liquids and food (30%). For the infants whose diet included solid food, the diversity was very low as most consumed foods from only one or two food groups. None were fed dark green leafy vegetables, eggs, and fleshy meat (Siziba et al. 2015: 173).

2.2.2.3 Unhealthy household environment and inadequate health services

The WHO reported that poor housing is associated with poor access to water and poor environmental quality. This contributes to the high prevalence of deaths from diarrheal disease (WHO 2018: 5). Mkhize and Sibanda (2020: 17) also agreed that for many households in SA,

poor access to water contributes to poor nutritional status in children as poor access to water often results in the children being at a higher risk of diarrhoea and waterborne infections. Roberts (2018: para. 1 line 1) stated that poor health and poverty are interlinked as poverty increases the risks of poor health, which traps people in poverty. Furthermore, the author indicated that globally, millions of children living in poverty with poor health access die annually from diseases such as diarrhoea (Roberts 2018: para. 1 line 5).

2.2.3 Immediate causes

2.2.3.1 Inadequate dietary intake

The UNICEF framework in Figure 2.1 identifies inadequate dietary intake and disease as immediate causes of undernutrition (UNICEF 2015). In the State of the World's Children Report, UNICEF mentions that one of the key drivers of malnutrition is poor diet quality (UNICEF 2019: 8). Two out of three children are not fed healthy, diverse diets that meet the recommendations for optimum growth and development for their age group. Even though exclusive breastfeeding can save lives, it is not adequately practised as only two in five children below six months are exclusively breastfed worldwide. UNICEF reported that globally, 44% of children between six months and 23 months have a low fruit and vegetable intake, and 59% are reported to have an inadequate intake of dairy products, fish and meat. In poorer households, only 20% of children are fed the minimum diverse diets required for growth and brain development (UNICEF 2019: 9).

The diet of many South African children lacks essential nutrients, which affects growth and development and nutritional status (Govender et al. 2021: 18; Nzama and Napier 2017: 82). Some of the contributing factors to inadequate dietary intake among population groups in SA include food shortages, affordability, poor diet quality and quantity (Labadarios et al. 2008: 253; Shisana et al. 2013: 177). According to Walsh and van Rooyen (2015: 133), 81% of urban households in the Free State reported food shortages compared to 46% of rural households. The percentage of households who reported that they had no money for food was also higher in urban households compared to rural households (88% and 73%, respectively). This resulted in household members consuming a limited variety of foods, reducing meal sizes, skipping meals and feeding children smaller meals than they required. The authors further reported that 59% of children from households in urban areas reported hunger, compared to 18% from rural areas (Walsh and van Rooyen 2015: 133).

Okop et al. (2019: 1) investigated the fruit and vegetable intake in two socio-economically disadvantaged communities in the Cape Town and Mount Frere in SA. Results from this survey indicated that 37.8% of participants ate at least two portions of fruit and vegetables daily and participants who consumed sugar-sweetened beverages were less likely to consume fruit and vegetables on a daily basis. Furthermore, there was a low consumption of fruit and vegetables, especially among the participants residing in the rural community (Okop et al. 2019: 9).

2.2.3.2 Disease

Infectious diseases such as diarrhoea, cholera, malaria and measles are also classified as immediate causes of malnutrition in children. The WHO (2017a: 1) stated that diarrhoea is one of the leading causes of malnutrition in children. Diarrhoea is often caused by contaminated food and water or as a result of an infection (Nguyen et al. 2021: 13). Untreated diarrhoea causes loss of appetite and induces vomiting. This leads to poor food intake as well as loss of nutrients (WHO 2017a: 1). Digestive disorders such as Crohn's disease and ulcerative colitis also contributes to malnutrition among children. Both these conditions affect the digestion and absorption of nutrients. Walson and Berkley (2018: 233) agree that diarrhoea is associated with stunting and that the risk of death from diarrhoea in malnourished children is four times higher than in well-nourished children.

According to UNICEF (2020a: 1), even though affordable and effective treatments are available, diarrhoeal disease is a major contributor to morbidity and mortality in developing countries. Most of children who die from diarrhoea are from South Asia and SSA. Carvajal-Velez et al. (2016: 6) assessed diarrhoea management practices in children below five years of age in 12 countries in SSA. Poor care was given to children in most of the countries surveyed. Sierra Leone was identified as the only country that provided the highest level of good management of diarrhoea. Furthermore, the authors reported that across the various countries surveyed, the quality of management was more likely to be good if care was sought from healthcare facilities than other sources. Poor or no treatment of diarrhoea may be fatal (WHO 2017a: 1). UNICEF (2020a: 1) recommends the Protect, Prevent and Treat Framework. Protection focuses on the implementation of good practices commencing at birth. These include exclusive breastfeeding in the first six months, adequate and nutritious complementary feeding and vitamin A supplementation. Prevention focuses on aspects such as proper handwashing with soap, creating a clean home environment, supplying children with clean safe drinking water and vaccinating children against the viruses that cause diarrhoea. In the South African

context, Lake et al. (2019: 55) also emphasise that improving access to water, sanitation and housing may decrease the incidence of diarrhoea and pneumonia, and respiratory tract infections.

2.3 Nutrient requirements of pre-school children

UNICEF (2019: 44) highlighted that adequate nutrition is essential in order for children to grow and reach their full potential. Failure to consume a balanced diet with all the nutrients in the recommended amounts leads to nutritional deficiencies. Table 2.1 lists the dietary reference intakes (DRIs) for micro and macronutrients for children. The section below will highlight the key nutrients commonly lacking in children's diets in South Africa (Labadarios *et al*. 2008: 261).

Table 2.1: DRIs for macro and micronutrients for children 24-60 months of age [Institute of Medicine (IOM) 2001: 1320]

Nutrient	DRIs per day 24-47 months of age	DRIs per day 48-60 months of age
Energy (kJ)	4150 EER ♀, 4376 EER♂	6870 EER♀, 7289 EER♂
Protein (g)	**13 g**	**19 g**
Total fat (g)	-	-
CHO (g)	**130 g**	**130 g**
Total dietary fibre (g)	19 g *	25 g *
Calcium (mg)	500 mg *	800 mg *
Iron (mg)	**7.0 mg**	**10 mg**
Magnesium (mg)	**80 mg**	**130 mg**
Phosphorus (mg)	**460 mg**	**500 mg**
Zinc (mg)	**3 mg**	**5 mg**
Selenium (mcg)	**20 mcg**	**30 mcg**
Iodine (mcg)	**90 mcg**	**90 mcg**
Vitamin A (mcg)	**300 mcg**	**400 mcg**
Thiamin (mg)	**0.5 mg**	**0.6 mg**
Riboflavin (mg)	**0.5 mg**	**0.6 mg**
Niacin (mg)	**6 mg**	**8 mg**
Vitamin B6 (mg)	**0.5 mg**	**0.6 mg**
Folate (mcg)	**150 mcg**	**200 mcg**
Vitamin B12 (mcg)	**0.9 mcg**	**1.2 mcg**
Pantothentate (mg)	2.0 mg *	3.0 mg *
Biotin (mcg)	8.0 mcg *	12 mcg *
Vitamin C (mg)	**15 mg**	**25 mg**
Vitamin D (mcg)	5 mcg *	5 mcg *

Nutrient	DRIs per day 24-47 months of age	DRIs per day 48-60 months of age
Vitamin E (mg)	**6 mg**	**7 mg**
Vitamin K (mcg)	30 mcg *	55 mcg *
Potassium (g)	3.0 g *	3.8 g *
Sodium (g)	1.0 g *	1.2 g *

Recommended Dietary Allowances (RDAs) in bold type and Adequate Intakes (AIs) in ordinary type followed by an asterisk (*), kJ: Kilojoules, EER: Estimated Energy Requirement, g: grams, CHO: carbohydrates, mg: milligrams, mcg: micrograms. There is no AI or RDA for fat as there is insufficient data to determine a defined level of fat intake at which the risk of inadequacy or prevention of disease occurs (IOM 2001: 422)

2.3.1.1 Energy

The Estimated Energy Requirements (EER) for young children vary and are typically based on the child's gender, age, height, weight and the activity level. Energy is derived from carbohydrates, protein and fat and an adequate energy intake is essential for optimum growth and development of children (Savarino *et al.* 2021: 5).

2.3.1.2 Protein

An adequate intake of protein is important as it supplies the body with essential amino acids required for numerous body functions, such as the formation of body tissues, strengthening bones and teeth, maintaining fluid balance, transporting lipids and oxygen around the body and protecting the body against diseases (Savarino *et al*. 2021: 9). Protein deficiency affects young children's growth and development, impairs brain and kidney function and reduces the body's ability to fight infections and diseases. A diet rich in animal and plant protein can meet the RDA for protein for pre-school children. Protein is important for growth and development, as well as tissue repair. Good quality sources of protein include milk, foods of animal origin eggs and fish (Savarino *et al*. 2021: 9).

2.3.1.3 Calcium

Calcium is essential for bone formation as well as the development of strong teeth. Other functions include muscle contraction, blood clotting and regulating cellular metabolism. Food sources of calcium include dairy products such as milk, yoghurt, cheese, sour milk and broccoli. Spinach also contains calcium; however, its bioavailability is poor (National Institutes of Health 2019a: 1).

According to the National Institutes of Health (2019a: 5) the absorption of calcium may be affected by various factors such as the amount of food consumed, the frequency of

consumption, the presence of components that bind to calcium and inhibit its absorption (such as phytic acid and oxalic acid) and age. Younger children absorb calcium more efficiently compared to adults. An inadequate intake of calcium increases the risk for the development of osteoporosis (National Institutes of Health 2019a: 5).

2.3.1.4 Zinc

Zinc is an essential nutrient in children's diets as a deficiency may cause poor growth and development and loss of appetite (National Institutes of Health 2019d: 1). Zinc deficiency also impairs the immune function (Savarino *et al*. 2021: 7). Foods rich in zinc include beef, fortified breakfast cereals, milk, poultry, whole grains, fish, shellfish, peanuts and legumes (National Institutes of Health 2019d: 1).

2.3.1.5 Vitamin A

Vitamin A is a fat-soluble vitamin found in various forms in different food sources. Vitamin A-active retinoids occur naturally in three forms: retinol, retinal and retinoic acid. These three forms are found in two variations, the β-ionone nucleus (vitamin A1) or the dehydrogenated β-ionone nucleus (vitamin A2) (Micronutrient Information Centre 2021: 1). Foods of animal origin contain preformed vitamin A (retinoids), whereas plant sources contain carotenoids, called provitamin A. Provitamin A carotenoids are fat-soluble pigments that give colour to fruit and vegetables and are converted by the body into vitamin A. Plant sources of vitamin A include, but are not limited to mangoes, papayas, sweet potatoes, spinach, carrots, pumpkin, yellow maize and legumes and seeds. Animal sources include beef liver, chicken, chicken livers, fish and shellfish, and eggs (Micronutrient Information Centre 2021: 1).

Vitamin A is primarily digested in the small intestine. The body converts vitamin A into a form that can be easily digested as vitamin A is bound to other food components. Retinol is usually bound to fatty acid esters such as retinyl palmitate and retinol and carotenoids are also commonly bound to proteins (Micronutrient Information Centre 2021: 1). When the retinol esters are separated from proteins, fat globules and other lipids are formed in the stomach. The fat globules pass through the stomach to the duodenum and are thereafter emulsified in the presence of bile. The presence of fat aids in the absorption of vitamin A. Carotenoids such as alpha and β-carotene are metabolised in the enterocytes, liver, and adipose tissue. These carotenoids are converted into vitamin A. The metabolism of retinoids also occurs within the

enterocytes. Retinal, produced from carotenoids is reduced to retinol (Micronutrient Information Centre 2021: 1).

Functions of vitamin A include the maintenance of healthy epithelial tissue, which assists the body by reducing the susceptibility to infection (Fernandez-Lopez *et al*. 2020: 24672). Vitamin A is essential in the cell-mediated aspect of immune response and individuals with inadequate vitamin A status are more susceptible to infections as compared to those with adequate levels. Moreover, vitamin A promotes mucus production in the eye, therefore, preventing dryness of the eye. Insufficient mucus production makes the eye prone to infections from bacteria, which leads to xerophthalmia (Micronutrient Information Centre 2021: 3). A plasma retinal concentration below 0.70 µmol/L or 20 µg/dL reflects VAD. Consequences of VAD include damaged cells, thereby allowing pathogens to invade the body easily. Furthermore, VAD weakens the immune system as it reduces the responsiveness of T lymphocytes and B lymphocytes and affects the production of antibodies. This increases the risk of infections. VAD also affects the tissue's ability to absorb iron, and is therefore linked to anaemia (National Institutes of Health 2019c: 1; Bailey *et al*. 2015: 26). In young children, vitamin A is essential to support growth and development (WHO 2021: 1). Children 24-47 months of age require 300µg of vitamin A per day, while children between 48-60 months require 400µg per day (IOM 2001: 1320).

2.3.1.6 Iron

Iron is vital for various cell activities. In the body, iron is mostly found in two proteins, namely, Hb found in the red blood cells, and myoglobin, found in the muscle cells. The primary role of Hb is the transportation of oxygen from the lungs to other body tissues. Myoglobin is responsible for the storage of oxygen in the muscles. Iron is also essential for the production of new cells, amino acids, hormones and neurotransmitters and forms part of different enzymes that play a role in energy metabolism (Young *et al*. 2018: 2).

According to the National Institutes of Health (2019b: 1), iron is found in various food sources such as beef, organ meat, oat bran, spinach, kidney beans, and other whole grains. Haem iron is only found in animal sources such as meats, poultry and fish; these are the best sources of iron as they are the most bioavailable. Non-haem iron is found predominantly in plant sources and some meats. Other non-haem dietary sources of iron include oat bran cereal, spinach and kidney beans (Young *et al*. 2018: 2).

Dasa and Abera (2018: 026) stated that the absorption of iron is partly dependant on the source. Non-haem iron is not absorbed as efficiently as haem iron. When iron is found in abundance in the body, it may lead to a decline in its absorption. Mucosal ferritin, a protein that helps the body absorb iron, obtains iron from the gastrointestinal tract and stores it in mucosal cells in the small intestines. This iron is released to another protein called mucosal transferrin. When the body requires the iron, it is transferred by mucosal transferrin to blood transferrin, a protein which transports iron to the rest of the body. Factors that enhance iron absorption include vitamin C, meat protein factor, and sugars (including those found in wine). Factors that hinder iron absorption include tannins found in tea and coffee (these compounds bind iron), phytates and fibres in soy products and whole grains, as well as calcium and phosphorus in milk (Dasa and Abera 2018: 26).

When the diet does not supply sufficient iron required for Hb synthesis, it decreases the number of red blood cells in the blood stream. Children below the age of five who do not consume adequate iron are at risk of iron deficiency. In this age group, a child may be classified as having anaemia if the Hb level is <11.0 g/dL (WHO 2011: 3). The risk of iron deficiency is higher in children with limited access to food due to poverty. Iron deficiency symptoms include pale skin, fatigue, poor regulation of body temperature, and loss of appetite. In young children, iron deficiency anaemia decreases learning ability and lowers attention span as it affects brain function, and causes growth retardation and an impaired immune response (National Institutes of Health 2019b: 1).

2.4 Factors that influence food intake of pre-school children

Challenges in feeding toddlers and pre-school children include difficulties such as selective intake and fluctuating appetite (Yang 2017: 380). Scaglioni *et al*. (2018: 2) highlighted that temperaments affect mealtime behaviour as the easy child is eager and willing to try new foods, whereas the difficult child adapts slowly and is reluctant when new foods are introduced into the diet. Repeated exposure to new foods is highly encouraged as especially the difficult child tends to accept foods after repeated exposure to the food item (Scaglioni *et al*. 2018: 2). Figure 2.3 shows the various factors that influence children's eating behaviours (Scaglioni *et al*. 2018).

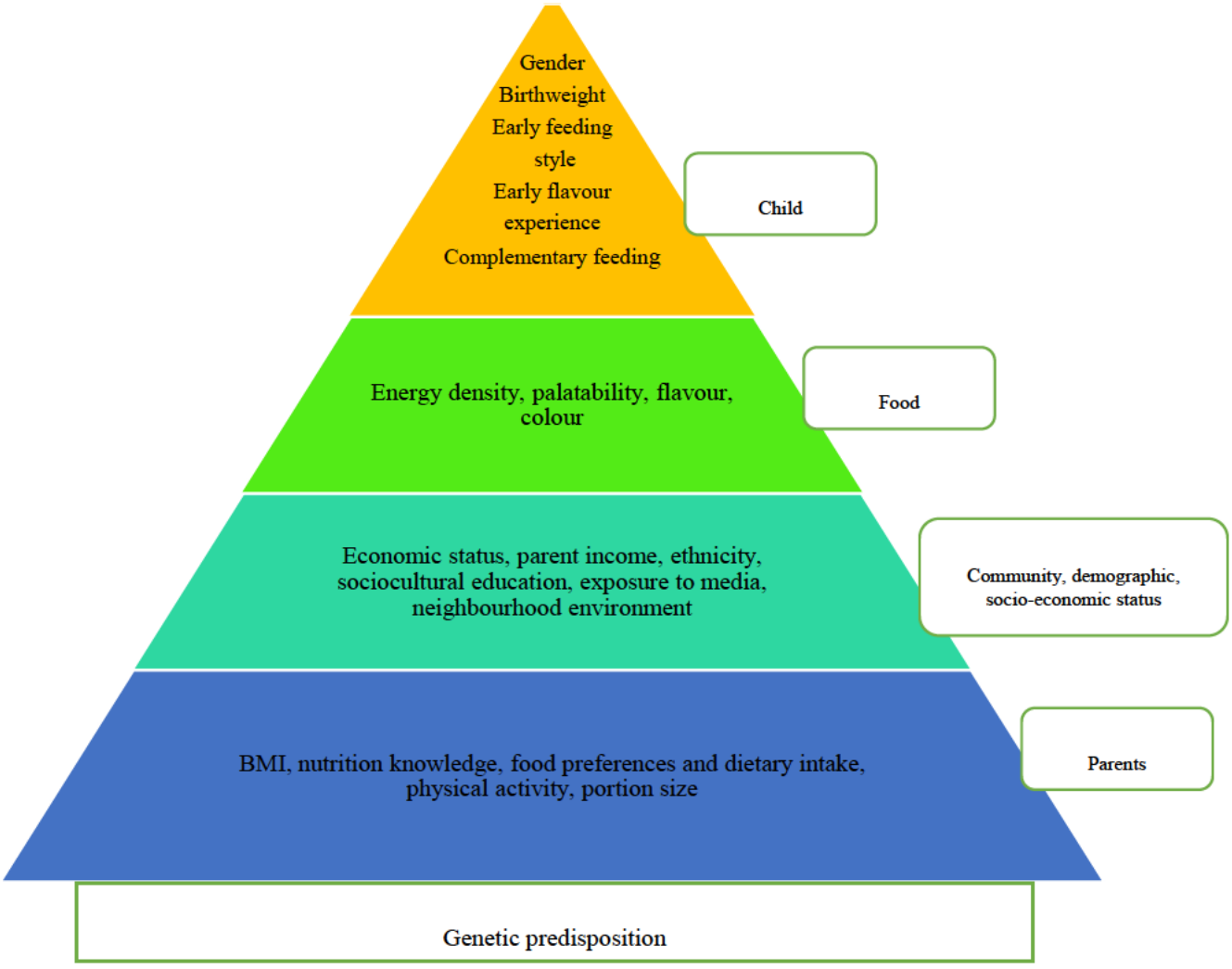

Figure 2.3: Environmental factors that influence children's eating behaviours (Scaglioni *et al.* 2018)

Literature suggests that human beings generally respond positively to sugar and salt and negatively to bitter tastes (Scaglioni *et al.* 2018: 3). Scaglioni *et al.* (2018: 3) also mentioned that early interventions aimed at developing healthy eating habits should be implemented during the first thousand days of life. The introduction of complimentary foods offers an opportunity for early learning about flavours as children are introduced to a variety of flavours and new foods. The authors further state that exposure to a wider range of new foods during the first year of life assists in modulating the acceptance of new foods, whereas if the process is delayed into the second year, the impact is limited (Scaglioni *et al.* 2018: 3).

Ventura and Worobey (2013: 3) define neophobia as an unwillingness to eat novel foods, or extreme dislike of anything new or unfamiliar. Young children commonly display neophobia when they are between two and five years of age. One of the causes of neophobia is the dislike

of sensory characteristics of a food. Children tend to enjoy foods that they are familiar with, highlighting that early and repeated exposure to nutritious foods may increase the chances of children opting for healthier foods as they grow older (De Cosmi *et al*. 2017: 5).

Scaglioni *et al.* (2018: 4) suggest that the family environment for children's health behaviours is important; however, underlying mechanisms of this influence need further investigation. Of importance is the family health climate, which refers to the shared perceptions and cognition regarding a healthy lifestyle within a family. The authors further explained that children learn by observation and imitating others, especially their parents and caregivers. As children grow older, social influences become more important. Furthermore, the media is known to shape knowledge, attitude, preferences and practices. Strategies that may improve children's eating behaviours include purchasing only healthy foods for home consumption, avoiding stores that sell unhealthy food and modelling healthy eating behaviours at home and in the school environment (Scaglioni *et al.* 2018: 12).

Figure 2.4 shows the cycle of micronutrient inadequacies throughout the lifespan (Bailey et *al*. 2015). Pregnant women have increased vitamin and mineral needs. Inability to meet these needs may result in infants born with low birth weight. Low birth weight infants have an increased risk of chronic diseases later in life, and impaired mental development. Survivors may progress to the next phase of life with effects such as stunted growth, reduced mental capacity, and may suffer from frequent infections. Failure to receive appropriate interventions may result in stunted adolescents who do not reach their full potential. They may become malnourished adults with higher risks of various diseases or fall pregnant and have malnourished infants and the vicious cycle continues. Therefore, these effects highlight the importance of addressing nutritional issues in the early stages of life (Bailey *et al*. 2015).

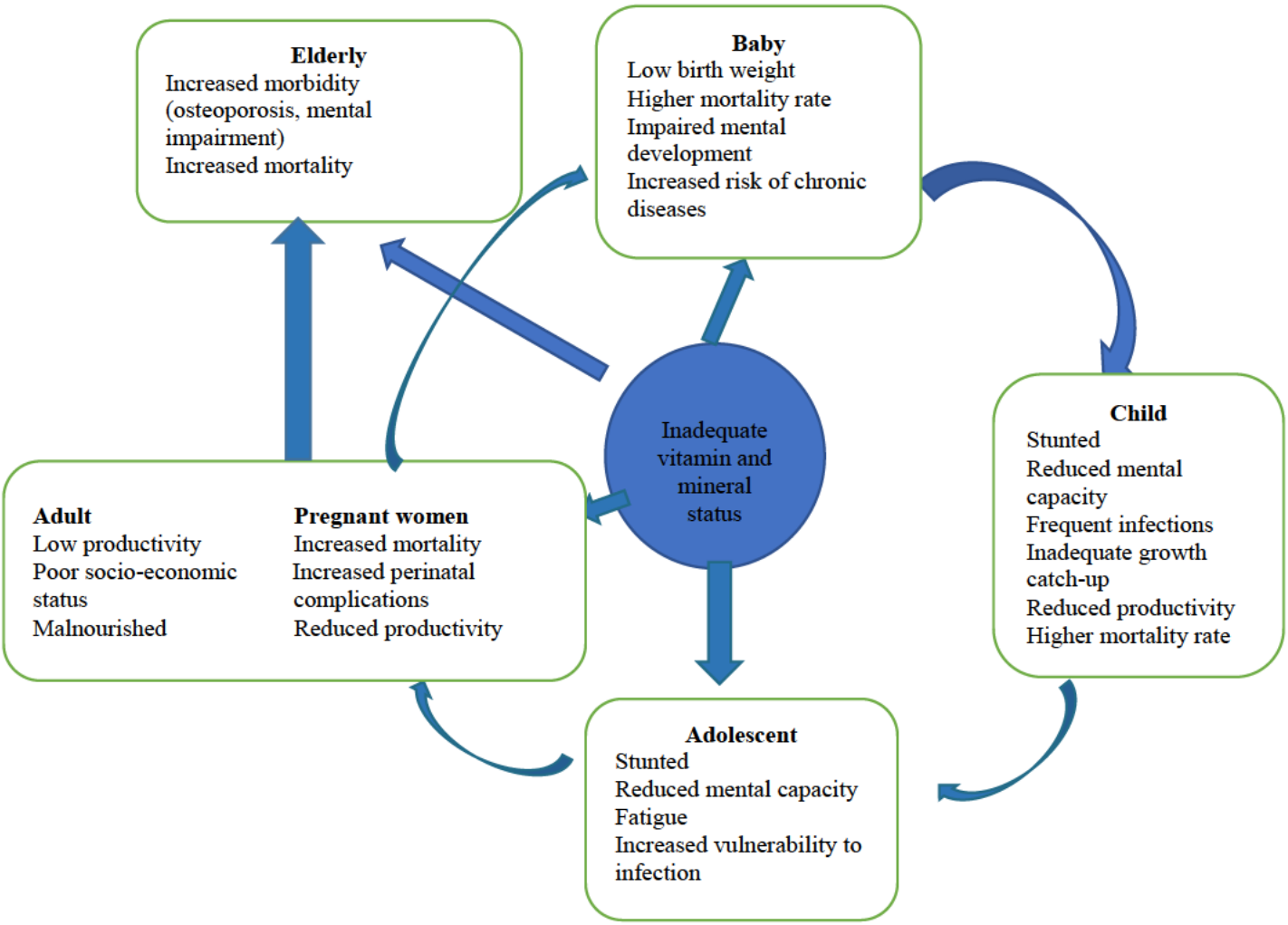

Figure 2.4: The conceptual framework for the cycle of micronutrient inadequacies across the life span (Bailey *et al*. 2015)

2.5 Strategies to address malnutrition

Food fortification, nutrition education, micronutrient supplementation and dietary diversification and modification are strategies found to be very effective in reducing micronutrient deficiencies and improving nutrition-related health problems (Olson 2021: 2; WHO 2019c; WHO 2021).

According to Bailey *et al.* (2015: 29), the type of intervention chosen to address micronutrient deficiencies should depend on the cause and severity. The authors further recommend that the chosen strategy should aim to eradicate the root cause of the deficiency and be appropriate for the target population. Furthermore, the feasibility of the intervention strategy should also be considered (Bailey *et al*. 2015).

Food-based approaches have been used to address malnutrition across the world. South Africa, like many countries, adopted these approaches. Figure 2.5 was developed in SA and implemented in a study to address VAD. The multi-faceted approach used included an agricultural component and nutrition education on vitamin A-rich foods, food preparation to preserve nutrients, and educating participants on correct infant feeding practices and food hygiene (Faber and Laurie 2011).

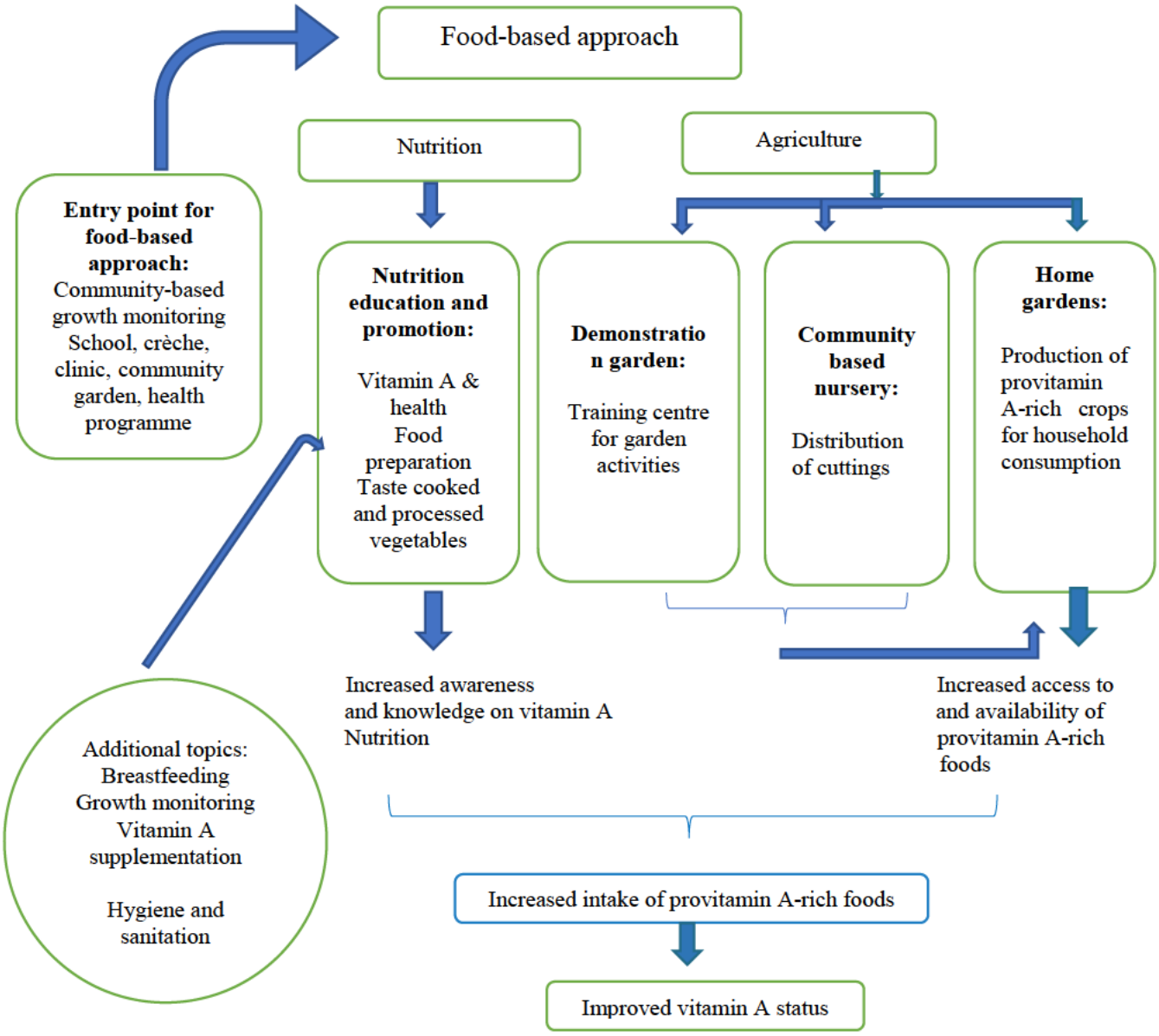

Figure 2.5: Food-based approach to address VAD (Faber and Laurie 2011)

2.5.1 Nutrition specific interventions and programmes to address micronutrient deficiencies

According to the FAO (2014: 1), nutrition-specific interventions aim to address the immediate causes of child malnutrition. These include strategies such as food fortification, home fortification with micronutrient powders, supplementation, dietary diversification and programmes aimed at promoting appropriate infant and young child feeding interventions (FAO 2014: 1). These strategies will be discussed next.

2.5.1.1 Food fortification

Food fortification may be defined as the process where a nutrient or nutrients are deliberately added to foods, whether the nutrient is naturally present in the specific food or not. This is to increase the nutritional value of the food, thereby contributing to the fight against identified nutrient deficiencies and improving health (WHO and FAO 2006: 24; Liyanage and Hettiarachchi 2011: 124). Food fortification is a strategy used globally to address micronutrient deficiencies. The WHO published guidelines covering the different aspects of fortification. These guidelines highlighted the importance of selecting appropriate vehicles and fortification methods for determining fortification levels, and guidance on how to effectively implement sustainable food fortification programmes. The guidelines further emphasise that in addition to the efficacy of the fortified food, other factors that determine the effectiveness of fortification programmes include effective implementation, monitoring, quality control, and compliance. Safety was also mentioned as an important aspect that needs to be ensured by various stakeholders such as industry, government and consumers (Micronutrient Forum 2015: 4).

Different countries in Africa commenced fortifying staple foods such as sugar, flour and maize meal. Zambia fortified sugar with vitamin A, and in Nigeria it became mandatory to fortify sugar with vitamin A and wheat flour and maize with multiple micronutrients such as vitamin A and iron (Micronutrient Forum 2015: 4). In SA, iodisation of salt was also implemented to reduce the prevalence of iodine deficiency and it became mandatory in 2003 to fortify staple foods such as maize meal and bread flour. The fortification of food was recommended based on the 1999 NFCS findings. Findings from the NFCS 1999 survey revealed that one-third of the households that participated in that survey spent very little on food due to budgetary constraints Labadarios *et al.* (2005: 536). Fortification is therefore a strategy that may aid in

improving the diets of poverty-stricken communities that are unable to afford a varied diet (Food Advisory Consumer Service 2019).

Das *et al.* (2013: 2) classified food fortification into three approaches, namely, mass fortification, targeted fortification and market-driven fortification. The last approach is conducted by food manufacturing companies, whereby a specific brand is fortified as per consumer demands. Mass fortification refers to the fortification of widely consumed foods such as wheat flour, salt and sugar. In contrast, targeted fortification involves the fortification of foods consumed by specific age groups such as young children. Mass fortification and targeted fortification are the most commonly used approaches to address micronutrient deficiencies (Das *et al.* 2013: 2).

Olson *et al.* (2021: 2) support the use of food fortification, stating that it is an effective long-term strategy used to alleviate widespread micronutrient deficiencies. An advantage of this method is that it inexpensive. The authors also mentioned that food fortification has some limitations. These include the fact that young children consume a limited amount of fortified staple foods compared to adults, therefore suggesting that the two age groups may not benefit in the same way. Liyanage and Hettiarachchi (2011: 127) mentioned that food fortification cannot be used in isolation to rectify micronutrient deficiencies in cases where the deficiency is too severe, or when the population has limited access to the fortified food. Another limitation of food fortification is the presence of infections that lead to an increased demand for micronutrients. Dwyer *et al.* (2015: 129) further indicated that food fortification effectiveness varies based on age, gender and the groups at risk of the micronutrient deficiency. The authors also mentioned that it is imperative that a suitable vehicle for food fortification is identified to prevent excessive intakes of nutrients in some sub-groups of the targeted population (Dwyer *et al.* 2015: 129).

The WHO and FAO (2006: 20) also agree that the limitations of food fortification include the fact that the fortified food may not necessarily be consumed by all members of the population who have that deficiency. In addition, fortified foods do not always reach the poorest people of the affected population due to limited access and low purchasing power. Furthermore, they argued that very low-income population groups usually consume traditional diets that lack multiple nutrients and it is very unlikely that they would obtain all the lacking nutrients from fortified food alone (WHO and FAO 2006: 20).

2.5.1.2 Home fortification with micronutrient powders

Home fortification (HF) is one of the methods used to improve diet quality of children (Suchdev *et al*. 2020: 1). Kupka (2014: 8) indicated that HF is an innovative way of ensuring diet quality of complementary foods to meet the nutrient needs of young children. The author stated that HF can be done by using micronutrient powders (MNPs) or small quantity lip-based nutrient supplements. This form of fortification is affordable and easy to store, transport and is highly acceptable (Kupka 2014: 8). The WHO (2019a: 1) stated that MNPs are suitable alternatives for providing micronutrients to populations where other interventions are difficult to implement. Gibson (2011: 7) mentioned that to supply the required micronutrients without effecting changes in feeding practices, complementary foods may be fortified using tablets, fat-based spreads or sprinkles. According to De Pee *et al*. (2013: 51), the distribution of MNPs is not used in isolation and generally forms part of a larger nutritional programme aimed at infants and young children. Even though the MNPs are usually provided for free, the authors suggest a model whereby the poor receive the MNPs for free, while middle and high-income consumers purchase the product at a reasonable price (De Pee *et al*. 2013: 51).

Siekmann *et al*. (2013: 34) advocated for market-based distribution of MNPs. The authors argued that a market-based approach would assist in reducing the burden on the public sector as MNPs are usually freely distributed to targeted participants. They also mentioned that this approach would increase the access and use of various products and would ensure sustainability in cases where organisations that donated the products are no longer able to continue. Furthermore, other population groups that may not necessarily be targeted would also have access to these products. The benefit of using MNPs is that the target population make no changes to the usual diet and the products are consumed in appropriate amounts. Finally, MNPs also provide a wider range of nutrients in a bioavailable form (De Pee *et al*. 2013: 51).

2.5.1.3 Supplementation

The WHO and FAO (2006: 13) describe supplementation as a method of providing doses of micronutrients in the form of a syrup, pills or capsules. The greatest advantage of this method in addressing micronutrient deficiencies is that it delivers the needed nutrient or nutrients in a form that is easily absorbed, in the required amount, and is a quick way of controlling micronutrient deficiencies. The WHO and FAO further state that supplementation is an

effective strategy used to lower the risk of morbidity in children below five years (WHO and FAO 2006: 13).

Supplementation is generally used in severe cases of micronutrient deficiencies and is also used for prevention purposes (WHO and FAO 2006: 13). Bailey *et al*. (2015: 29) argue that across various regions, vitamin A supplementation has been a success with regards to prevention of night blindness and infant mortality. They also mentioned that for this strategy to be effective, educational programmes need to be in place and the supplement given should be feasible. Berti *et al*. (2014: 41) agree that supplementation and/or fortification with iron, zinc, vitamin A, folic acid and iodine are the most cost-effective strategies to address micronutrient malnutrition, if there is access to health care and long-term coverage and monitoring of the programmes implemented (Berti *et al*. 2014: 41).

Vitamin A supplementation is linked with reducing mortality rates and reduced incidence of diarrhoeal disease among children residing in developing countries. Supplementation improves gut functioning and therefore, decreases the severity of diarrhoea. Administration of high doses of vitamin A supplementation [100 000 International Units (IU) for 6 to 11 months and 200 000 IU for 12-59 months] every six months, which was established as 'large doses' are absorbed well, stored and metabolized over a long period (WHO 2011: 3).

Supplementation programmes have been implemented in some African countries. Even though this is a cost-effective strategy, the impact is short-term and difficulties have been encountered regarding reaching communities living in areas with restricted access (Helen Keller International Vitamin A Supplementation Program 2021: 9). Mayo-Wilson *et al.* (2011: 141) concluded that for young children between six months to five years, vitamin A supplements are very effective in improving vitamin A stores, cost-effective and can be easily administered if interventions are implemented at the time the children receive other vaccines. Imdad *et al.* (2017: 2) and Berti *et al.* (2014: 43) agree that vitamin A supplementation is an effective strategy for preventing illnesses and death among children between six months and five years in developing countries. Berti *et al.* (2014: 3) also reported that national vitamin A supplementation programmes in countries like India, Bangladesh and Nepal reported a positive association between receiving vitamin A supplementation and morbidity and mortality related to undernutrition in children between one and five years.

Authors such as Liyanage and Hettiarachchi (2011: 124) highlighted that micronutrient supplementation offers a cost-effective short-term solution but does not address the causes of the deficiency. Supplementation also targets a certain group or individuals and not most members of the population (Liyanage and Hettiarachchi 2011: 124). Even though supplementation has its limitations, Mason *et al.* (2018: 2) argue that cessation of vitamin A supplementation in children is not recommended as evidence shows that supplementation can reduce mortality by 12 to 24%. They further stated that vitamin A supplementation is a valuable health intervention that reaches approximately 270 million children between six and 59 months. Petry *et al.* (2019: 16) suggests targeting vulnerable groups when implementing vitamin A supplementation programmes to avoid toxicity in population groups that are not deficient. Rayfield (2017: 4) supports vitamin A supplementation for children between six months and five years of age. The author emphasised that in addition to ensuring that the supplementation programme is delivered in a cost-effective and practical way, such as integrating it with routine health services or immunisation programmes, a wider range of vitamin A-related interventions should be implemented alongside a supplementation programme. These include promotion of vitamin A-rich diets, breastfeeding and food fortification (Rayfield 2017: 4).

2.5.1.4 Dietary diversification and modification

Sustainable solutions are vital in promoting food security and health for all populations. Organisations like the FAO advocate the production and consumption of micronutrient-rich diets (FAO 2010: 2). Dietary diversification needs to be encouraged for individuals to consume micronutrient-rich foods to reduce the prevalence of deficiencies. The authors further highlighted the difficulty of meeting iron requirements from staple-based diets due to the low bioavailability of iron from such foods. Diets lacking variety have also been linked with a deficiency of other micronutrients resulting in multi-micronutrient deficiencies. Promoting strategies that address the production, supply and consumption of a variety of fruit and vegetables can increase the intake of plant-based nutrients, and therefore contribute to the alleviation of micronutrient deficiencies (FAO 2015: 6).

2.5.1.5 National School Nutrition Programme

According to the Department of Basic Education (DBE) (2019), the National School Nutrition Programme (NSNP), previously known as Primary School Nutrition Programme (PSNP), was initiated in 1994. This programme was initially administered by the DOH until 2003 and transferred to the DBE in 2004. The NSNP offers nutritious meals to quintile 1, 2 and 3 primary and secondary schools across SA as they are of low socioeconomic status. The programme aims to alleviate hunger, improve the learner's learning capacity, and provide nutrition education to learners (DBE 2019: para. 1 line 2).

Mawela and Van den Berg (2018: 4) reported that the NSNP has been very effective in improving the learners' punctuality and has increased school attendance. The authors findings further showed that the pass rates and performance in sport activities had improved. Hochfeld *et al.* (2016) also concurred as findings from a study in the Eastern Cape showed similar findings regarding improved school attendance, improved results and improved learner's general health.

2.5.1.6 Breastfeeding and correct complementary feeding

Incorrect feeding practices contribute to malnutrition and mortality in children under five (SA DOH 2007). SA's infant and young child feeding policy (IYCF) was implemented in 2007 to promote appropriate feeding practices aimed at improving the health of infants and young children. The mother-baby friendly initiative (MBFI) previously called baby-friendly hospital initiative (BFHI), was developed and implemented to promote and support breastfeeding as the optimal infant-feeding choice. KZN also developed guidelines on MBFI for healthcare facilities. Even though the policy was developed and implemented through various programmes and initiatives, South Africa has a low rate of exclusive breastfeeding (SA DOH 2007: 9).

Various factors contribute to the lack of exclusive breastfeeding and breastfeeding. These include negative perceptions of breastfeeding among younger women and girls, the mother's attributes such as age, education level as well as the family and community environment (Nieuwoudt *et al*. 2019: 9). Pressure to maintain an ideal body shape and desire for social acceptance were mentioned as some reasons why some mothers opt not to breastfeed (Du Plessis *et al*. 2016: 112). Pillay *et al*. (2018: 16) conducted a study on infant feeding practices of teenage mothers in Umlazi in KZN. The study showed that 14 weeks after birth, 50.7% of

the mothers were exclusively breastfeeding and 49.3% were either giving the baby breastmilk with other foods or not giving the baby any breastmilk. Reasons for not exclusively breastfeeding included having insufficient breastmilk (72.2%), having to return to school or work (13.9%), being advised by a family member to change to mixed feeding (11.1%) and being too sick to breastfeed (2.8%). Therefore, this study shows that even though awareness has been created on the benefits of breastfeeding, barriers still exist (Pillay *et al*. 2018: 16).

2.5.2 Nutrition sensitive programmes and interventions

Ruel et al. (2013: 236) indicated that various complementary sectors are involved in nutrition - sensitive interventions and programmes. These include agriculture, health, social protection, early child development, and water and sanitation. These interventions and programmes address underlying determinants of malnutrition and often target poor populations with a high malnutrition rate. Furthermore, nutrition-sensitive programmes have the potential to fast track progress in improving nutrition by improving the household and community environment where children grow and develop (Ruel et al. 2013: 236).

To address malnutrition, the FAO suggests that interventions be implemented throughout the food system commencing from production to processing, transportation, consumption and waste management. Nutrition sensitive agriculture can help in the fight against malnutrition by increasing accessibility and availability of food through increased food production, promoting sustainable agriculture and increasing the nutrient content of food through fortification (FAO 2017: xi). Ogden *et al*. (2017: para. 4 line 5) emphasised that well designed nutrition specific interventions are aligned to support the enhancement of dietary diversity and nutritional outcomes.

In the following section, biofortification, home and school gardens and the use of the OFSP will be discussed.

2.5.2.1 Biofortification

Bouis and Saltzman (2017: 49) define biofortification as the breeding and genetic modification of plants to improve the nutrient content of the crop. Micronutrient deficiencies cannot be alleviated by a single intervention and biofortification complements existing interventions. According to the WHO (2019c: 1), biofortification presents an alternative of reaching populations where fortification and supplementation may be hard to implement. One of the

key advantages of this method is that it is cost-effective and reaches rural populations, which generally would be disadvantaged due to a lack of diverse diets. Younis *et al.* (2015: 3) emphasised the benefits of biofortification stating that it is a once-off self-sustaining investment that can produce crops with essential micronutrients that can decrease nutrition-related problems such as VAD, anaemia and cognitive impairment.

Biofortification can be attained using agronomic practices, conventional plant breeding and genetic modification involving gene insertions or induced mutations. In agronomic practices, the zinc, selenium and iodine content of staple food crops (such as wheat, maize, rice, beans) is increased by adding fertilizers to the soil. The iron content may also be enhanced by adding fertilizer to the foliage. Conventional plant breeding, on the other hand, may be conducted to improve the concentrations of iron and zinc in seeds of crops. Lastly, genetic modification uses various approaches such as the production of cereal grains with a higher content of methionine and cysteine to enhance zinc absorption and a low phytic acid content. Genetic engineering may also be used for some crops such as rice, to enhance the bioavailability of nutrients such as β-carotene (Gibson 2011: 20). The WHO (WHO 2019c: 1) indicated that suitable biofortification projects include iron biofortification of beans, rice, sweet potatoes and legumes. Zinc biofortification is suitable for maize, wheat, beans and rice. Furthermore, provitamin A carotenoid fortification is suitable for sweet potatoes and maize (WHO 2019c: 1).

Saltzman *et al.* (2013: 9) and Ruel *et al.* (2013: 540) elaborate further, stating that even though biofortified staple foods cannot match the provision of high levels of minerals and vitamins per day obtained from supplements or industrially fortified foods, this strategy can assist to increase the daily intake of micronutrients for individuals in various phases of the lifecycle. The authors also mentioned that the one-time investment required in plant breeding biofortification can produce micronutrient-rich materials for farmers to grow for many years. Crops used in conventional breeding include the OFSP, maize, cassava and rice. Ruel *et al.* (2013: 541) also confirmed that intakes of iron-biofortified rice and beans improved iron status. They further stated that biofortified OFSP was shown to be effective in improving serum retinol levels of children between three to five years of age in Uganda (Ruel *et al.* 2013: 541).

Both Bouis *et al.* (2011: S31) and Gibson (2011: 19) agree that biofortification is a feasible option for improving micronutrient status of individuals, even in poor communities located in rural areas. The authors further state that the advantage of biofortification is that it can be more accessible, even to members of the population who rely on self-production. Among the many

benefits of biofortification, Bouis and Saltzman (2017: 50) and Bouis *et al.* (2011: S32) highlight sustainability and cost-effectiveness. They emphasised that once a system is in place, this method is highly sustainable, and the nutritionally enhanced varieties can be used continually. The costs of maintaining the desired traits in the crops are minimal (Bouis and Saltzman 2017: 50 and Bouis *et al.* 2011: S32).

Like any method, biofortification has some limitations. Compared to supplementation and fortification, the additional micronutrient content achieved through biofortification may be lower (Hotz 2013: 175). Lockyer *et al.* (2018: 326) further stated that biofortification requires large investments upfront, and it takes longer for micronutrient status of consumers to be improved, as it takes time to implement new crop strategies. The extent to which the body stores of various nutrients increase varies between different age groups and greatly depends on the amount of staple food consumed. The success also depends on proper implementation. Figure 2.6 below depicts a three-phase pathway of the impact of biofortification (Lockyer *et al.* 2018: 326).

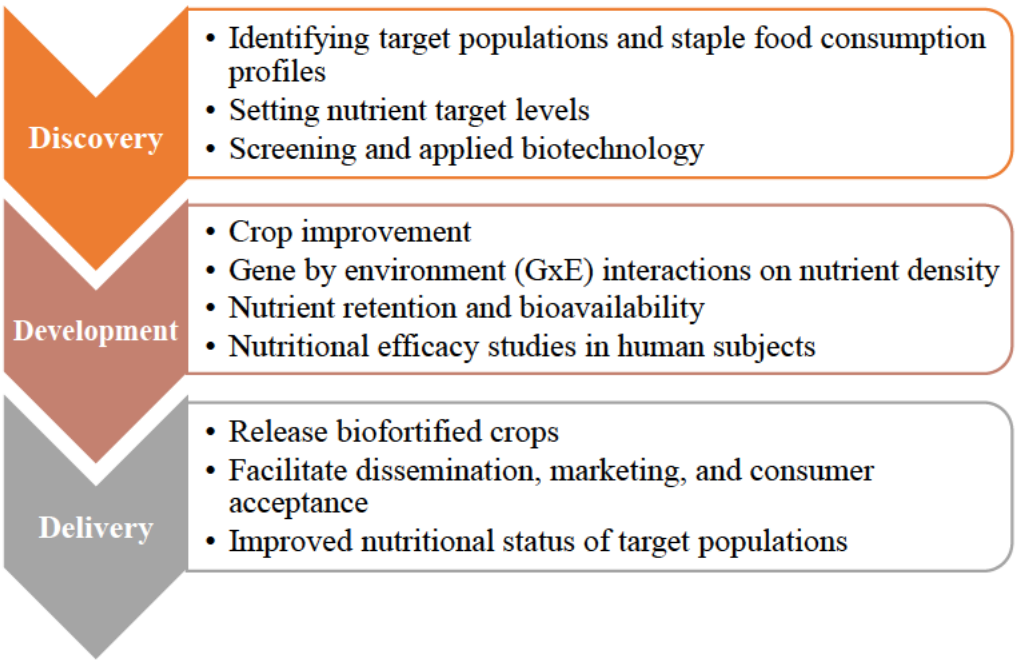

Figure 2.6: HarvestPlus pathways of the impact of biofortification (Bouis *et al.* 2011)

Three milestones to be achieved for biofortification to succeed were presented by Ruel *et al.* (2013: 540). The objectives of the breeding must be achieved (targeted concentration for each micronutrient), the bioavailability of micronutrients must be retained for the intake to yield the desired increase in status and lastly, there must be a sufficient farmer adoption rate and intake

by target population. Johnson *et al*. (2017: 12083) investigated the effectiveness of biofortification as a strategy to address micronutrient deficiencies. The authors found that biofortification is not only effective in terms of agricultural impact, but also has a positive health impact. The biofortified varieties bred were successful in delivering the targeted nutrients and were acceptable to farmers and consumers. Furthermore, the study also showed that regular consumption of biofortified crops resulted in improved vitamin A and iron status (Johnson *et al*. 2017: 12083).

2.5.2.2 Home and school gardens

Home gardens were discovered to be important sources of micronutrients for poverty stricken rural communities. With proper selection, a wider variety of fruit and vegetables can be cultivated all year to provide a sustainable supply of micronutrients. Food gardens provide access to healthy diets, with sufficient macro and micronutrients. These gardens make an important contribution in rural areas where populations have limited income. In most rural communities where access to land and water is not limited, food gardens have the potential to supply most of the required non-staple foods (FAO 2010: 10).

Faber and Laurie (2011: 163) agree that one of the long-term sustainable strategies that can assist to alleviate vitamin A and other nutritional deficiencies is home gardens. Home garden projects have been implemented to address VAD in South Africa. These include the Ndunakazi project conducted in KZN and the Lusikisiki project in the Eastern Cape. Both projects aimed to improve children's vitamin A status by producing and promoting an adequate intake of provitamin A-rich vegetables and fruit, especially the OFSP. The Ndunakazi project also included a nutrition education and growth monitoring component. Results from this study showed an increase in vitamin A intake and vitamin A status among two to five-year-old children. Furthermore, the maternal knowledge of nutrition and vitamin A-rich foods also increased (Faber and Laurie 2011: 167). Faber and Laurie (2011: 172) reported that in the Lusikisiki project, a similar approach was employed, however, there was greater focus on mobilising the community and technology transfer. Findings showed an increase in the consumption of β-carotene rich vegetables among children in the project households (Faber and Laurie 2011: 172). The Mdantsane for Vitamin A Program also promoted the intake of β-carotene rich vegetables and in particular, the OFSP. Results showed that both knowledge of foods rich in vitamin A and consumption of OFSP had increased (Laurie *et al.* 2015: 967).

2.5.2.3 Orange-fleshed sweet potato (OFSP)

The sweet potato (Ipomoea batatas L.) is a starchy tuberous root that is part of the Convolvulaceae family. It originated from Central America and North Western South America (Helen Keller International Vitamin A Supplementation Program 2021: 11). Mitra (2012: 1) reported that the sweet potato crop is widely grown in different parts of the world, with Asia responsible for 78% of its production. Kapinga *et al*. (2007: 83) stated that over 2 million tons of sweet potato is produced in SSA annually, which contributes to approximately 5% of global production. This rate of production is estimated to double by 2020. In the African continent, producers include Uganda, Tanzania, Malawi, Mozambique and SA. The sweet potato is an essential crop in Eastern and Southern Africa, predominantly cultivated for domestic consumption (Kapinga *et al*. 2007: 83).

The DAFF (DAFF 2011: 1) has identified Limpopo, Mpumalanga, KZN and the Western Cape as major production areas for OFSP in South Africa. Three major types accessible for commercial production are the orange-fleshed which may have orange or copper skin with a high sugar and β-carotene content. The OFSP varieties include Beauregard, Hernandez, Beerwah Gold, NC-3, LO-323, Centennial, Darby and Jewel. The South African OFSP cultivars characteristically have long tubers, and grow quickly (DAFF 2011: 1).

Factors that impact the growth of this plant include temperature, light, rainfall, soil and altitude. Pre-production practices are essential to ensure optimal growth of the crop. The sweet potato grows well in warm conditions, preferably in temperatures between 21°C and 29°C, with a tolerance of 18°C as the lowest temperature and 35°C as the highest temperature. These roots grow best in sandy loam soil that is well-drained, while heavy clay soil is not suitable as it may affect the shape of the sweet potato, leading to a crop with visible growth cracks. The soil should be assessed annually to evaluate the pH, nutrient levels, and other soil properties before the ground is prepared for planting (DAFF 2011: 3).

The DAFF (DAFF 2011: 6) emphasised that the soil should be prepared into raised beds or mounds (approximately 30 cm high and 40 cm wide) to facilitate the growth of loose roots to prevent restrictions. The climate predominantly determines the planting time as certain conditions such as light frost may be destructive to the sweet potato plant and high temperatures are required for a period of approximately four to five months. The sweet potato crop is tolerant to drought and it can grow under very dry conditions, even though increasing the moisture

levels may be suitable. In the early stages of growth, weeds may grow. Methods used to control weeds include the use of herbicides before planting and the use of rotary finger cultivators. Pest control is an important part of plant management as the sweet potato weevil and giant termites are known to attack the plant. After harvest, it is important to destroy all crop residues and rotate the crops to maintain a low number of weevils (DAFF 2011: 6).

The speed of root development is slow in cooler weather conditions, affecting root maturity. When the crop is grown during the dry season, it is estimated that at approximately 20 to 22 weeks from the time of planting, the roots will be ready for ploughing. For commercial production, the comprehensive harvesting process needs suitable equipment. The excavated roots are then gathered manually and protected from overexposure to direct sunlight (DAFF 2011: 12).

The DAFF (DAFF 2011: 13) emphasised that it is imperative that root curing occurs immediately after harvesting. This process includes holding the roots at a high temperature (30°C) and high relative humidity (85 to 90%) for seven to ten days. This is to facilitate the healing of harvesting wounds and the formation of a protective layer of cells. Curing of sweet potato roots is not a compulsory commercial practice as it can be costly; however, it is a worthwhile exercise as it does not only allow the roots to be stored for a lengthy period, but also increases the sweetness and assists in the maintenance of low levels of rot infections. Skin damage is prevented by submerging underwater, washing and drying in a heated tunnel. Drying the roots thoroughly before packing helps prevent post-harvest rot. The sweet potatoes are then graded and packaged. Optimal temperatures for storing the roots are between 14 and 16°C, with relative humidity between 75 to 80% to inhibit water loss (DAFF 2011: 13).

The nutritional content of the sweet potato varies, depending on the cultivar. Leighton (2007: 60) conducted a nutritional analysis of four sweet potato cultivars from different regions in SA. These OFSP varieties were Resisto, W119, Jewel and A15 (Table 2.2). The samples to be analysed were prepared by washing and boiling them with the skin on, in a closed stainless-steel pot. The roots were cooked intact, and 500 ml of water was added at the commencement of the cooking process and replenished only if required. The roots were cooked until just done. Results showed differences in the nutritional content of the different varieties. The Resisto variety had a higher nutrient content of β-carotene, carbohydrates, calcium and vitamin C compared to the other varieties (Leighton 2007: 61).

Table 2.2: Summary of the nutritional content of cooked OFSP cultivars (Leighton 2007)

Nutrient	Resisto per 100g	Jewel per 100g	W119	A15
Beta carotene (µg)	9230	6853	4323	6880
Carbohydrates (g)	20.9	18.2	134	17.9
Iron (mg)	0.45	0.71	0.64	0.74
Calcium (mg)	143	115	65.5	105
Zinc (mg)	395	3.96	4.18	2.85
Vitamin C (mg)	8.56	6.37	5.91	7.45

µg: micrograms, g: grams, mg: milligrams

Table 2.3 shows the vitamin A requirements for children between one to three years of age and four to eight years of age (IOM 2001; van Jaarsveld 2007: 327).

Table 2.3: Vitamin A requirements for young children between one to three years and four to eight years of age (IOM 2001; van Jaarsveld 2007: 327)

Age group	RDA/day (µg RAE)	EAR/day (µg RAE)	UL (µg/day)	Beta carotene (µg)
1 to 3 years	300	210	600	300µg RAE x 12 = 3600µg β-carotene
4 to 8 years	400	275	900	400µg RAE x 12 = 4800µg β-carotene

RDA is the intake that meets the nutrient needs of 97-98% of individuals in that gender group, 1 Retinol Activity Equivalent (RAE) = 1µg Retinol = 12µg β-carotene, EAR (Estimated Average Requirement) is the intake that meets the estimated needs of a nutrient for 50% of individuals in that specified group, Tolerable Upper Intake Level (UL) is the maximum nutrient intake by an individual, which is unlikely to pose risks of adverse health effects (IOM 2001)

Van Jaarsveld *et al.* (2006: 322) assessed the retention of β-carotene in boiled OFSP and during its storage. Findings showed that the retention of the β-carotene content was substantial and the authors assert that that the retention depends on the cooking conditions and the root size of the crop. The authors suggested that the best method for retaining β-carotene is boiling the OFSP whole, immersed in water covered with a lid until just done (Van Jaarsveld *et al.* 2006: 328).

Various studies have been conducted to assess consumer acceptance of OFSP. A study conducted by Kapinga *et al.* (2007) in Uganda revealed that children preferred a deep orange variety as compared to other sweet potato varieties. The participants from the Ugandan study also indicated that the colour was attractive and the OFSP was less fibrous. Results from sensory evaluation tests indicated that this was due to the taste, texture and colour. These findings may possibly imply that varieties that are richer in β-carotene can be easily included in the diets of young children (Kapinga *et al.* 2007: 13).

Van Heerden (2007: 62) tested consumer acceptability of four OFSP products in six regions across four provinces in SA. Different age groups were included from middle and lower-

income groups. The panellists liked all four OFSP products; OFSP juice, OFSP chips, OFSP doughnuts and OFSP leaves. As compared to the other three products, the doughnuts were liked the most by the participants, with the majority of participants indicating that they would make or buy all four products. Results from this study concluded that OFSP-based products have the potential to increase the consumption of this crop (Van Heerden 2007: 62).

Leighton (2007: 69) also conducted sensory evaluation and consumer acceptability tests of different OFSP varieties (Resisto, W119, Khano and Beauregard) and a WFSP variety (Blesbok) using a trained panel. The results indicated that the flavour and texture of OFSP varieties were different and that the white-fleshed variety was more moist and fibrous as compared to the OFSP. When assessing consumer acceptability of Resisto (OFSP) and Blesbok (WFSP), 85% of the panellists preferred the taste of the OFSP as compared to the WFSP. Fifty three percent indicated that they preferred the colour of OFSP with 22% stating that they neither liked nor disliked the colour. Findings from this study also revealed that when the participants were informed of the nutritional value of the OFSP; the majority (86%) indicated that they would be willing to buy this variety, therefore suggesting that some consumers need nutrition education concerning the nutrient composition of the less known β-carotene rich vegetables. The author also found that the majority of the participants had not been exposed to the OFSP variety previously, correlating with findings by Laurie (2007: 55), who stated that food-based approaches emphasizing use of the OFSP can be implemented on a wider scale to target different role players.

In Table 2.4, Laurie (2007: 23) compared the flesh colour, carotenoid content, advantages and disadvantages of OFSP varieties available in South Africa.

Table 2.4: Sweet potato varieties used in food-based projects in SA (Laurie 2007: 23)

Name	Flesh colour	Carotenoid content (µg/100 g)	Advantages	Disadvantages
Resisto	Very dark orange	15844	Excellent taste	Sensitive to drought
Khano	Dark orange	13710	High yield	Average to poor taste
A15	Darker orange	9180	Medium to high carotenoid content	Average taste
W-119	Orange	7574	Good taste	Poor storability
Excel	Orange, yellow cortex	5330	Very good taste	Low yield
Serolane	Orange with yellow ring	6181	Very good taste	Poor storability, low yield

Laurie (2007: 19) reported favourable conditions for promoting the OFSP in SA. These include high levels of adaptability, and that it is not labour intensive. The Agricultural Research Council (ARC) is set to continue the breeding of OFSP, focussing on varieties that are high in β-carotene, tolerant to drought, tasty, high yielding and resistant to pests (Laurie 2007: 19).

2.6 Conclusion

This chapter provided a detailed overview of the studies related to the main research area and aims of the current study. Addressing micronutrient deficiencies in young children is vital as it is in line with SDG 2. Such intervention programmes should target the most vulnerable populations to make a significant contribution in improving children's health. Based on the extensive literature review on prevalent VAD and IDA among SA children and the potential of the OFSP as a nutrient dense crop, the researcher identified yoghurt as a suitable healthy snack that could be used as a vehicle to increase the consumption of OFSP in the children's diet and potentially improve the intake of various nutrients to enhance optimal growth and development. The researcher decided to develop the OFSP yoghurt based on the recommendation by the SA DOH stating that yoghurt can be added to children's diets and the proposed SA Paediatric Food Based Dietary Guidelines which recommend that children in this age group should consume milk, *maas* or yoghurt every day. Furthermore, research reports also indicate a low vitamin A and calcium intake among children in this age group. Yoghurt is rich in nutrients and should be part of the diet for children below five years of age. The production of yoghurt using the OFSP is anticipated to contribute to the essential nutrients required for optimum development. Due to the high nutrient content of yoghurt, it can be used to deliver micronutrients and yoghurt has the potential to improve health. In the next chapter, the yoghurt production process and the OFSP development process will be discussed.

CHAPTER 3: YOGHURT PRODUCTION PROCESS AND OFSP YOGHURT DEVELOPMENT

3.1 Introduction

According to Fuller (2011: 5), a new product may be defined as a product not formerly manufactured by a company and introduced by that company into the marketplace. There are different types of new products. These include line extensions, repositioned existing products, developing an existing product in a new form and reformulating an existing product. Winger and Wall (2006: 3) stated that nutrition researchers may also develop food products as part of interventions to address identified deficiencies in a population group. In this chapter, the process for manufacturing yoghurt and the OFSP yoghurt development process will be discussed as this study involved the development of a yoghurt with OFSP to improve nutritional status of children between 24-60 months of age.

3.2 Yoghurt

Weerathilake *et al.* (2014: 1) indicated that worldwide, one of the most consumed fermented milk products is yoghurt. The word is taken from the Turkish work *yoğurmak*, meaning to coagulate, curdle or thicken. Yoghurt is called by different names in various regions. In India, it is called *dahi*, in Egypt it is called *zabadi* and in Portugal it is called *coalhada.* It is reported that herdsmen in the Middle East who carried milk in bags made of intestinal gut discovered that the contact with intestinal juices caused the milk to curdle and turn sour (Fisberg and Machado 2015: 1) In addition to supplying the diet with vitamins and minerals, yoghurt offers many health benefits such as improved intestinal health, and immune function (Nagpal *et al*. 2012: 1). Yildiz (2010: 3) defines yoghurt as a semi-solid fermented dairy product produced by adding bacteria into milk, which is thereafter fermented between 43°C–45°C. The role of the good bacteria (referred to as starter culture) is to ingest milk sugars and release lactic acid. The increase in acidity levels results in the coagulation of the milk proteins into a curd through denaturation. The desirable acid levels (pH of 4.3) prohibit the multiplication of pathogenic bacteria (Yildiz 2010: 3).

3.2.1 Types of yoghurt

The various types of yoghurt include set, stirred, drinking and fruit yoghurt (Yildiz 2010: 5). The consistency, aroma and flavour of yoghurt vary based on the type produced. A set yoghurt is left to set in the consumer container, whereas a stirred yoghurt is produced in a container in which the curd is broken as the product is dispensed into serving containers. In the production of drinking yoghurt, additional milk and flavours such as fruit syrups are added to the stirred yoghurt base. This type has a shorter shelf-life due to a higher pH than other yoghurt types. When producing fruit yoghurt, the fruit may be placed on top or at the bottom of the yoghurt or stirred into the yoghurt (Yildiz 2010: 5).

3.2.2 Ingredients in yoghurt production

3.2.2.1 Milk

Chandan and O'Rell (2013: 218) indicated that the two main ingredients used when making yoghurt are milk and a starter culture. Dairy-based or plant-based milks may be used. It is vital that milk selected for yoghurt production should contain a low bacterial count, low coliform count, yeast and mould. The presence of coliform, yeast, mould and high levels of bacteria would infer that the milk was handled using unsanitary equipment or held at incorrect temperatures. Milk may be contaminated by psychrophiles or phsychrotops between 3°C to 10°C. Pasteurization is therefore essential to destroy coliform, yeast, mould and psychrophiles (Chandan and O'Rell 2013: 218).

3.2.2.2 Starter culture

According to Gürakan and Altay (2010: 100) and Yildiz (2010: 8) a blend of thermophilic bacteria, *Streptococcus salivarius subsp. Thermophilus* (ST) and *Lactobacillus delbrueckii subsp. Balgaricus* (LB) are mostly used in the production of yoghurt. They may be used independently; however, using the two strains together is advisable as acid production is higher when used in combination in a ratio of 1:1. ST multiplies quicker and generates acid and carbon dioxide. The proteolytic activity of LB produces amino acids and stimulatory peptides. The ST decreases to a pH of five and as fermentation continues, the LB further decreases to a pH of approximately four (Gürakan and Altay 2010: 100; Yildiz 2010: 8).

During yoghurt production, the LB and ST bacteria produce lactic acid, which decreases the pH and causes milk protein to coagulate. Their metabolites, such as carbonyl compounds, non-

volatile or volatile acids, and exopolysaccharides, strongly affect the quality of yoghurt. Growth of lactic acid bacteria in milk induces many changes that are desirable in yoghurt. These changes include the synthesis of different metabolites (lactic acid, exopolysaccharides, and aroma compounds) and the modification of the texture and the nutritional value of the product (Soomro and Masud 2008: 67).

Figure 3.1 shows that during fermentation, lactic acid bacteria (LAB) convert lactose (milk sugar) into lactic acid or other metabolites (glycolysis). The protein casein is hydrolysed into peptides and free amino acids (proteolysis), and the milk fat is broken down into free fatty acids (lipolysis) (Chen *et al.* 2017: 317). According to McAuliffe *et al.* (2019: 911), depending on the LAB species, lactose can undergo homofermentation or heterofermentation. In the homofermentation, LAB and sugars enter the pathways through the Embden-Meyerhof-Parnas (EMP) and in heterofermentative species, the process occurs via the phosphoketolase pathway (PKP). Pyruvate is a key intermediate in the generation of lactic acid through glycolysis and some can be converted to flavour compounds such as diacetyl and acetoin. Lipolysis leads to the formation of free fatty acids, which are precursors of flavour compounds like methylketones, secondary alcohols, esters and lactones. Casein releases short peptides which generate amino acids which are further converted into flavour compounds (McAuliffe *et al.* 2019: 911).

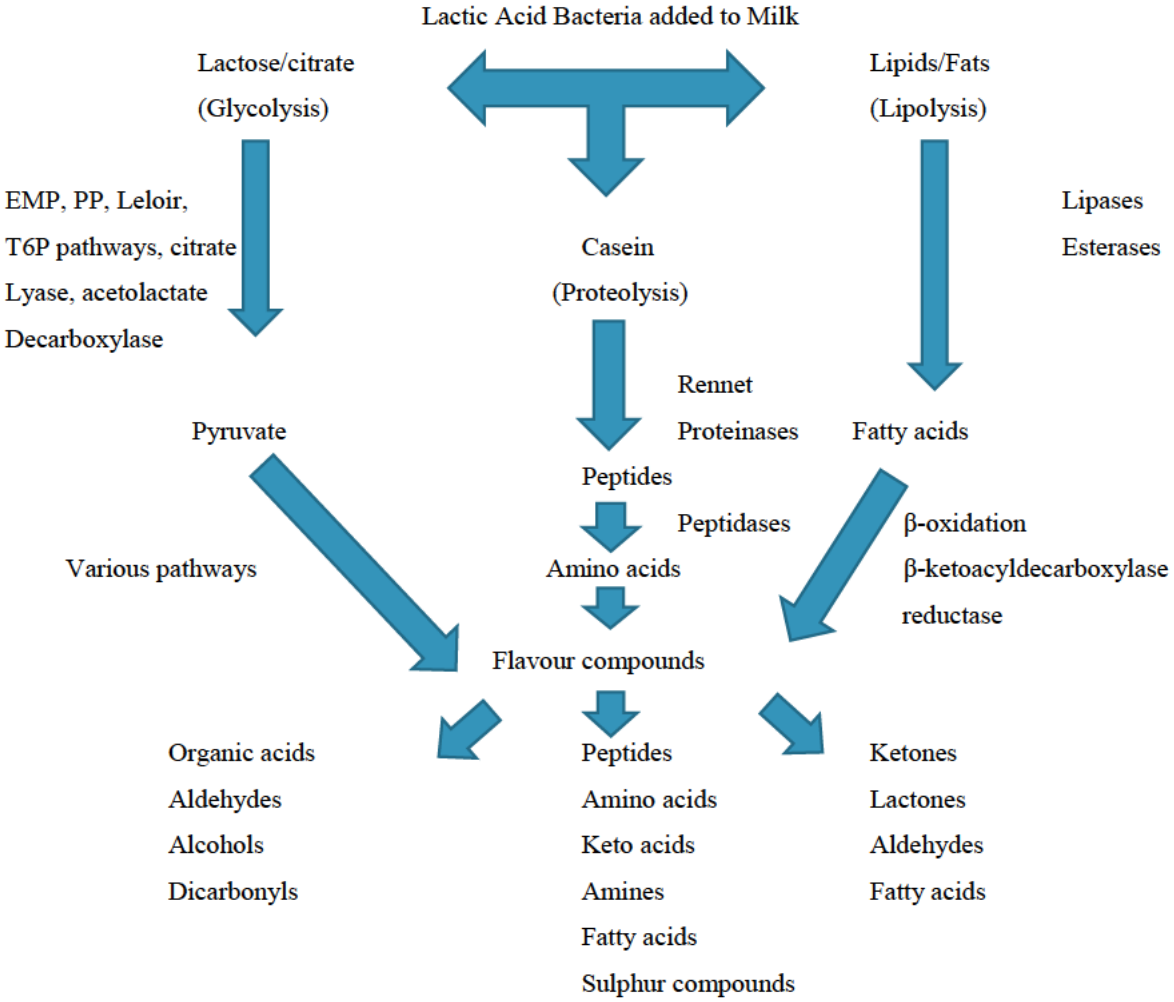

Figure 3.1: The primary metabolic pathways resulting in generation of flavour in fermented dairy products (McAuliffe *et al*. 2017)

Other live cultures such as *lactobacillus acidophilus*, *lactobacillus subsp. casei* and *bifidobacteria* may be added to yoghurt as probiotics. Probiotics improve lactose digestion, strengthen the immune system, lower cholesterol levels and improve gut health (Yadav *et al.* 2015: 26; Kechagia *et al*. 2013: 3). Nagpal *et al*. (2012: 1) also mentioned that probiotics increase the bioavailability of nutrients, decrease the risk of infections caused by helicobacter pylori and reduce the symptoms of lactose intolerance.

3.2.2.3 Whey protein

Chandan and O'Rell (2013: 222) stated that whey protein concentrates (WPC) may be added in yoghurt making to reduce whey separation due to their water holding capacity. WPC contain between 34%-80% of protein, whereas whey protein isolates (WPI) contain approximately 92% of protein. To be cost-effective, WPC is usually used in yoghurt production. Furthermore, WPC provide good quality whey protein and calcium. Some manufacturers may use WPI and

WPC-80 as these contain lower levels of lactose and have a high protein content (Chandan and O'Rell (2013: 222).

3.2.2.4 Sweeteners

According to Özer (2010: 65) and Chandan and O'Rell (2013: 224), sweeteners (nutritive and non-nutritive) are commonly added to the yoghurt-base when manufacturing flavoured yoghurt. The level depends on the desired sweetness of the finished product. Most manufacturers use sucrose in granulated or in liquid form. Caution should be exercised when sweetening the yoghurt as sugar solids in the yoghurt mix should not be higher than 11% as a higher percentage may affect the effectiveness of the yoghurt starter culture. It is common practice to add the sugar before pasteurisation of the milk for various reasons. These include the destruction of any asmpholic yeasts and mould found in the sugar and the consistency is usually not affected when the sugar is not added into the coagulum. Furthermore, this is also done to reduce the risk of contamination (Özer 2010: 65; Chandan and O'Rell 2013: 224).

Chandan and O'Rell (2013: 227) further explained that corn sweeteners affect the fermentation of yoghurt and are therefore not commonly used in yoghurt making; however, they may be used in the fruit preparations that are added after fermentation to flavour the yoghurt. A common practice is to use corn sweeteners in frozen yoghurt as they are added post-fermentation. Non-nutritive sweeteners such as aspartame, sucralose, stevia, saccharin and neotame are often used in yoghurt production. Sucralose is sweeter and more stable to heat than aspartame. Aspartame is added to the yoghurt-base post-fermentation and if used, the product should indicate that it has phenylalanine. For maximum sweetness, aspartame is best used in granular form. Saccharin has a bitter taste and is not widely used compared to stevia. The latter is very sweet and should be used sparingly (Chandan and O'Rell (2013: 227).

3.2.2.5 Stabilisers

Chandan and O'Rell (2013: 265) stated that stabilisers are added primarily to enhance the consistency, extend shelf-life, reduce the separation of whey, increase viscosity and maintain gel structure after the mixing stage. The choice of stabiliser depends on the type of yoghurt, the desired consistency, availability of processing equipment, the effect of stabiliser in masking the flavour of the yoghurt and the formulation of the yoghurt. Stabilisers used include whey protein concentrates, tapioca starch, gelatine, and pectin. Caution should be exercised in the

selection of stabilisers as the interaction of some ingredients with the milk constituents may negatively affect the yoghurt mixture. Gelatine is popular in frozen yoghurt; however, when exposed to elevated temperatures during processing, it degrades. If gelatine is used in isolation, it may create a jelly-like texture which is not desirable in the finished product. Common combinations are modified starch and gelatine as well as gelatine and pectin. Modified corn or tapioca starch is also a popular stabiliser in yoghurt making. The advantage is the bland flavour and smooth texture and the ability to withstand various intense processing conditions. Pectin is most ideal for cup yoghurt and may be used in isolation or in combination with other hydrocolloids in the production of set and stirred yoghurt. Pectin should be used with caution as high amounts cause a chalky and sandy texture, and low viscosity in stirred yoghurt (Chandan and O'Rell 2013: 265).

3.2.3 Production process of set and stirred yoghurt

Yoghurt is generally produced by the modification of the original composition of milk, pasteurization, homogenisation and fermentation using thermophilic starter culture, followed by flavouring. The type of milk used is selected according to the type of yoghurt made, such as full cream milk for full cream yoghurt (Weerathilake *et al.* 2014: 3). Figure 3.2 shows the sequence in yoghurt production stages for set and stirred yoghurt (Weerathilake *et al.* 2014).

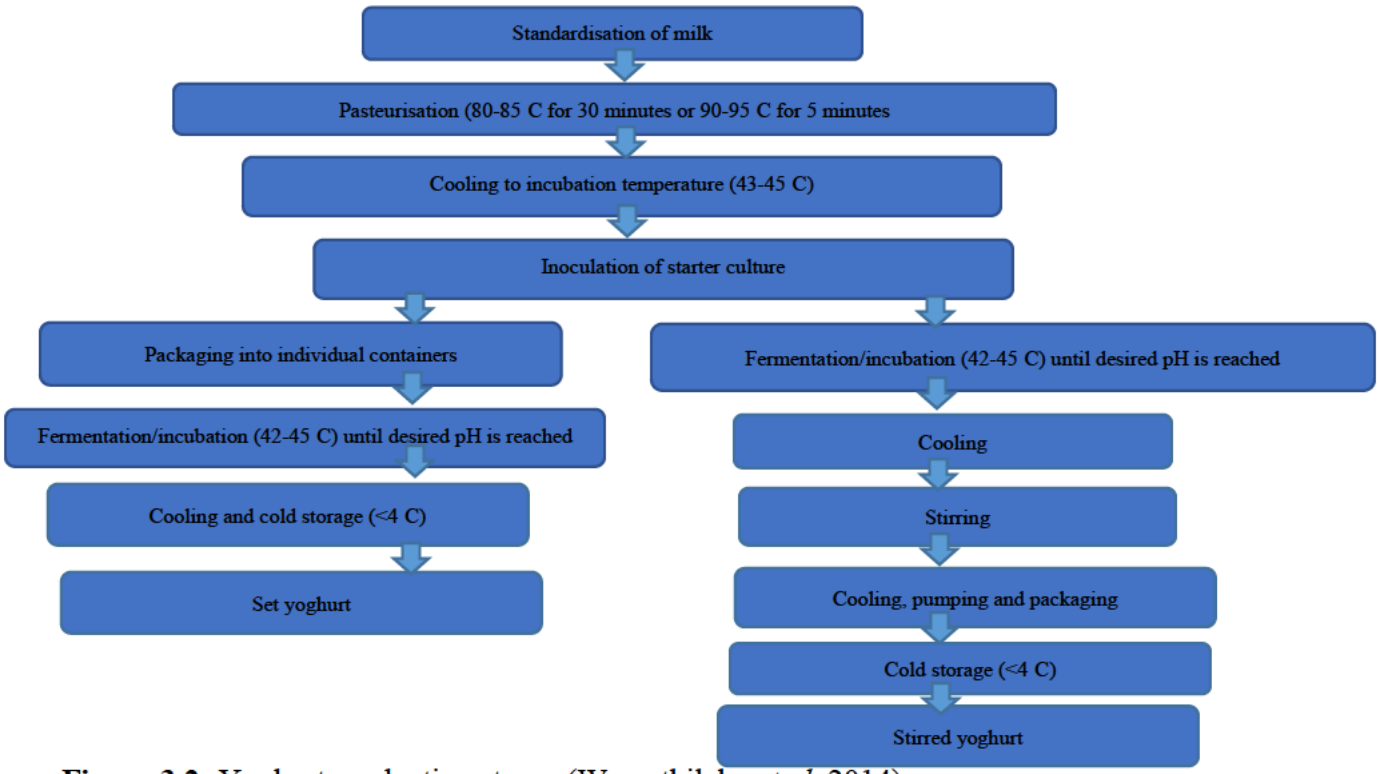

Figure 3.2: Yoghurt production stages (Weerathilake *et al.* 2014)

Yildiz (2010: 9) stated that dairy-based yoghurt manufacturers often use cow's milk of any fat content. The milk is standardised to achieve the desired fat content. After the clarification and separation of milk into cream and skim milk, the mixture is pasteurised for half an hour at 85°C or ten minutes at 95°C. This is to ensure a sterile environment suitable for the growth of the starter culture and to denature and coagulate whey proteins to develop the consistency and texture. Yoghurt manufacturers typically increase the solids non-fat (SNF) levels to enhance gel strength of set yoghurt and the consistency of stirred yoghurt. This is done by adding milk powder, buttermilk powder, whey powder, whey concentrate, whey protein powder or whey protein concentrate. Some manufacturers opt for skimmed milk powder to avoid the oxidized aroma that is normally caused by whole milk powder. Levels should not exceed 4% as higher levels may result in yoghurt with lumps and a powdery taste. Similarly, when adding whey-derived powders, levels should not exceed 3%. Stabilisers are added to inhibit wheying off during incubation and storage. Stabilisers also enhance the mouthfeel, texture, viscosity and appearance of the yoghurt. The choice and amount of Stabiliser to be used is based on the yoghurt's ideal chemical properties and physical characteristics. A yoghurt mix with a higher content of solids needs a lower level of stabiliser. Furthermore, the stabiliser type determines the temperature to be used for incubation (Weerathilake *et al*. 2014: 4; Yildiz 2010: 63).

The milk is homogenised using a homogeniser or vocaliser using pressures of 10-20 MPa in the first stage and 5 MPa in the second stage. Homogenisation increases the firmness and water holding capacity. The microstructure and physical properties of the yoghurt are influenced by heat treatment. Benefits of heat treatment include destroying microorganisms that would affect the fermentation process. Furthermore, heat treatment denatures whey proteins, improves the texture and releases milk compounds that will stimulate the growth of the starter culture. The mixture is then cooled to approximately 43-46°C, and the culture is added. The yoghurt mixture is incubated at a constant temperature of 43°C with no agitation. The temperature should be carefully monitored as high temperatures may kill or negatively affect the effectiveness of the starter culture. Very low temperatures prolong the fermentation time, resulting in altered taste of the yoghurt. During fermentation, the titratable acidity (TA) is monitored until 0.85 -0.90% and the pH between 4.2 and 4.3. Fermentation may take three to four hours until the desired pH levels are reached. The yoghurt is then blast chilled to refrigeration temperatures to stop the fermentation process. Set yoghurts are blast chilled in cooling tunnels, whereas stirred yoghurt is cooled, flavoured as per product specifications and refrigerated to slow microbial degradation (Weerathilake *et al*. 2014: 4; Yildiz 2010: 9).

3.2.4 Food safety in yoghurt production

Quality control is an important aspect in manufacturing yoghurt. The HACCP food safety system is used to ensure safety and quality of yoghurt. All seven principles of the HACCP program must be strictly controlled. Control points (CP) and critical control points (CCP) should be identified to prevent all potential hazards such as microbial, chemical and physical hazards. Özer and Kirmaci (2010: 235) suggested the monitoring of the control points and critical control points in Figure 3.3.

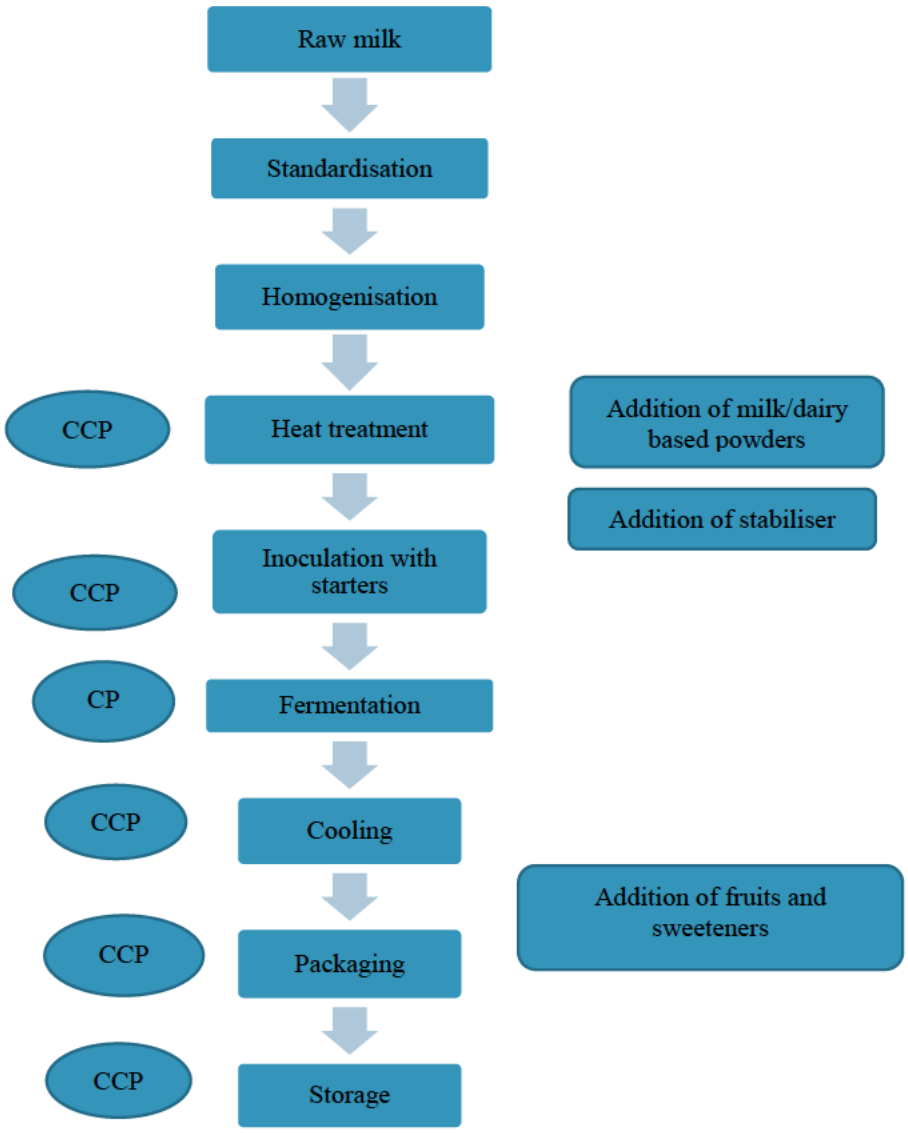

Figure 3.3: Critical Control Points in yoghurt production (Muresan *et al.* 2020)

3.2.5 Quality characteristics of yoghurt

The quality of yoghurt is important and may be affected by various factors. Good quality yoghurt is characterised by a pleasant taste, aroma, colour and has a smooth and firm consistency. The main cause of syneresis, one of the common textural defects in yoghurt is the rearrangement of the network of the casein micelles. As the gel shrinks, water will expel from the network. A broken coagulum may be caused by very low protein content and low-fat content of yoghurt mix. Furthermore, the extent of denaturation of whey protein due to increased temperature and time also causes syneresis. Incubation conditions also influence the quality of the yoghurt. There are conflicting views with regards to the effect of temperature on firmness. Some reports show that using a lower temperature (approximately 30ºC) results in a firmer yoghurt; however, this method significantly increases fermentation time. Others reported that using 42ºC leads to a firmer gel compared to 30ºC (Rani *et al.* 2012: 2).

Sfakianakis and Tzia (2014: 178) stated that poor consistency and viscosity of yoghurt may be caused by incorrect adjustment of SNF content of the yoghurt mix and emphasised that yoghurt producers should take caution when increasing the SNF as it increases fermentation, which may affect the flavour of the final product. One of the vital quality attributes of yoghurt is acidity. Oladimeji *et al.* (2016: 102) stated that the temperature, type of starter culture and length of incubation time may affect the pH, titrable acidity and viscosity of yoghurt. Increasing the incubation temperature resulted in a firmer and thicker gel. Moreover, the incubation temperature also affected the sensory attributes of yoghurt. The authors' findings showed that samples incubated at 30ºC had a smooth, creamy texture and the taste was not tangy. Samples incubated at a higher temperature had a sourer taste (Oladimeji *et al.* 2016: 102).

Rani *et al.* (2012: 2) also mentioned that poor hygiene practices (personal and equipment used) and an incorrect storage temperature cause growth of pathogenic bacteria. In addition to product safety concerns, the presence of yeast affects the flavour of yoghurt, as it gives a yeasty bitter flavour. Heat treating the milk at correct temperatures reduces pathogenic microorganisms and sterilisation destroys the microbial content of milk (Rani *et al.* 2012: 2).

3.2.6 Sensory evaluation of yoghurt

According to Corrieu and Béal (2016: 623), appearance, texture, aroma, odour, taste and after-taste are the primary sensory attributes evaluated in yoghurts. Kemp *et al.* (2009: 1) explained

that sensory evaluation of yoghurt may be objective or subjective. In objective testing, a trained panel is used to evaluate the product's sensory properties. Objective tests may be classified into two categories: discrimination tests and descriptive tests. Discrimination tests are used to indicate whether there are sensory differences between samples, whereas descriptive tests show the nature and extent of a sensory difference. Subjective testing, also known as affective or consumer testing measures the consumer reaction to sensory properties of the product. Consumer sensory testing assists in identifying sensory attributes that may influence the acceptability of the product in the market, and it may form part of quality assurance of raw materials. Various scales may be used to assess these attributes, ranging from five to nine-point hedonic scales (Corrieu and Béal 2016: 623).

3.2.7 Nutritional profile of yoghurt

According to Weerathilake *et al.* (2014: 5), yoghurt is a source of milk proteins, carbohydrates, minerals and vitamins. The fat content varies according to the type of milk used and the milk source. In terms of the Agricultural Product Standards Act no 119 of 1990, the milk fat content should be between 3.3-4.5% for full cream yoghurt, between 0.5-1.5% for low fat and not more than 0.5% for fat-free yoghurt. The minimum milk protein content should be 2.7%. For yoghurt with added ingredients and/or fruit, the milk fat content would be similar to the categories stated above; however, milk protein content should be 2.0%. Furthermore, yoghurts in the latter category should contain at least 10^7 colony forming units per gram (CFU/g) of viable yoghurt culture micro-organisms per gram of a product. The dry matter content should be at least 14.5% and 13.5% (m/m) for full-cream and low-fat yoghurt, respectively (DOH 2018: 17). Weerathilake *et al.* (2014: 5) further stated that yoghurt is rich in other nutrients such as calcium, several B vitamins, especially riboflavin and thiamine. The content of folic acid or folate in yoghurt depends on the lactic acid bacteria used. Gómez-Gallego *et al.* (2018: 32) agree that yoghurt is a good source of protein, calcium phosphorus, riboflavin and vitamin B12.

3.2.8 Yoghurt and health

Gómez-Gallego *et al.* (2018: 34) reported that yoghurt plays an important part of a diet that promotes good health. Calcium, protein, phosphorus magnesium and zinc are required for bone health. The bioavailability of calcium in yoghurt facilitates uptake by the small intestine. Calcium is noted to play a vital role in bone mineral density. Furthermore, regular yoghurt consumption is associated with a lower risk of type two diabetes. Gómez-Gallego *et al*. (2018:

30) concurs that yoghurt may also be suitable for those with lactose intolerance as it contains less lactose than milk. Moreover, the authors also reported that regular consumption of fermented milk products with bacterial strains has been noted to reduce infections, common cold, allergies and decrease the duration of diseases in the respiratory tract. However, the effect of yoghurt consumption on allergic disease is related to specific probiotics consumed (Gómez-Gallego *et al*. 2018: 30).

3.3 Development of OFSP yoghurt

The researcher first investigated the form in which the OFSP could be used in yoghurt making. Initial investigations included drying the OFSP into ground powder. The steps are shown in Figures 3.4 to Figure 3.7. The OFSP roots were washed under cold running water to prevent oxidation and the ends were cut off with a sharp knife. The roots were then dried and weighed. Thereafter, the OFSP was peeled into strips using a vegetable peeler, pat dried using a kitchen towel and placed on an oven rack. The OFSP strips were then dried in an electric oven at 60ºC until crispy. The length of time it took for the sweet potato to dry varied. The strips that were cut on the outer part of the OFSP root dried quicker than those peeled off from the inner part of the root. The time ranged from 1 hour to 1 hour and 30 minutes. The OFSP crisps were then cooled at room temperature and ground into powder using an electric power blender. The powder was placed in a sealable, airtight Ziploc bag and stored in an airtight container, at room temperature. Ten kilograms of OFSP roots yielded approximately 1 kg of OFSP powder.

Figure 3.4: OFSP root weighed

Figure 3.5: Drying of OFSP strips

Figure 3.6: Dried OFSP strips

Figure 3.7: Ground OFSP powder

Challenges encountered during the drying of the OFSP included the length of time to produce the powder and low yield. The researcher also investigated for how long the OFSP powder could be kept in a sealed container at room temperature. The OFSP powder was bright orange in colour after production. After approximately two months, the OFSP powder changed slightly in colour. The change in colour was in alignment with findings by Chilungo *et al.* (2019: 362), who reported that OFSP flours change in colour when exposed to light, oxygen and moisture. Amajor *et al.* (2014: 50) reported that the moisture content of OFSP flour affects the quality of the flour and reduces the shelf life. The use of the OFSP in powder form in the developed yoghurt would have required making the powder in advance, while the OFSP was in season and keeping an adequate supply for the intervention period. The vitamin A content of the OFSP powder was analysed at a laboratory accredited by the South African National Accreditation System (SANAS). A freshly ground sample was compared with a sample that had been stored in an air-tight container at room temperature for two months. The vitamin A was measured as β-carotene and results were converted to vitamin A, as retinol activity equivalents (RAE), by using the conversion factor of 1µg RAE = 12µg natural β-carotene (IOM 2001). The fresh OFSP powder contained 369µg/100g and the stored OFSP powder contained 12µg of vitamin A. This was not feasible due to the length of time required to produce the OFSP powder and low yield obtained and therefore the researcher opted not to use the OFSP in this form.

The second option was to investigate the use of the OFSP as a purée (Figures 3.8 to Figure 3.11). The process of peeling was similar to that of the OFSP powder. The OFSP roots were peeled under running cold water, cut longitudinally and placed in an aluminium pot and just enough cold water was added to almost cover the roots. The OFSP roots were boiled on an electric stove using medium heat until the roots were tender or until a toothpick was inserted

with ease. To prevent oxidation, the lid was kept on during the cooling process. After cooling, the cooked OFSP was blended using a power blender. The water from the cooking process was added to the purée, just enough for it to be blended into a thick paste. Thereafter, the purée was weighed and placed in a Ziploc bag, labelled, inserted in a plastic container and frozen at -18ºC until required. The yield of the OFSP roots for the purée was significantly more per gram compared to the OFSP powder. The results showed that the purée consisted of 346µg/100g of vitamin A.

Figure 3.8: Preparation of OFSP root

Figure 3.9: OFSP roots in a pot

Figure 3.10: Freshly made OFSP purée

Figure 3.11: OFSP puree frozen for 12 days

Figure 3.3 presented in this chapter was followed in the production process of the OFSP yoghurt, and it was produced in a well-ventilated food preparation laboratory using a yoghurt making machine (Figure 3.12). Pasteurised ultra-high temperature (UHT) full cream milk was purchased from a local supermarket. The milk was heat treated at 80ºC for 30 minutes in a yoghurt maker (Figure 3.12). As suggested by Muresan *et al.* (2020: 3) and Yildiz (2010: 9), this process is necessary to destroy pathogenic microorganisms, and to improve the environment favouring the development of lactic acid bacteria and the consistency of the

yoghurt. The milk was then cooled to 43ºC. Whey powder was added to increase the SNF content to enhance the gel strength and consistency of the OFSP yoghurt, as recommended by Chandan and O'Rell (2013: 223) and Yildiz (2010: 8). Tapioca was added to reduce syneresis during incubation and to improve the viscosity (Weerathilake *et al*. 2014: 4; O'Rell 2013: 223). The yoghurt base was inoculated with thermophilic starter culture (YOMIX 215) at 43ºC, consisting of a combination of *streptococcus thermophilus*, *lactobacillus delbrueckii subsp. Lactis, lactobacillus acidophilus and Bifidobacterium lactis*. Yildiz (2010: 8) recommends using *streptococcus thermophiles and lactobacillus delbrueckii subsp* together as they multiply at a faster rate. The yoghurt base was fermented in a hot water bath at 45ºC until a pH of 4.5 was reached. The yoghurt was thereafter cooled, and flavoured with the OFSP purée. Pasteurised liquid sugar was added to increase sweetness slightly; and natamycin was added to prevent against growth of yeast and mould (Alkaya and Karalomlu 2016: 2), and the yoghurt was thereafter packaged into food grade plastic tubs with lids, and refrigerated at 4ºC.

Figure 3.12: OFSP yoghurt maker

3.3.1 Quality control during OFSP yoghurt production

According to the United States Food and Drug Administration (USDA) (USDA 2017 para 1 line 1), the Hazard Analysis and Critical Control Point (HACCP) is a management system that addresses food safety through the analysis and control of hazards (biological, chemical or physical) from raw material production to consumption of the finished product. Figure 3.13 shows the HACCP flow chart developed for the production of the OFSP yoghurt. Potential hazards were classified as biological (microbial) and physical and Critical Control Points (CCP) and Control Points (CP) were identified. A CP is a step where a hazard can be controlled and a CCP is a step at which a control measure is applied; it is crucial to prevent or eliminate a safety hazard or reduce it to acceptable levels (Muresan *et al*. 2020: 14).

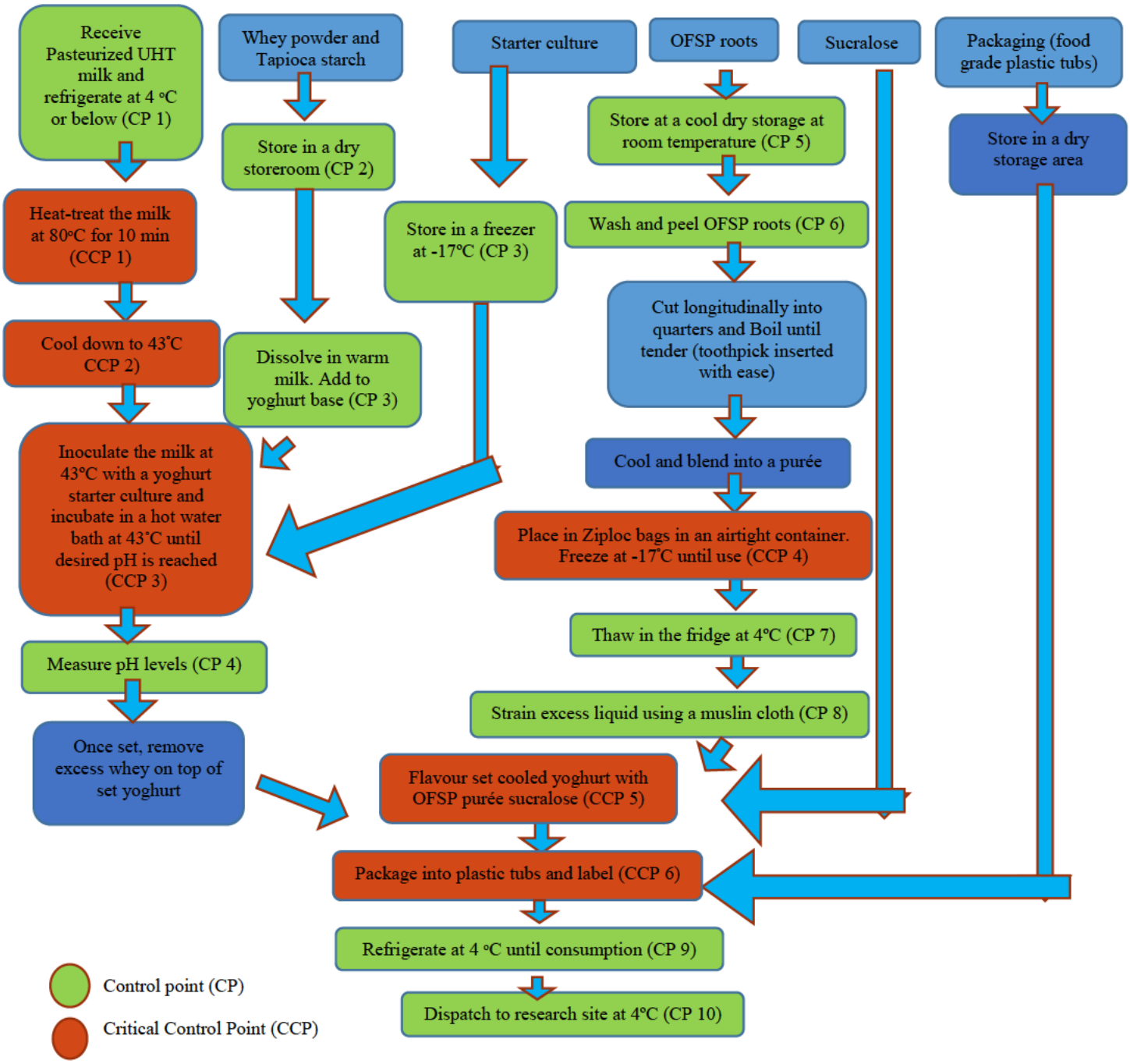

Figure 3.13: HACCP flow chart for OFSP yoghurt

Successful development and implementation of a HACCP programme requires prerequisite programmes (PRPs), such as good manufacturing practices (GMPs) and good hygiene practices (GHPs). Prerequisite programmes outline basic environmental and operating conditions that are essential for producing safe food. These include constructing and designing facilities that allow production flow that minimises cross contamination from raw to cooked food, written

specifications for all ingredients and packaging supplies, quality assurance procedures, standard operating procedures for sanitation, receiving and storage of ingredients. Furthermore, it is crucial to have written and implemented cleaning and sanitation procedures for equipment, and employees or food handlers should be trained on cleaning and sanitation procedures, including personal hygiene (USDA 2017: para. 4 line 2).

The OFSP yoghurt was produced in a well-ventilated food preparation laboratory. To reduce chances of contamination during the production of the OFSP yoghurt, a cleaning checklist (refer to Appendix E) was used by the researcher to ensure that good hygiene standards were always maintained. The laboratory was pest-free, and no other food preparation took place during the yoghurt production sessions. The good hygiene practices (GHP) implemented in the production of the OFSP yoghurt included regular disinfection and cleaning of work surfaces, equipment, and utensils (Muresan *et al.* 2020: 7). Personal hygiene such as covering hair and regular handwashing were also monitored. Good manufacturing practices (GMPs) adhered to included the maintenance of the cold chain during food storage (Meng *et al.* 2018: 1334).

The assessment of the likelihood that a hazard would occur was conducted and preventative measures were implemented to minimise the risk of occurrence or prevent the occurrence of hazards. The HACCP plan implemented during the OFSP yoghurt production is presented in Table 3.1.

Table 3.1: HACCP plan for OFSP yoghurt production

Process step	Hazards	Control measures	Control point	Critical limits	Monitoring procedures	Corrective action
Receive pasteurised UHT milk and refrigerate at 4°C	Microbial	Temperature	CP	Temperature 4°C	Check packaging for damages and temperature control	Return damaged cartons to supplier
Heat treat milk	Microbial	Time and Temperature	CCP	Temperature and time	Temperature control	Adjust temperature as required
Cool down to 45°C	Microbial	Temperature	CCP	Temperature <45°C	Temperature control	Adjust temperature
Addition of Stabilisers and whey powder	Microbial Physical	GMP: correct storage of ingredients	CP	Introduction of foreign materials	Check for foreign objects and that packaging is sealed	Correct storage practices
Inoculate milk at 42°C with starter culture and incubate until desired pH is reached	Microbial	Temperature	CCP	Inoculation temperature and incubation temperature	Temperature recorder	Adjust temperature
Measure pH at regular intervals	Microbial Physical	Time and Temperature	CP	Wash pH meter before each temperature check	pH monitoring	Sterilise pH meter
Remove excess whey on top of set yoghurt	Physical	Cleaning	GMP	Introduction of any foreign object	Check hygiene practices	Wash utensils
Storage of OFSP roots at a cool dry storage	Microbial	Temperature	CP	Introduction of foreign materials	Check that OFSP roots are dry	Correct storage practices
Wash and peel OFSP roots Cut longitudinally and boil until tender	Physical Microbial	Cleaning Cleaning	CP GMP	Presence of foreign objects Introduction of foreign materials	Check that OFSP roots are thoroughly washed Check hygiene practices	Correct hygiene procedures Correct hygiene procedures
Cool and blend into a purée. Freeze at -18°C	Physical Microbial	Cleaning Temperature	GMP CCP	Presence of any foreign objects Temperature	Check hygiene practices Temperature control	Correct hygiene practices Adjust temperature
Thaw in fridge at 4°C	Microbial	Temperature	CP	Temperature	Temperature control	Adjust temperature
Strain excess liquid using a muslin cloth	Microbial	Cleaning	CP	Presence of foreign objects	Check hygiene practices	Correct hygiene practices
Flavour yoghurt with OFSP purée and sucralose	Microbial	Cleaning	CCP	Hygiene: utensils and personal hygiene	Check hygiene practices	Correct hygiene practices
Package and label	Microbial	Cleaning and	CCP	Sterilize packaging	Check hygiene practices	Correct hygiene practices
Refrigerate	Microbial	Temperature	CP	Temperature 4°C or below	Temperature control	Adjust temperature
Dispatch to research sites	Microbial	Temperature	CP	4°C or below	Temperature control	Adjust temperature

3.3.2 Sensory evaluation of OFSP yoghurt

To evaluate consumer acceptance, the sensory properties of the yoghurt were evaluated by a trained panel consisting of 11 staff members from the Department of Food and Nutrition Consumer Sciences at the Durban University of Technology (DUT). Stone (2018: 2) indicated that for descriptive sensory evaluation, the optimal number of participants should not be more than 12 and not less than ten as having less than participants would make it difficult to obtain expected significances. A five-point Likert scale which ranged from options of *Dislike extremely* to *Like extremely* was used (refer to Appendix F). Two yoghurt samples (sample one, which had a thicker consistency as it was flavoured with 25g of OFSP purée compared to sample two, which was flavoured with 15g of OFSP purée) were served in tasting cups and were coded using random three-digit numbers. Water was served in a tasting cup to cleanse the palette (Sharif *et al.* 2017: 375). The sensory properties evaluated were the appearance, aroma, taste, and texture. Most of the panel members preferred sample one with most rating the appearance, taste, and texture as *Like extremely*. The aroma was predominantly rated as *Like very much*. When asked to comment on their preferred sample, panel members who preferred sample one mentioned aspects such as the mouthfeel was excellent or the mouthfeel was creamy, the sample was tasty with just the right level of sweetness, and the consistency was good; some stated that the yoghurt was not sweet enough. Some panel members mentioned that sample two was a bit runny, not sweet enough, did not have a better mouthfeel compared to sample one and that the texture was not as smooth (Table 3.2).

Table 3.2: Sensory evaluation results by a trained panel

Category	Sample 1					Sample 2				
	Dislike extremely % (n)	Dislike % (n)	Neither like nor dislike % (n)	Like % (n)	Like extremely % (n)	Dislike extremely % (n)	Dislike % (n)	Neither like nor dislike % (n)	Like % (n)	Like extremely % (n)
Appearance	0	0	36.3 (4)	27.3 (3)	36.3 (4)	0	0	9.1 (1)	72.7 (8)	18.2 (2)
Aroma	0	0	18.2 (2)	72.7 (8)	9.1 (1)	0	0	27.3 (3)	63.6 (7)	9.1 (1)
Taste	9.1 (1)	0	27.3 (3)	36.3 (4)	27.3 (3)	9.1 (1)	18.2 (2)	18.2 (2)	45.4 (5)	9.1 (1)
Texture	0	9.1 (1)	27.3 (3)	18.2 (2)	45.4 (5)	0	9.1 (1)	18.2 (2)	72.7 (8)	0

After sensory evaluation was conducted by the trained panel, a sample of ten children between 24-60 months (four between 24-47 months and six between 48-60 months) were selected from an ECD in a semi-rural area with a similar socio-demographic profile to the research setting. Consent was obtained from parents or caregivers of the children. These ten children were not part of the study population. At the ECD centre, the children were given sample one and two to taste and indicate

which one they preferred. The children were too young to be able to rate appearance, aroma and texture and therefore a simpler scale was used, consisting of a sad face and a smiley face (refer to Appendix G). The children were asked to taste the two samples and indicate the sample they preferred. All the children indicated that they preferred sample one, which was thicker and was flavoured with 25g of OFSP purée than sample two, which was less thick and was flavoured with 15g of OFSP purée (Table 3.3).

Table 3.3: Sensory evaluation results by children

Paired preference	**Sample 1 % (n)**	**Sample 2 % (n)**
Liked the taste	100% (10)	0%
Disliked the taste	0%	100% (10)

3.3.3 Microbial analysis of OFSP yoghurt

Microbiological analysis was conducted at a SANAS accredited laboratory using two samples of the OFSP yoghurt. Method no. MM 02 (Violet Red Bile Lactose (VRBL) agar at 37 ºC for 1 day – South African Bureau of Standards (SABS) International Organization for Standardization (ISO) 4832:1991) was used to analyse the coliform count, and the yeast and mould count was analysed using method no. MM 03 (Chloramphenicol agar at 25 ºC for 4 days – SABS ISO 7954:1987). The results showed that the freshly produced sample had <10 CFU/g for coliforms, yeast and mould. The sample that had been stored for 15 days (it was anticipated that the yoghurt would not be kept for longer than 15 days after production) had <10 CFU/g for coliforms and yeast, and it consisted of 35 CFU/g for mould.

3.3.4 Proximate composition of OFSP yoghurt

Table 3.4 shows the proximate composition of the two samples analysed. The moisture content was 82.5g per 100g of the freshly produced OFSP yoghurt and fat and protein were 3.2g and 3.8g, respectively.

Table 3.4: Proximate composition of OFSP yoghurt

Test parameter	Method no.	Freshly produced sample	Sample stored for 15 days
Moisture (g/100g)	In-House 105°C-3 hours	82.5	82.4
Total solids (g/100g)	In-House calculation	17.5	17.6
Ash (g/100g)	AM 04	0.8	0.7
Fat (g/100g)	AM 07a	3.2	3.4
Protein (g/100g)	AM 03 Buchi app. Note no 3xx001en	3.8	3.9

g:grams; °C: degrees Celsius

3.4 Conclusion

This chapter reviewed literature on the new yoghurt manufacturing process and the process followed in the production of OFSP yoghurt. The next chapter presents the methodology used in the research study.

CHAPTER 4: METHODOLOGY AND INTERVENTION

4.1 Introduction

The aim of this chapter is to provide a description of the research design, methodology and data analysis employed in the study and describe how the intervention was implemented. Data collection methods used at the baseline and endline are explained.

The purpose of the study was to develop and test the impact of an OFSP yoghurt on the nutritional status of pre-school children in Durban, KZN, SA by determining nutritional status of preschool children, developing the product, implementing it as an intervention and then assessing the nutritional status of the pre-school children to determine the impact of the OFSP yoghurt.

4.2 Research design

4.2.1 Setting

KZN is one of South Africa's nine provinces. Durban is the largest city in the province and falls under the eThekwini Municipality. Botha's Hill is situated in the Valley of a Thousand Hills, west of Durban. It is a small town, approximately 8.5km from Hillcrest. The results of Census 2011 indicated that the population in this small town consists of predominantly black African citizens and the main language spoken in the area is IsiZulu (Statistics SA 2012).

This study was conducted at Ward 103 in Botha's Hill. Botha's Hill was selected as it is one of the semi-rural areas nearest to Durban and the researcher required a location that would make it possible to make daily trips to the research site during data collection and during the intervention.

The map in Figure 4.1 shows the area where the study was conducted.

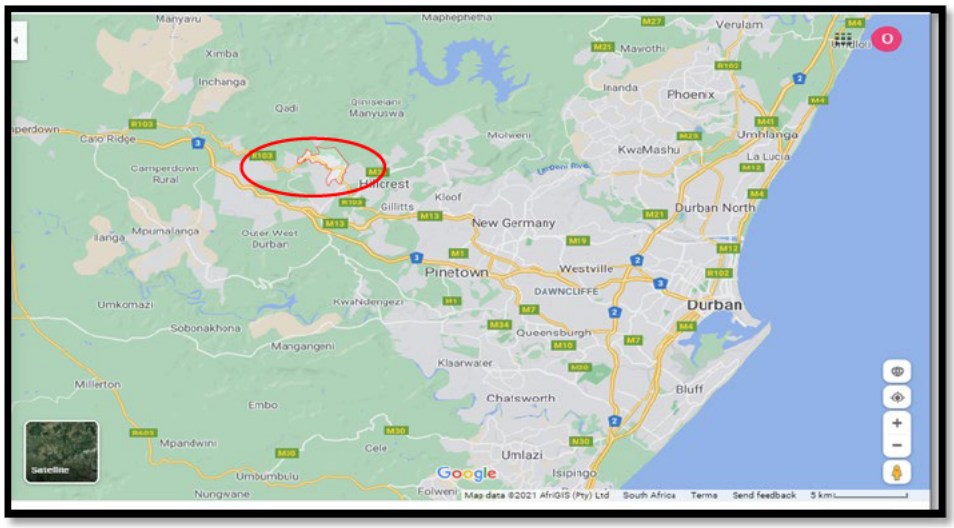

Figure 4.1: Map of Durban (Google Maps)

4.3 Study setting and sample procedures

A sampling frame consisting of registered ECD centres in Botha's Hill was used. Simple random sampling techniques were followed (Joubert and Ehrlich 2007: 96). A list of the ECD centres was drawn and each centre was allocated a number. Random numbers were then drawn to select the ECD centres that would be approached to participate in the study. Two registered ECD centres were randomly selected to participate in the study. From the selected centres, random numbers were selected again, to allocate an EG and a CG. ECD centre A was the EG and ECD centre B was the CG.

Thereafter, a meeting was held with the principals of the selected ECDs to explain the research project and request permission. After obtaining consent from principals of the ECDs, the researcher attended a meeting with the parents/guardians of possible participants to explain the research project. This was to enable all stakeholders to make informed decisions as to whether they wished to participate in the research study.

4.3.1 Sampling

The target number of participants for this project was a total of 100 children. The researcher selected this number due to costs implications and the vulnerability of the study population to VAD. Some intervention studies involving school age children consisted of approximately 100 participants. Iraheta (2021: para. 1 line 7) conducted an intervention study aimed at assessing the effect of biscuits enriched with a micronutrient formula on the nutritional status using a sample size of 84 school children. Medoua *et al.* (2016: para. 3 line 3) compared the effect of corn-soya

blend porridge with ready to use supplement to treat moderate acute malnutrition using a sample size of 81 children 25-59 months of age. Ribaya-Mercado *et al.* (2007) conducted an intervention study aimed at assessing the influence of dietary fat on the effectiveness of carotene-rich plan foods in improving vitamin A status of children using a sample size of 116 children.

The final number of participants was determined by the number of 24-60 month-old children at that ECD centre whose parents/caregivers had given consent. In ECD centre A (selected to be the EG), the total number of children in the required age group was 110. The information letter was given to all the parents/caregivers of the children in that age group. The total number of parents/caregivers who gave consent was 83. Three of the children were absent on the days of blood collection and therefore could not be part of the study. One child refused to participate and did not want her finger to be pricked to collect the blood sample and was therefore also excluded from the study to avoid incomplete data sets. These factors resulted in ECD centre A having a total of 79 participants at baseline.

In ECD centre B (selected to be the CG), the total number of children in the 24-60 months age group was 99. The information letter was also sent to all parents and a similar process was followed as in ECD centre A. The response rate was lower as 43 parents gave consent. On blood collection day, six children were absent and were therefore excluded in the study. The final sample for ECD B was 37. This ECD centre was selected to be the CG. Therefore, the total number of participants in the current study at baseline was 116 children.

Figure 4.2 shows the EG playground.

Figure 4.2: EG ECD centre playground

The image in Figure 4.3 shows the classrooms for children 24-47 months of age in the EG group.

Figure 4.3: EG classroom for children 24-47 months of age

Figure 4.4 shows the classrooms for children 48-60 months of age in the EG group.

Figure 4.4: EG classroom for children 48-60 months of age

Figure 4.5 shows the EG kitchen.

Figure 4.5: EG kitchen

4.4 Ethical considerations

Ethical clearance for this study was obtained from the IREC at DUT (IREC 019/13; refer to Appendix H). The basic ethics code of behaviour was adhered to, as outlined by the South African Medical Research Council (SAMRC) (SAMRC 2017). Participation was on a voluntary basis. No one was coerced into being part of the study. Informed consent was obtained from the principals of the ECDs (refer to Appendix I) and parents/guardians of the children. An information letter was provided to all guardians/parents of the children and the research study was explained in English (Appendix J) or IsiZulu (Appendix K). According to Strode *et al.* (2010: 247) children under the age of 18 years are legal minors and have limited legal capacity to act independently without the assistance of an adult and for health research, there is currently no clear legal statue specifying when children can independently consent to research, but researchers are guided by ethical norms. In addition to parental consent, older adolescents are allowed to give consent to low-risk research. The children in the current study were too young to give consent and to comply with ethical guiding principles. As detailed in the information letter, a child could withdraw at any stage during the research process if they wished to do so. All information obtained during the data collection process was kept confidential. The names of the children were not used but they were instead

allocated numbers. The human rights of the children were respected at all times and they were not exposed to any form of danger by the research team.

4.5 Methodology

The study was conducted over a six-year period (Figure 4.6). Proposal writing commenced in November 2012 and the OFSP development work started in January 2014 and was finalised in November 2016. Challenges were encountered regarding securing a specialist who could assess serum retinol using dried blood spot and that resulted in the data collection commencing in May and June 2017. The intervention took place from 24 July to 24 October 2017. The length of the intervention was selected as other studies showed an improvement in a similar time frame. A study by Van Jaarsveld *et al*. 2005: 1081) showed an improvement in vitamin A levels of children after consuming boiled mashed OFSP for 53 days and a positive effect on vitamin A levels was reported by Haskell *et al*. (2004: 705) after 60 days of supplementing the diet of the participants with sweet potatoes. Furthermore, Jamil *et al*. (2010: 1896) conducted a study where women of reproductive age consumed boiled OFSP for six days a week for 60 days.

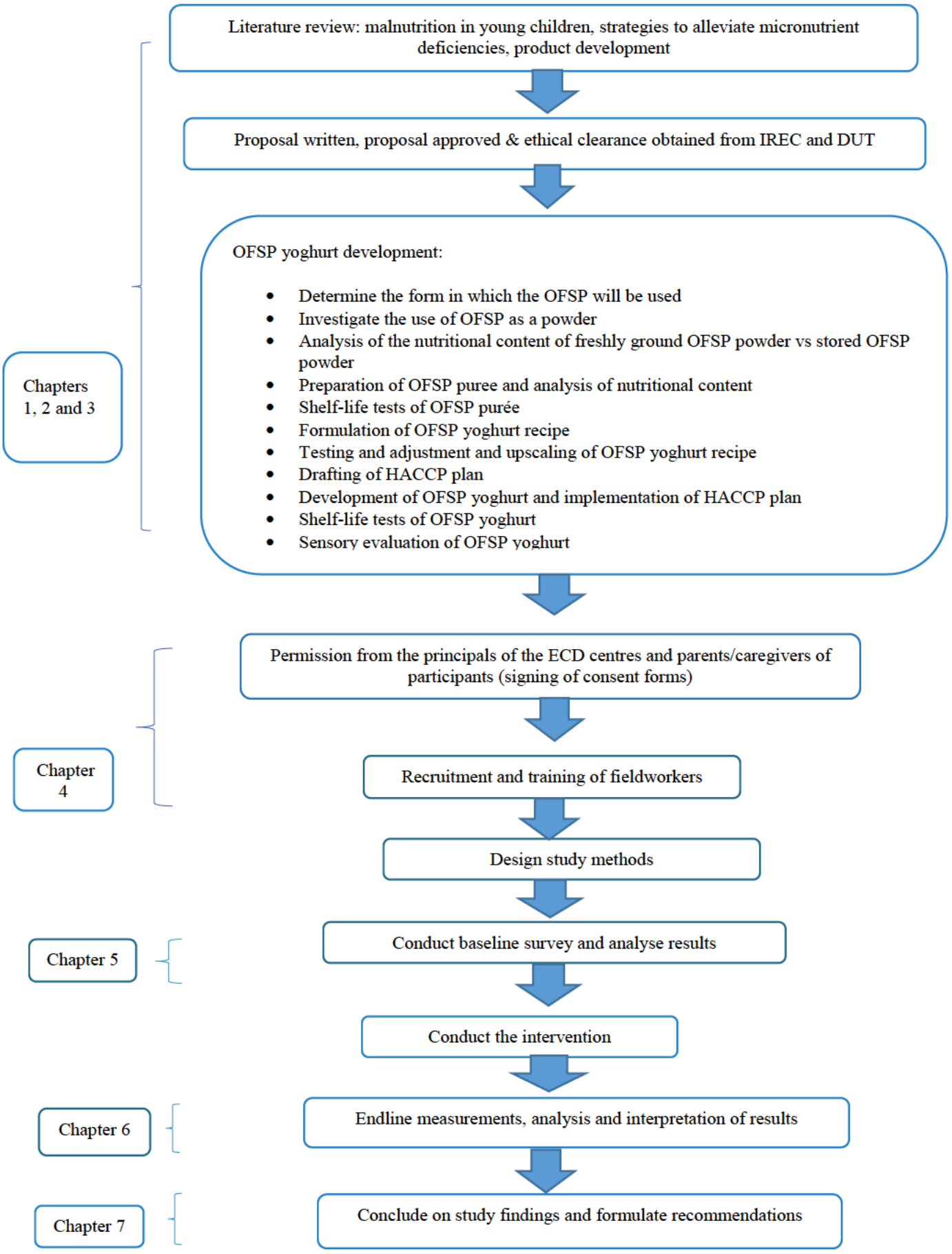

Figure 4.6: The empirical study design

4.5.1 Inclusion and exclusion criteria

The inclusion criteria for the study participants were as follows:

- Only children between 24-60 months of age, attending the selected ECD centres.
- The study population consisted of only the children whose parents/guardians had given consent to participate in the study.
- Both boys and girls were included in the study.

The exclusion criteria were as follows:

- Children younger than 24 months of age and older than 60 months of age.
- Children who were lactose intolerant, or who had any allergies to dairy products. Parents or guardians were requested to provide this information at the consent stage.
- Children who would develop an adverse reaction to the yohgurt during the intervention.
- Children from other ECD centres, other than the two selected for the EG and the CG.

4.6 Fieldworker training

Ten third year Food and Nutrition Consumer Science students were recruited and trained by the researcher to assist with data collection. The two fieldworker training sessions were conducted in March 2017 (refer to Appendix L). These training sessions (3 hours per session) covered the following areas:

- Basic ethical principles in research.
- Procedures for taking anthropometric measurements and how to record measurements on the anthropometric measurements form.
- Procedures for completing all questionnaires used in the study.

The fieldworkers were also required to participate in a practical simulation where they weighed, measured and interviewed one another using the questionnaires. The researcher observed the manner in which these activities were conducted and provided the necessary guidance.

4.7 Study design and administration of measuring instruments

The study design was a quasi-randomised control trial in nature. For the baseline and endline, trained fieldworkers completed all questionnaires in an interview situation with the parent/caregiver of the child, as the children who participated in the current study were too young to independently answer the questions. After the completion of the questionnaires, the researcher checked that each questionnaire was fully completed, to avoid missing data sets. When questionnaires were not fully completed, a follow-up was made with the relevant participants to complete the missing information. All 116 participants (EG: n=79 and CG n=37) completed all three questionnaires at baseline. The questionnaires used are described next.

4.7.1 Socio-demographic questionnaire

All questionnaires were administered by trained fieldworkers via one-on-one interviews with the guardian or parent of the child. Each interview took approximately 30 minutes. A socio-demographic questionnaire designed by Napier (2006) was used to determine the socio-demographic profile of the households prior to the intervention, to give an indication of the income, food expenditure, and access to electrical appliances. Permission was granted by Napier and the questionnaire was adapted for use in the current study. A few challenges were encountered by fieldworkers when administering this questionnaire as some participants felt the questions regarding their household finances were a private matter. Some participants did not disclose the household income, while others indicated that they did not know how much the household income was. This questionnaire was completed with the parent/guardian of the child at the ECD centres. This questionnaire was used only in the baseline and not repeated at the endline, as no drastic changes in the household profile were anticipated after the three-month intervention period. The socio-demographic questionnaire data was used to determine the multi-dimensional poverty index (MPI) score of the households (United Nations Development Programme and Oxford Poverty and Human Development Initiative 2019).

4.7.2 Multi-dimensional Poverty Index

In the current study, the global multi-dimensional poverty index was used (United Nations Development Programme and Oxford Poverty and Human Development Initiative 2019) instead of the South African MPI (SA MPI). The global MPI and the SA MPI differ regarding the standard of living measure. The decision regarding which MPI to use was based on the desire to compare

data with international standards, and the socio-demographic questionnaire used in the study did not differentiate between lighting, cooking and heating fuel, as required in the SA MPI (Statistics SA 2014: 6).

The MPI score was calculated to assess the level of acute multi-dimensional poverty of households of the participants. As described by Alkire and Santos (2010: 7), the MPI score is assessed using three dimensions of poverty, namely, health, education and standard of living. Each dimension of poverty consists of ten indicators, as shown in Figure 4.7. Each indicator under health and education is weighted equally at 1/6 and each indicator under standard of living is weighted equally at 1/18. Under the dimension of health, the child mortality indicator is assessed using information pertaining to any child death in the family. The second indicator, nutrition, looked at whether any child or adult is malnourished in the family. In the second dimension entitled education, the household would be considered deprived under the indicator on years of schooling if no household member had completed five years of schooling and if any school-aged child was out of school in years one to eight. Lastly, with regard to the standard of living, a household was classified as deprived if it did not have electricity; if the household members have to walk more than 30 minutes to get water; if it did not have a flush toilet; if the floor was dirt, sand or dung, and if wood, charcoal or dung was used as cooking fuel. Regarding assets, if the household did not own more than one of the following assets namely; a radio, a television, a cell phone, a motorbike, a refrigerator or if they did not own a car, they were considered deprived. It is important to note that deprivation in one indicator does not represent poverty and therefore the household was identified as multi-dimensionally poor if it was deprived in a combination of indicators (Alkire and Santos 2010: 7).

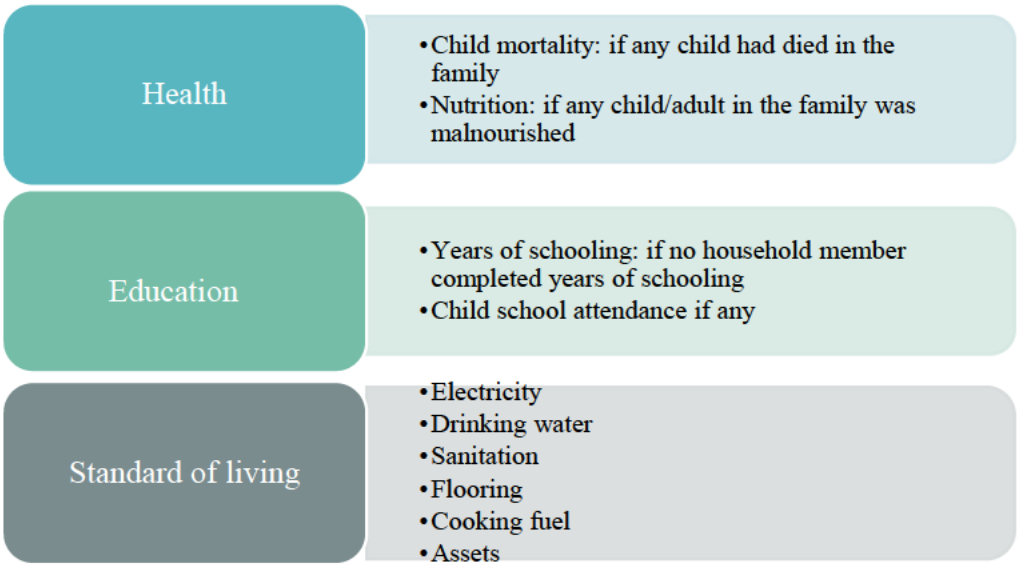

Figure 4.7: Dimensions and indicators of MPI (Alkire and Santos 2010)

4.7.3 24-hour recall questionnaire

The 24-hour recall questionnaires were administered by the trained fieldworkers via one-on-one interviews with the parent or caregiver of the child participant. This questionnaire was repeated three times, one two weekdays and on one week-end day. For the week days, the parents/caregivers were asked to provide details on what the child ate while at home and the information regarding what they children ate while at creche was obtained at the ECD centres. Twenty-four-hour recall questionnaires measure the actual intake of the participants and detailed information regarding the food consumed and cooking method can be obtained as the questions are open-ended. This questionnaire relies on the memory of the participant and recall bias may be present. Moreover, the 24-hour recall questionnaire needs to be repeated on different days to adequately represent the habitual intake due to day to day variations (FAO 2018: 21).

The 24-hour recall dietary data was captured and analysed using the Food Finder® computer software (version 3.0) developed by the SAMRC (SAMRC 2002). The data was used to indicate actual nutrient intake and was presented in means and standard deviation in figures and tables. Nutrient adequacy ratios (NAR) were also calculated using data from this questionnaire. The NAR was calculated for energy and selected nutrients as the ratio of daily individual intake to the standard recommended amounts for the participant's gender and age category (Steyn *et al*. 2007: 644). Furthermore, the top 20 foods consumed were established from this data. The nutrient intake was compared to the EAR for the age and gender group of participants (Table 2.1 in Chapter 2).

4.7.4 Food frequency questionnaire

The food frequency questionnaires (FFQ) (Oldewage-Theron and Kruger 2008) were administered by the trained fieldworkers via one on one interviews with the parent or caregiver of the child participant. The FFQ was used to assess the food intake of the participants to determine the Food Group Diversity Score (FGDS) and Food Variety Score (FVS). FFQs are easy to administer to large sample sizes, have a low respondent burden and can be used to capture a range of foods. The disadvantages include the fact that the list of foods cannot cover all foods consumed by the participant, which may lead to underreporting and the FFQ also does not give precise information about portion size of food consumed (FAO 2018: 14). Food frequency data was captured on a Microsoft Excel spreadsheet and analysed for descriptive statistics using the SPSS version 24 computer software programme (IBM 2021) and presented in means and standard deviation in

figures and tables. The FGDS and FVS were calculated over a seven-day period and grouped according to recommendations as shown in Table 4.1 (Matla 2008).

Table 4.1: FGDS and FVS categories (Matla 2008)

Score	Food groups	Food variety
Low	0-3 food groups	Less than 30 individual foods
Medium	4-5 food groups	30-60 individual foods
High	6-9 food groups	More than 60 individual foods

4.7.5 Anthropometric measurements

Weight and height measurements were taken by trained fieldworkers once at baseline and once at endline. An electric SECA scale (model 874, Hamburg, Germany) was used. The scale was placed on a flat surface and the fieldworker ensured 0.0 was displayed on the scale before weighing each child. The child being weighed was assisted to remove their shoes and heavy jackets. The child was instructed to stand still in the middle of the scale, with feet slightly apart. Each child was weighed twice (and the average was calculated by adding the two measurements then divide by two) to ensure accuracy of measurements taken (WHO and UNICEF 2019: 40). The weight was recorded to the nearest 0.1kg. A SECA stadiometer (model 213, Hamburg, Germany) was used to measure the height of the participants. The child whose height was being measured was assisted to take their shoes off and instructed to stand on the baseboard with their feet slightly apart. The fieldworker ensured the child's head was not tilted upwards and that the child stood still and the sliding panel was moved onto the head. The height measurement was taken twice, an average was calculated (by adding the two measurements taken then dividing by two) and recorded to the nearest 0.1cm (WHO and UNICEF 2019: 41).

Weight and height measurements were captured and analysed through the WHO Anthro® software version 3.2.2 and were used to indicate wasting, stunting, underweight, and overweight and obesity among the children (WHO 2008: 14). Table 4.2 lists the z-score categories used for each growth indicator (WHO 2008: 14).

Table 4.2: The cut-off points used in the interpretation of anthropometric results (WHO 2008: 14)

Z-score	Growth indicator		
	Height for age (To determine stunting)	**Weight for height (To determine wasting)**	**Weight for age (To determine underweight)**
>+3SD	Very tall, rarely an issue	Obese	
>+2SD to <+3SD	Normal height for age	Overweight	
>+1 SD to<+2 SD	Normal height for age	Possible risk of overweight	
<0 to <+1SD	Normal height for age	Normal weight for height	
<-1 SD to >-2 SD	Normal height for age	Normal weight for height	
<-2SD to >-3SD	Stunted	Wasted	Underweight
<-3SD	Severely stunted	Severely wasted	Severely underweight

SD: standard deviation

4.7.6 Blood collection and analysis for vitamin A and iron

The blood samples were not collected using venipuncture as that would be invasive for children. Using the finger-prick method, blood samples were collected by a phlebotomist and dried blood spots (DBS) were used to determine biochemical indicators of vitamin A and Hb levels of the participants. The participants washed their hands and rubbed them together to generate warmth to promote blood circulation. A pea-sized amount of a topical anaesthetic cream was applied to the fingertip 20 minutes before pricking. The fingertip was thereafter pricked with a sterile retractable lancet and blood drops were allowed to fall freely inside the pre-printed circles on labelled DBS cards. The DBS cards were then placed in drying racks and left to dry at room temperature. All safety protocols for blood collection were observed (WHO 2005: 3). After drying, the DBS cards were placed inside sealable airtight plastic bags from the DBS collection kit, and a desiccant sachet was placed inside the cooler boxes to keep samples dry and transported to the laboratory in a temperature-controlled environment with dry ice inside the cooler box and regular temperature monitoring (WHO 2005: 7). The samples were thereafter stored at -70ºC until analysis (Craft *et al*. 2000: 883).

DBS were used as they are less invasive than blood collection by venipuncture. DBS can be used in remote populations where access to facilities is limited. Advantages of DBS include accessibility to younger participants and remote populations, easier collection, transportation and storage of samples (Craft *et al.* 2000: 882). A disadvantage of DBS is that it has lower analytical sensitivity (Tuaillon *et al.* 2020: 2). The blood analyses were conducted in a SANAS accredited laboratory.

Biochemical indicators of vitamin A were assessed using HPLC and vitamin A levels <0.70 µmol/L indicated vitamin A deficiency (Craft 2001: 1627S; National Institutes of Health 2019c: 1). Haemoglobin levels were measured using a Hb meter and compared to prescribed cut-offs (<11.0 g/dL) for iron deficiency for the 24-60 month age group (WHO 2011: 3).

4.8 Delivery of the OFSP yoghurt and store-bought yoghurt to research sites

The yoghurt was delivered by the researcher every Monday and Wednesday for the duration of the intervention. The yoghurt was transported in big cooler boxes with ice packs to ensure that the cold chain was maintained. Upon arrival at the ECD centres, the yoghurt was kept in the refrigerator until consumption. Deliveries were made every Monday and every Wednesday. Children who were absent from the ECD centre did not eat the yoghurt on the days they were absent. The delivery schedule was adhered to and no days were missed so there was yoghurt available at the ECD centres every weekday throughout the intervention period. There was no interruption to the intervention.

4.9 Administration of the developed OFSP yoghurt and the commercially bought yoghurt

The intervention commenced on the 24th of July 2017 for both groups and ended on the 24th of October 2017. The 24th of July 2017 was the day the ECDs re-opened after the June holidays. This was a three-month intervention. The children were given the yoghurt (100g) during the 10:00 mid-morning snack time daily, before the children consumed any snack they may have brought from home. The ECD teachers called out the names of the children, gave them the yoghurt and supervised the children while eating the yoghurt. The ECD teachers fed the younger children. In both groups, the children seemed to like the taste of the yoghurt and finished their portions with no difficulty. The children who ate more slowly were encouraged by the teachers to finish and seemed happy with the compliments they received upon finishing the yoghurt. Furthermore, the yoghurt was eaten before play time and seeing their peers already in the playground encouraged the children eating more slowly to finish as they were eager to go play.

The interventions started with only one week left in July 2017 and there was a higher level of absenteeism in the EG than in the CG. In the EG, 50.0% (n=35) of the participants were absent for the entire five week days and therefore did not eat the yoghurt, and 10.0% (n=7) were absent once during the first week of the intervention. Less than half of participants (40.0%; n=28) ate the yoghurt for the entire five days as they were present at the ECD on all days. Out of the 37

participants in the CG, 16.2% (n=6) of the participants were absent for the entire five week days and therefore did not eat the yoghurt and 13.5% (n=5) were absent once during the first week of the intervention. Less than half of the participants (45.9%; n=17) ate the yoghurt for the entire five days as they were present at the ECD on all days. The attendance improved in the first week of August 2017 as 84.2% (n=59) and 81.0% (n=30) of participants ate the yoghurt on all five days of the week in the EG and CG, respectively. In the EG, 2.8% (n=2) of the participants did not eat the yoghurt at all due to absenteeism all week. The attendance thereafter became more regular for participants in both groups. In the last week of October 2017, some participants left the ECD centre, as indicated in Figure 7.1 in Chapter 7.

4.10 Compliance

To ensure compliance, all children that participated in the study were given yoghurt daily and there was enough to cater for all participants. The teachers supervised the children, to ensure that each child consumed his or her portion. There was no wastage of yoghurt in both groups.

4.11 Challenges encountered during the intervention

Absenteeism was a challenge, particularly at the beginning of the intervention. The second challenge encountered were the delays from the team of experts that had to travel from outside of the KZN province to take blood samples for analysis. This led to the endline tests being delayed and eventually taking place at the beginning of November 2017. This resulted in loss of some participants as some were no longer attending the ECD centres from November onwards. Attempts to follow-up were futile. It was mentioned by the principal of the ECD centre that it was the norm for some parents not to send their children to the ECD centre in November and December to avoid paying fees for those two months.

4.12 Conclusion

This chapter presented an outline of methods used for data collection and data analysis methods used at baseline and endline. The intervention was implemented on schedule and commenced timeously as per plan; however, there was a delay in collecting data for endline, as explained under section 4.11. In the next chapter, the baseline results are presented and discussed.

CHAPTER 5: BASELINE RESULTS

5.1 Introduction

The purpose of this study was to develop and test the impact of an OFSP yoghurt on the nutritional status of pre-school children in Durban, KZN, SA. A baseline survey was conducted to establish the socio-demographic profile of the households, assess the nutritional status and determine the food intake of the child participants. An intervention was implemented from 24 July 2017 to 24 October 2017 and thereafter, impact was assessed at endline.

The aim of this chapter is to present and discuss the results obtained from the baseline survey.[2] These will include the socio-demographic profile of households, anthropometric results, dietary intake results and blood results. The methodology for the baseline survey was reported in Chapter four. Because the child participants were too young to answer the questionnaires, all questionnaires were therefore answered by a parent or caregiver of the child. The gender of participants shown in Table 5.1 is that of the person who answered the questionnaires on behalf of the child participant. Furthermore, the total of all *Yes* or *No* questions adds to 100 percent; therefore, when reporting on responses to such questions, only the affirmative responses are reflected, unless there was something of great significance in the negative response.

5.2 Socio-demographic results

5.2.1 Family composition and accommodation

Table 5.1 shows that for both groups, most of the participants who answered the questionnaires on behalf of the child, were women (86.1%; n=68 in the EG and 81.1%; n=30 in the CG). Over half of the participants (62%; n= 49 in the EG and 62.2%; n= 23 in the CG) were mothers of the child. In the EG, 16.5% (n=13) of participants were grandmothers compared to 8.1% (n=3) in the CG.

With reference to the children, the majority of the participants in the EG (55.7%; n=44) were 24-47 months of age, whereas the majority in the CG (62.2%; n=23) were 48-60 months of age. Out

[2] Publication based on this chapter:
Makanjana, O. and Naicker, A. Nutritional Status of Children 24–60 Months Attending Early Child Development Centres in a Semi-Rural Community in South Africa. Int. J. Environ. Res. Public Health 2021, 18, 261. https://doi.org/10.3390/ijerph 18010261

of the 79 participants in the EG, 49.4% (n=39) were girls, whereas out of the 37 participants in the CG, 51.4% (n=19) were girls.

Table 5.1: Profile of adult and child participants

Gender of the adults who answered the questionnaires	**EG (n=79) % (n)**	**CG (n=37) % (n)**
Men	13.9 (11)	18.9 (7)
Women	86.1 (68)	81.1 (30)
Relationship of the adult participant to the child participant	**EG (n=79) % (n)**	**CG (n=37) % (n)**
Mother	62 (49)	62.2 (23)
Grandmother	16.5 (13)	8.1 (3)
Father	10.1 (8)	8.1 (3)
Grandfather	1.3 (1)	2.7 (1)
Brother	0.0 (0)	8.1 (3)
Sister	3.8 (3)	10.8 (4)
Aunt	5.1 (4)	0.0 (0)
Uncle	1.3 (1)	0.0 (0)
Age of the child participants	**EG (n=79) % (n)**	**CG (n=37) % (n)**
24-47 months	55.7 (44)	37.8 (14)
48-60 months	44.3 (35)	62.2 (23)
Gender of the child participants	**EG (n=79) % (n)**	**CG (n=37) % (n)**
Girls	49.4 (39)	51.4 (19)
Boys	50.6 (40)	48.6 (18)

As indicated in Table 5.2, the majority of participants in both groups lived in a rural village (94.9%; n=75 in EG and 97.3%; n=36 in the CG) and there was a gravel road outside the yard of most participants in both groups (57.0%; n=45 in the EG and 62.2%; n=23 in the CG). A similar percentage of houses in both groups (91.1%; n=72 in EG and 91.9%; n=34 in CG) were made with bricks, whereas 7.6% (n=6) and 5.4% (n=2) were made with clay in EG and CG, respectively. Most of the houses in both groups had more than four rooms (60.8%; n=48 in the EG and 51.4%; n=19 in the CG). In the EG, 20.3% (n=16) of houses had three to four rooms, while in the CG, there were 32.4% (n=12). Some households had houses with one to two rooms (19%; n=15 in the EG and 16.2%; n=6 in the CG). Table 5.2 also shows that 44.3% (n=35) and 43.2% (n=16) of households in the EG and CG, respectively, had one to four members. The percentage of households with more than ten members was 6.3% (n=5) in the EG and 10.8% (n=4) in the CG. More households in the EG group (21.5%; n=17) reported cases of child deaths in the previous year than the CG (10.8%; n=4).

Table 5.2: Residential demographic characteristics

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Type of residential area		
Rural village	94.9 (75)	97.3 (36)
Township	5.1 (4)	2.7 (1)
Other people live in the house		
Yes	100 (79)	97.3 (36)
All household members permanent residence in the household		
Yes	97.5 (77)	94.6 (35)
Other houses/shacks in the same yard		
Yes	63.3 (50)	70.3 (26)
Type of road outside the yard		
Tar road	43.0 (34)	37.8 (14)
Gravel	57.0 (45)	62.2 (23)
Size of dwelling		
More than four rooms	60.8 (48)	51.4 (19)
Three to four rooms	20.3 (16)	32.4% (12)
One to two rooms	19.0 (15)	16.2 (6)
Type of dwelling		
Grass	1.3 (1)	2.7 (1)
Clay	7.6 (6)	5.4 (2)
Brick	91.1 (72)	91.9 (34)
Number of people who live in the household		
One to four	44.3 (35)	43.2 (16)
Five to seven	34.2 (27)	32.4 (12)
Eight to ten	15.2 (12)	13.5 (5)
More than ten	6.3 (5)	10.8 (4)
All members eat and sleep in the house at least four days per week		
Yes	98.7 (78)	97.3 (36)
Household living arrangements		
Living with relatives	21.5 (17)	21.6 (8)
Renting a house/flat	5.1 (4)	5.4 (2)
Living in own house/flat	73.4 (58)	73.0 (27)
Length of residency in the current dwelling		
Less than one year	1.3 (1)	2.7 (1)
One to five years	17.7 (14)	27.0 (10)
More than five years	81.0 (64)	70.3 (26)
Child deaths in the household		
Yes	21.5 (17)	10.8 (4)

Table 5.3 shows that in the EG, 98.7% (n=78) of households had adult women occupants and 79.7% (n=63) had adult men occupants. In the CG, all households had adult women and 81.1% (n=30) had adult men. The percentage of households headed by the mother was the same as those headed by the father in the EG (36.7%; n=29). In the CG, the percentage of households headed by the father was 37.8% (n=14) and 27.0% (n=10) were headed by the mother.

Table 5.3: Presence of adult men and women in the household and head of the household

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Presence of adult men and women in the household		
Males	79.7 (63)	81.1 (30)
Females	98.7 (78)	100 (37)
Head of the household		
Father	36.7 (29)	37.8 (14)
Mother	36.7 (29)	27 (10)
Grandmother	17.7 (14)	18.9 (7)
Grandfather	2.5 (2)	16.2 (6)
Aunt	2.5 (2)	0.0 (0)
Mother and father	2.5 (2)	0.0 (0)
Great grandmother	1.3(1)	0.0 (0)

Figure 5.1 shows that 60.8% (n=48) of households in the EG and 40.5%; (n=15) in the CG had tiles on the floors. Nineteen point zero percent (n=15) of households in the EG and 43.2% (n=16) in the CG had cement floors.

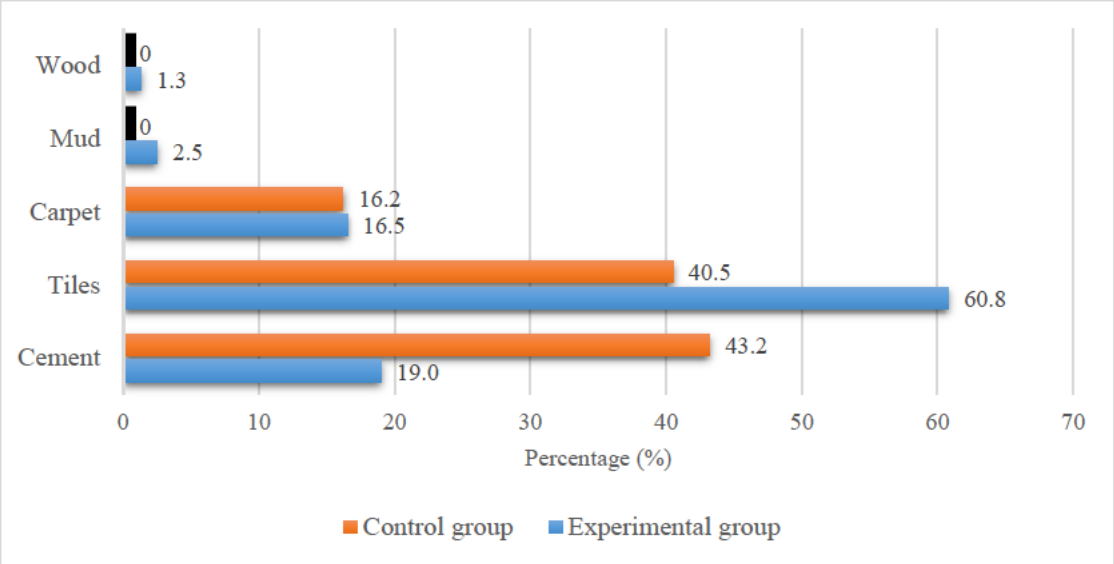

Figure 5.1: Type of floor inside the dwelling (EG=79; CG=37)

In the EG, 40.5%, n=32 of households and 13.5% (n=5) of households in the CG had mice/rats. The most common pests in both groups were mosquitos (65.8%; n=52 in the EG and 64.9%; n=24 in the CG), followed by ants (39.2%; n=31 in the EG and 43.2%; n= 16 in the CG), and cockroaches (43%; n=34 in the EG and 35.1%; n=13 in the CG) (Figure 5.2).

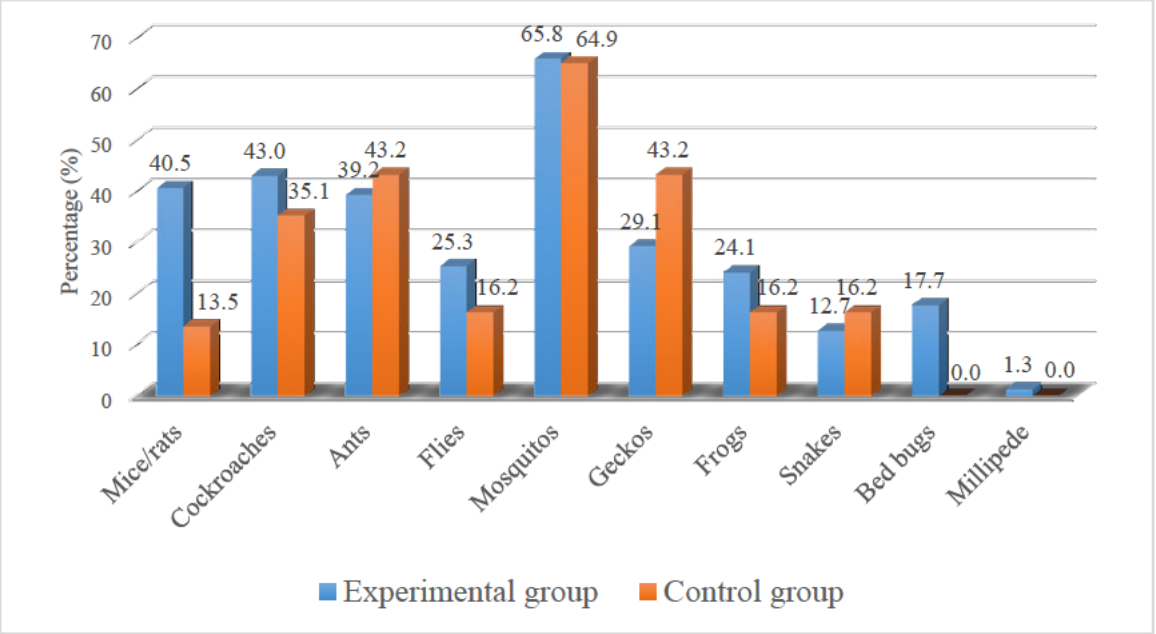

Figure 5.2: Presence of household pests (EG=79; CG=37)

Table 5.4 indicates that 6.3% (n=5) of households in the EG and 10.8% (n=4) of households in the CG reported that the house was too small. Furthermore, 13.9% (n=11) and 8.1% (n=6) of participants in the EG and CG, respectively stated that the roof of the house leaked when it rains.

Table 5.4: Issues with the current state of the house

Variables	EG % (n)	CG % (n)
Problems with the state of the house		
House too small	6.3 (5)	10.8 (4)
Roof leaks when it rains	13.9 (11)	8.1 (6)
Floor becomes damp when it rains	1.3 (1)	2.7 (1)
Roof unstable when windy	0.0 (0)	2.7 (1)

Figure 5.3 shows that 54.4% (n=43) and 67.6% (n=25) of households had a tap outside the house (inside the yard) in the EG and CG, respectively. Some households in the EG (45.6%; n=36) and CG (32.4%; n=12) had a tap inside the house. The percentage of households that had a flush/sewage toilet was 39.2% (n=31) in the EG and 40.5% (n=15) in the CG. More households in the EG had waste removal services (75.9%; n=60) compared to the CG (48.6%; n=18).

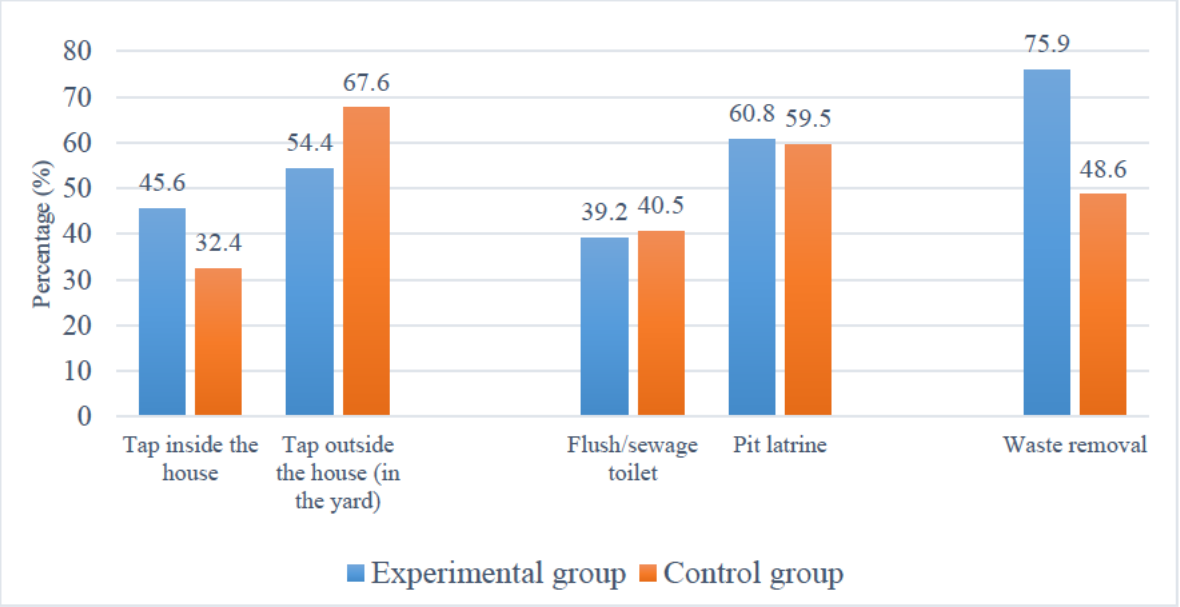

Figure 5.3: Household access to sanitation facilities (EG=79; CG=37)

Table 5.5 shows that the majority of the participants (73.4%; n=58 in the EG and 78.4%; n=29 in the CG) indicated that all children in the household had birth certificates. Over half (59.5%; n=47) of the participants in the EG and 59.4% (n=22) in the CG indicated that all children in the household had completed immunisations.

Table 5.5: Children with birth certificates and children who completed immunisation

Variables	**EG (n=79) % (n)**	**CG (n=37) % (n)**
Number of children who had birth certificates		
All	73.4 (58)	78.4 (29)
None	1.3 (1)	0.0 (0)
Number of children who completed immunisation		
All	59.5 (47)	59.4 (22)

As listed in Table 5.6, the majority of participants from both groups used taxis for transport (87.3%; n=69 in the EG and 78.4%; n=29 in the CG). Table 5.6 also shows that 34.2% (n=27) of children in the EG and 37.8% (n=14) in the CG walked to the ECD centre. The percentage of children who used arranged transport to get to the ECD centre was 43% (n=34) in the EG and 54.1% (n=20) in the CG.

Table 5.6: Types of transport used by household members

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Type of transport used		
Taxi	87.3 (69)	78.4 (29)
Bus	6.3 (5)	2.7 (1)
Own vehicle	5.1 (4)	18.9 (7)
Walk	1.3 (1)	0.0 (0)
Transport used by children to go to the ECD centre		
Walk	34.2 (27)	37.8 (14)
Bus	5.1 (4)	5.4 (2)
Taxi	15.2 (12)	2.7 (1)
Arranged transport	43.0 (34)	54.1 (20)
Family car	2.5 (2)	0.0 (0)

5.2.2 Education and language

Almost all participants (98.7%; n=78) in the EG and 100% in the CG mainly spoke IsiZulu at home. A very small percentage (1.3%, n=1) of participants in the EG spoke SeSotho (Table 5.7).

Table 5.7: Main language spoken in the household

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Main language spoken		
IsiZulu	98.7 (78)	100 (37)
SeSotho	1.3 (1)	0.0 (0)

As shown in Figure 5.4, the highest level of education of 46.8% (n=37) of adult participants in the EG and 56.8% (n=21) in the CG was Grade 12. The percentage of adult participants with a college qualification was 21.5% (n=17) in the EG and 21.6% (n=8) in the CG. Furthermore, 5.1% (n=4) and 13.5% (n=5) of adult participants in the EG and CG, respectively, had a qualification from a Technikon or University.

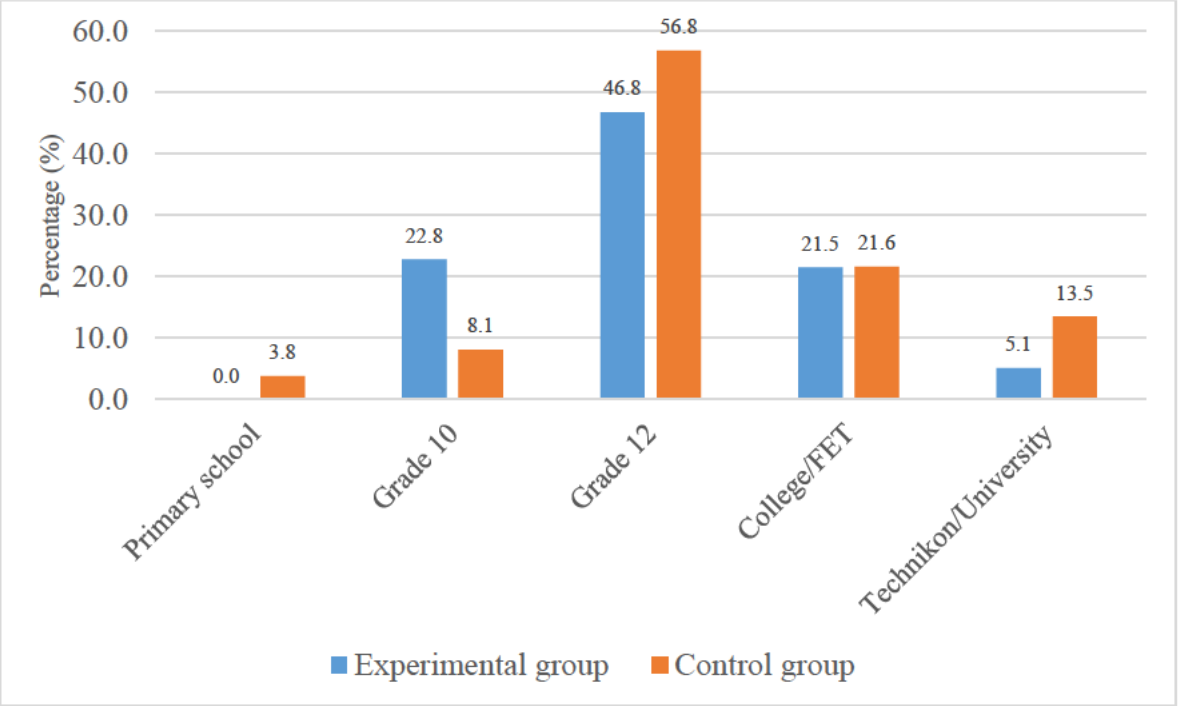

Figure 5.4: Highest level of education in the household (EG=79; CG=37)

5.2.3 Work status and income

Table 5.8 indicates that over half (54.4%; n=43) of the adult participants in the EG were employed, whereas in the CG, 45.9% (n=17) were employed. Among those employed, 55.8% (n=24) in the EG and 35.2% (n=6) in the CG were permanently employed. Some participants were employed temporarily (41.9%; n=18 in the EG and 41.1; n=7 in the CG). Table 5.8 also shows that 45.6% (n=36) participants in the EG were unemployed. Fifty-eight point three percent (n=21) of the unemployed participants were at home, 25.0% (n=9) were students, 8.3% (n=3) were retired and 8.3% (n=3) were housewives. In the CG, half of the participants (n=10) that were unemployed were at home, 40.0% (n=8) were students, 5.0% (n=1) were retired and 5.0% (n=1) were housewives. Sixty-nine point four percent (n=25) of the unemployed participants in the EG were actively looking for a job, whereas 45.0% (n=9) in the CG were actively looking for a job.

Table 5.8: Employment status of the participants

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Participants currently employed		
Yes	54.4 (43)	45.9 (17)
Type of employment for currently employed participants	**EG (n=43) % (n)**	**CG (n=17) % (n)**
Permanent	55.8 (24)	35.2 (6)
Temporary	41.9 (18)	41.1 (7)
Fixed term contract	2.3 (1)	23.5 (4)
Status for unemployed participants	**EG (n=36) % (n)**	**CG (n=20) % (n)**
Participants currently unemployed	45.6 (36)	58.3 (20)
At home	58.3 (21)	50.0 (10)
Students	25.0 (9)	40.0 (8)
Retired	8.3 (3)	5.0 (1)
Housewives	8.3 (3)	5.0 (1)
Duration of unemployment for currently unemployed participants	**EG (n=36) % (n)**	**CG (n=20) % (n)**
Three years and above	50.0 (18)	40.0 (8)
One to three years	22.2 (8)	5.0 (1)
Six to eleven months	13.9 (5)	15.0 (3)
Have never been unemployed	8.3 (3)	35.0 (7)
Less than six months	5.6 (2)	5.0 (1)
Participants actively looking for employment	**EG (n=36) % (n)**	**CG (n=20) % (n)**
Yes	69.4 (25)	45.0 (9)
Part-time jobs on weekends/holidays	**EG (n=36) % (n)**	**CG (n=20) % (n)**
Yes	25.0 (9)	20.0 (4)

Table 5.9 shows that 10.1% (n=8) of households in the EG and 27% (n=10) in the CG had an income above R6000. Furthermore, 24.1% (n=19) of households in the EG and (27.0%; n=10) in the CG had an income between R3501 to R6000. Forty-four point four percent of households (n=35) in the EG had an income between R2001 and R3500, whereas 13.5% (n=5) of households in the CG were in the same category. Some participants did not disclose the monthly household income (10.1%; n=8 and 10.8%; n=4) in the EG and CG, respectively. In most of the households, one person contributed to the household income (45.6%; n=36 in the EG and 45.9%; n=17 in the CG). Two people contributed to household income in 36.7% (=29) of the households in the EG and 37.8% (n=14) in the CG.

Table 5.9: Household income and number of people contributing to the income

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Monthly household income		
Less than R2000	11.5 (9)	19.0 (7)
R2001 to R3500	44.4 (35)	13.5 (5)
R3501 to R6000	24.1 (19)	27.0 (10)
≥R6001	10.1 (8)	27.0 (10)
Did not disclose	10.1 (8)	10.8 (4)
Did not know	0.0	2.7 (1)
Number of people contributing to household income		
One	45.6 (36)	45.9 (17)
Two	36.7 (29)	37.8 (14)
Three	11.4 (9)	10.8 (4)
Four	5.1 (4)	2.7 (1)
Five	1.3 (1)	2.7 (1)

5.2.4 Household food security

Table 5.10 shows that 26.6% (n=21) of participants in the EG spent below R500 on food per month. Twenty one point five percent (n=17) in the EG and 51.4% (n=19) of the participants in the CG spent between R1000 and R2000 on food per month. Seventeen point seven percent (n=14) and 16.2% (n=6) of participants in the EG and CG, respectively spent between R501 and R800 per month. Furthermore, 19.0% (n=15) of participants in the EG reported that they did not know how much money was spent on food each month. The mother was the decision maker regarding how much money should be spent on food per month in over half of the households in both groups (54.4%; n=43 in the EG and 64.9%; n=24 in the CG), followed by the grandmother (20.3%; n=16 and 18.9%; n=7). Table 5.10 also shows that 91.1% (n=72) of participants in the EG and 91.9% (n=34) in the CG bought food from a supermarket. More participants in the EG (79.7%; n=63) purchased food once a month than in the CG (75.7%; n=28). Other participants purchased food twice a month (7.6%; n=6 and 16.2%; n=6) in the EG and CG, respectively. In the EG, the father decided on the type of food to be purchased in 68.4% (n=54) of the households and in the CG, the mother made the decision in 86.5% (n=32) of the households.

Table 5.10: Food purchasing information

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Amount of money spent on food per month		
0-R300	11.4 (9)	0.0 (0)
R301-R500	15.2 (12)	0.0 (0)
R501-R800	17.7 (14)	16.2 (6)
R801-R999	6.3 (5)	16.2 (6)
R1000 to R2000	21.5 (17)	51.4 (19)
R2001 and above	6.3 (5)	8.1 (3)
I don't know	19.0 (15)	2.7 (1)
Did not disclose	2.5 (2)	5.4 (2)
Decision maker on how much money is spent on food per month		
Mother	54.4 (43)	64.9 (24)
Grandmother	20.3 (16)	18.9 (7)
Father	11.4 (9)	13.5 (5)
Mother and father	7.6 (6)	0.0 (0)
Uncle	3.8 (3)	0.0 (0)
Aunt	1.3 (1)	2.7 (1)
All adults in the household	1.3 (1)	0.0 (0)
Place where food is purchased		
Supermarket	91.1 (72)	91.9 (34)
Tuckshop	5.1 (4)	0.0 (0)
Wholesaler	3.8 (3)	8.1 (3)
How often food is purchased		
Everyday	3.8 (3)	2.7 (1)
Once a week	6.3 (5)	5.4 (2)
Once a month	79.7 (63)	75.7 (28)
Twice a month	7.6 (6)	16.2 (6)
Every week	1.3 (1)	0.0 (0)
Three times a month	1.3 (1)	0.0 (0)
Decision maker on how much money is spent on food per month		
Mother	3.8 (3)	86.5 (32)
Father	68.4 (54)	0.0 (0)
Aunt	1.3 (1)	2.7 (1)
Grandmother	21.5 (17)	10.8 (4)
Mother and father	3.8 (3)	0.0 (0)
All adults in the household	1.3 (1)	0.0 (0)

Figure 5.5 shows that 35.4% (n=28) of participants in the EG and 51.4% (n=19) in the CG reported that there was sometimes insufficient money to purchase food in the household. The percentage of participants who indicated that there was never a time when there was insufficient money was 40.5% (n=32) in the EG and 32.4% (n=12) in the CG. Fifteen point two percent (n=12) in the EG indicated that there was seldom a time when there was no money to buy food, compared to 10.8% (n=4) in the CG. Furthermore, 2.5% (n=2) of participants in the EG and 5.4% (n=2) in the CG stated that there was often insufficient money for food in the household. The results also show that 5.1% (n=4) of participants in the EG always lacked money to buy food.

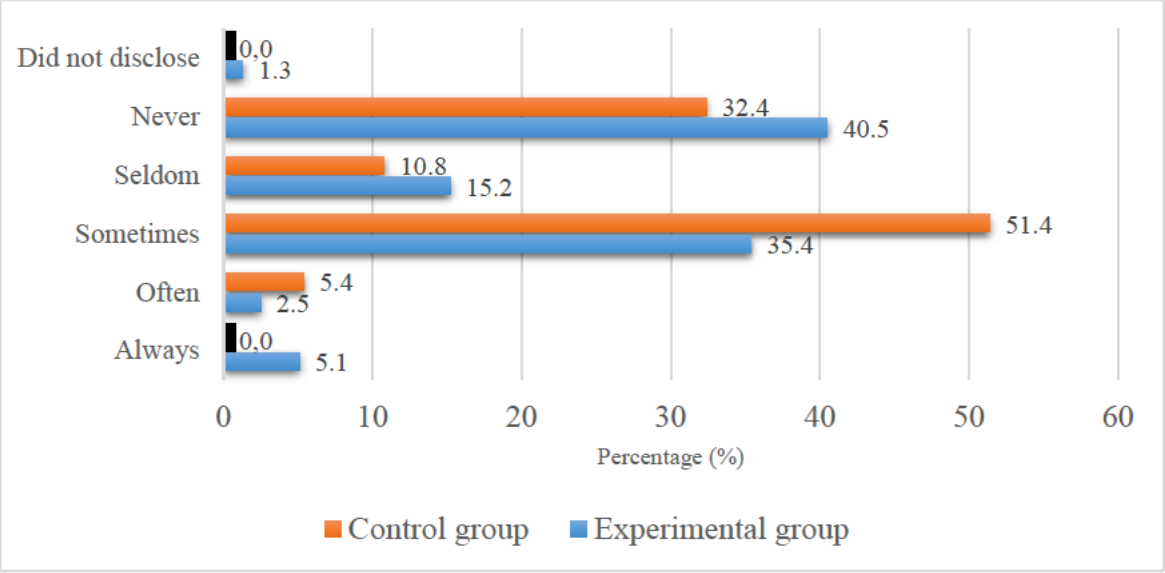

Figure 5.5: Frequency of a lack of money to purchase food in the household (EG=79; CG=37)

Figure 5.6 indicates that 32.9% (n=26) of participants in the EG and 2.7% (n=1) in the CG consumed four meals a day. Only 3.9% (n=3) of participants in the EG consumed two meals a day compared to 16.2% (n=6) in the CG. Furthermore, the majority of participants from both groups consumed three meals a day (63.3%; n=50 in the EG and 78.4%; n=29 in the CG).

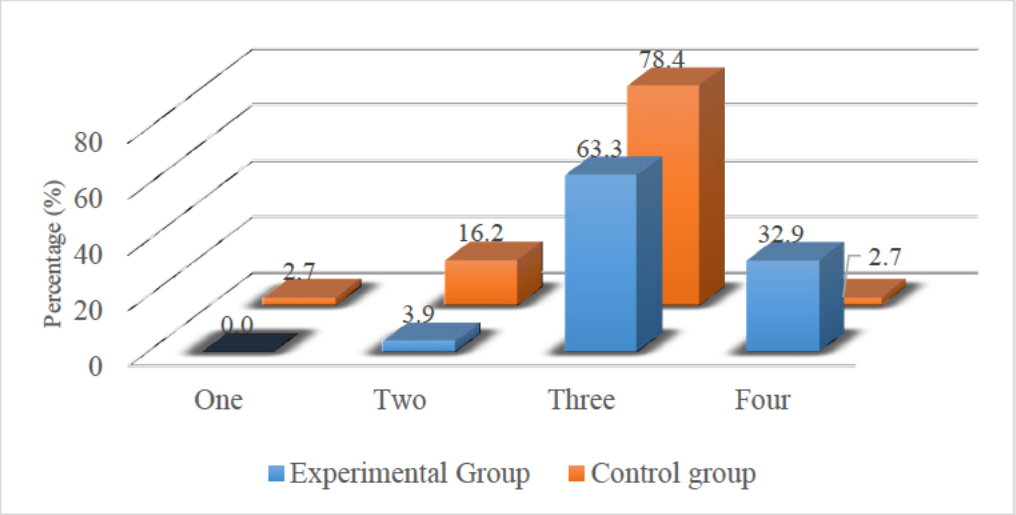

Figure 5.6: Number of meals consumed per day in the household (EG=79; CG=37)

Figure 5.7 shoes that the majority of adults from both groups (81.0%; n=64 in the EG and 81.1%; n=30 in the CG) consumed most meals at home and some consumed most meals at work (16.4%; n= 13 in the EG and 18.9%; n=7 in the CG).

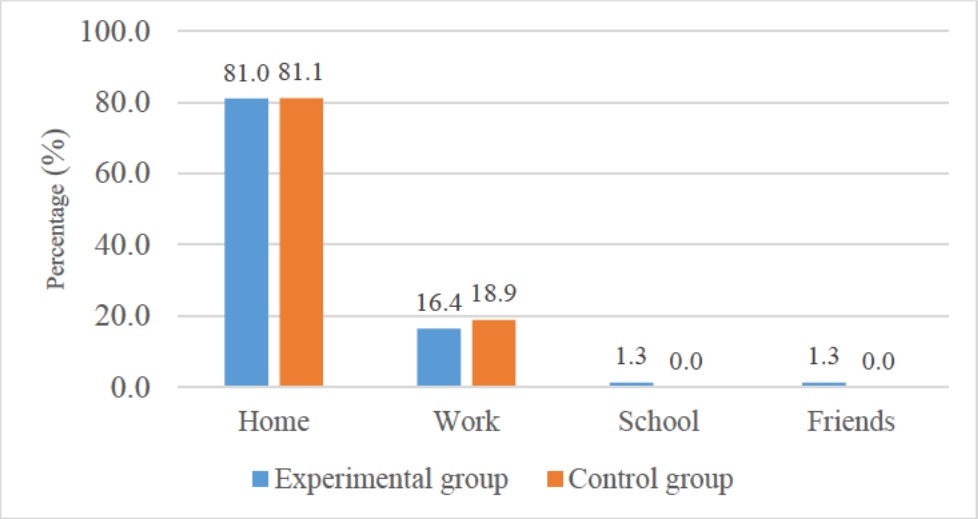

Figure 5.7: Place where adults ate most meals (EG=79; CG=37)

It was reported that 44.3% (n=35) in the EG and 67.6% (n= 25) in the CG consumed most meals while at home. Results also show that 55.3% (n=16) and 32.4% (n=12) of children in the EG and CG, respectively consumed most meals at the ECD centre (Figure 5.8).

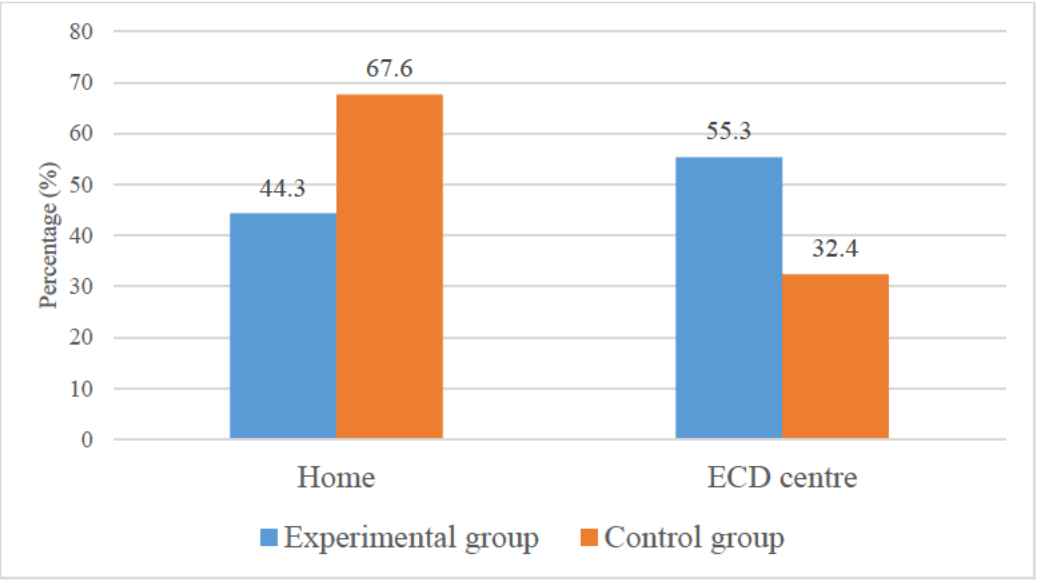

Figure 5.8: Place where children consumed most meals (EG=79; CG=37)

Table 5.11 shows the allocation of food preparation responsibilities in the household. Mothers were responsible for food preparation in the majority of the households in both groups (70.9%; n=56 in the EG and 83.8%; n=31 in the CG). Grandmothers were responsible for food preparation in 13.9% (n=11) of the households in the EG and 8.1% (n=3) in the CG. In both groups, the majority of the household members that were responsible for feeding young children were mothers

(69.6%; n=55 in the EG and 83.8%; n=31 in the CG). Table 5.11 also shows that the majority of households in both groups used stainless steel pots (82.3%; n=65 in the EG and 83.8%; n=31 in the CG). Most households in both groups used electricity for food preparation (93.7%; n=74 in the EG and 86.5%; n=32 in the CG). A few households used gas, 2.5%; (n=2) in the EG and 8.1%; (n=3) in the CG. Paraffin was used in a few households in both groups CG (3.8%; n=1 in the EG and 2.7%; n=1 in the CG).

Table 5.11: Food preparation and feeding responsibilities and household resources

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Person responsible for food preparation in the household		
Mother	70.9 (56)	83.8 (31)
Grandmother	13.9 (11)	8.1 (3)
Sibling	5.1 (4)	5.4 (2)
Aunt	3.8 (3)	0 (0)
Mother and father	3.8 (3)	2.7 (1)
All females in the household	1.3 (1)	0.0 (0)
Helper/domestic worker	1.3 (1)	0.0 (0)
Person responsible for feeding young children in the household		
Mother	69.6 (55)	83.8 (31)
Grandmother	17.7 (14)	8.1 (3)
Sibling	5.1 (4)	2.7 (1)
Grandfather	2.5 (2)	0.0 (0)
Father	1.3 (1)	0.0 (0)
All adult females in household	1.3 (1)	0.0 (0)
Mother and father	1.3 (1)	0.0 (0)
Helper/Domestic worker	1.3 (1)	2.7 (1)
Aunt	0.0 (0)	2.7 (1)
Types of pots used in the household		
Cast iron	0.0 (0)	10.8 (4)
Aluminium	17.7 (14)	5.4 (2)
Stainless steel	82.3 (65)	83.8 (31)
Types of fuel used for food preparation		
Wood fire	0.0 (0)	2.7 (1)
Paraffin	3.8 (3)	2.7 (1)
Electricity	93.7 (74)	86.5 (32)
Gas	2.5 (2)	8.1 (3)

5.2.5 Household assets

Table 5.12 shows that the majority of the households in both groups had an electrical stove and a microwave (84.8%; n=67 and 83.5%; n=66 in the EG, 86.5%; n=32 and 75.7%; n=28 in the CG, repectively). The number of the households that had a hot plate was 45.6% (n=36) in the EG and 27% (n=10) in the CG. The percentage of households with a fridge with freezer was almost the same for both groups (93.7%; n=74 for EG and 94.6%; n=32 for the CG). In both groups, more

households had televisions sets rather than radios. In the EG, 92.4% (n=73) of the households had television sets and 86.1% (n=68) had radios. Likewise, 91.9% (n=34) of households in the CG had television sets, whereas 83.8% (n=31) had radios. Results further show that 37.8% (n=14) of the participants in the CG had a gas stove, whereas 38% (n=30) of households in the EG had a gas stove.

Table 5.12: Household assets

Variables	EG (n=79) % (n)	CG (n=37) % (n)
Electrical assets		
Electrical stove	84.8 (67)	86.5 (32)
Microwave	83.5 (66)	75.7 (28)
Hot plate	45.6 (36)	27.0 (10)
Fridge with freezer	93.7 (74)	94.6 (35)
Electrical iron	94.9 (75)	100 (37)
Electrical kettle	89.9 (71)	91.8 (34)
Telephone/cell phone	93.7 (74)	94.6 (35)
Radio	86.1 (68)	83.8 (31)
Television	92.4 (73)	91.9 (34)
Non-electrical assets		
Gas stove	38.0 (30)	37.8 (14)
Primus/Paraffin stove	32.9 (26)	32.4 (12)
Lounge suite	73.4 (58)	73.0 (27)
Dining room suite	68.4 (54)	73.0 (27)
Bed with mattress	98.7 (78)	100 (37)
Mattress only	15.2 (12)	29.7 (11)
Car	12.7 (10)	32.4 (12)
Bicycle	15.2 (12)	8.1 (3)

5.3 Multi-dimensional poverty index score

The MPI score for the EG was 9.75. This therefore indicates that the EG was 32.5% multi-dimensionally poor. The biggest contributor to the MPI score was the lack of assets, followed by lack of sanitation (Table 5.13).

Table 5.13: MPI score of the EG

MPI Measure	Results	Weight	MPI Score
Health			
Child mortality (n=79)	11.3% of households had a child die in the past	X1/6	1.8
Nutrition	0% of the children were underweight	X1/6	0
Education			
Years of schooling	0% had no schooling	X1/6	0
Child enrolment	0% children were not attending school	X1/6	0
Standard of living			
Electricity	0% had no access	X1/18	0
Drinking water	0% had no access	X1/18	0
Sanitation	60.7% had no access (had pit latrine)	X1/18	3.37
Flooring	2.5% of households had dung, sand or mud as floor	X1/18	0.1
Cooking fuel	0% of households used wood or charcoal to prepare food	X1/18	0
Assets	**% owning less than two**		
Radio	92.4	X1/108	0.85
Television	83.5	X1/108	0.77
Telephone/cell phone	29	X1/108	0.26
Motorbike	100	X1/108	0.92
Refrigerator	96.2	X1/108	0.89
Assets	**% not owning a vehicle**		
Car	86%	X1/108	0.79
TOTAL			9.75

As reflected in Table 5.14, the MPI score for the CG was 8.11/30. Therefore, the CG was 27.0% multi-dimensionally poor.

Table 5.14: MPI score of the CG

MPI Measure	Results	Weight	MPI Score
Health			
Child mortality (n=37)	8.1% of households had a child die in the past	X1/6	1.35
Nutrition	0% of the children were underweight	X1/6	0
Education			
Years of schooling	0% had no schooling	X1/6	0
Child enrolment	0% children not attending school	X1/6	0
Standard of living			
Electricity	0% had no access	X1/18	0
Drinking water	0% had no access	X1/18	0
Sanitation	48.6% had no access (had pit latrine)	X1/18	2.7
Flooring	0% of households had dung, sand or mud as floor	X1/18	0
Cooking fuel	2.7% of households used wood or charcoal to prepare food	X1/18	0.1
Assets	**% owning less than two**		
Radio	70.2	X1/108	0.65
Television	75.6	X1/108	0.70
Telephone/cell phone	24.3	X1/108	0.22
Motorbike	100	X1/108	0.92
Refrigerator	94.5	X1/108	0.87
Assets	**% not owning a vehicle**		
Car	64.8	X1/108	0.6
TOTAL			8.11

5.4 Anthropometric results

For the purpose of comparing anthropometric results from the EG with CG and boys with girls, each group was divided according to age (24-47 months of age and 48-60 months of age) so that the comparisons could be made per gender and age group.

5.4.1 Girls' baseline anthropometric results

Table 5.15 shows that all girls 24-47 months of age had a normal height for age in both groups. Among girls 48-60 months of age, 100% (n=16) in the EG and 66.7% (n=8) in the CG had a normal height for age. Stunting was found in 16.6% (n=2) of girls in the CG and 16.7% (n=2) were severely stunted. In the younger girls 24-47 months of age, 4.3% (n=1) in the EG and 14.3% (n=1) in the CG were obese. None of the girls 48-60 months of age in the EG were obese, whereas in the CG, 33.3% (n=4) were obese. Moreover, 8.7% (n=2) and 28.6% (n=2) of girls 24-47 months of age were overweight in the EG and CG, respectively. In the age group 48-60 months, overweight was noted in 16.7% (n=2) in the CG only. The risk of overweight was higher in the EG than the CG. Among the younger girls, 21.7% (n=5) in the EG and 14.3% (n=1) in the CG were at risk of overweight. In girls 48-60 months of age, 50.0% (n=8) in the EG and 41.7% (n=5) in the CG were at risk of overweight.

Table 5.15: Girls' baseline anthropometric results for EG and CG

Z score	Classification	EG: Girls (n=39)		CG: Girls (n=19)	
Height for age:		**24-47 months (n=23) % (n)**	**48-60 months (n=16) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=12) % (n)**
>-2 SD to <+3SD	Normal height for age	100 (23)	100 (16)	100 (7)	66.7 (8)
<-2SD to >-3SD	Stunted	0 (0)	0 (0)	0 (0)	16.6 (2)
<-3SD	Severely stunted	0 (0)	0 (0)	0 (0)	16.7 (2)
Weight for height		**24-47 months (n=23) % (n)**	**48-60 months (n=16) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=12) % (n)**
>+3SD	Obese	4.3 (1)	0 (0)	14.3 (1)	33.3 (4)
>+2SD to <+3SD	Overweight	8.7 (2)	0 (0)	28.6 (2)	16.7 (2)
>+1 SD to<+2 SD	Possible risk of overweight	21.7 (5)	50.0 (8)	14.3 (1)	41.7 (5)
>-2 SD to <+1SD	Normal weight for height	65.3 (15)	50.0 (8)	42.8 (3)	8.3 (1)
<-2SD to >-3SD	Wasted	0 (0)	0 (0)	0 (0)	0 (0)
<-3SD	Severely wasted	0 (0)	0 (0)	0 (0)	0 (0)
Weight for age		**24-47 months (n=23) % (n)**	**48-60 months (n=16) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=12) % (n)**
<-2SD to >-3SD	Underweight	0 (0)	0 (0)	0 (0)	0 (0)
<-3SD	Severely underweight	0 (0)	0 (0)	0 (0)	0 (0)

5.4.2 Boys' baseline anthropometric results

Table 5.16 indicates the baseline anthropometric results for boys. Stunting was noted among the older boys in both groups (10.5%; n=2 in the EG and 36.4%; n=4 in the CG). None of the boys in the CG were severely stunted in both age groups, whereas in the EG, 4.8% (n=1) was severely stunted in the 24-47 month age group. Wasting was found in 5.3% (n=1) of boys 48-60 months of age in the EG only. Among boys in the EG, the risk of overweight was found in 33.3% (n=7) of boys 24-47 months of age and in 21.1% (n=4) of boys 48-60 months of age. In contrast, the risk of overweight among boys in the CG was higher among the 48-60 months age group (36.3%; n=4) than in the 24-47 months age group (14.3%; n=1). Some participants 24-47 months of age were overweight in both groups (9.5%; n=2 and 42.8%; n=3 in the EG and CG, respectively) and in the 48-60 months age group, 10.5% (n=2) of boys in the EG and 27.3% (n=3) in the CG were overweight. Furthermore, obesity was found in 28.6% of CG boys 24-47 months of age.

Table 5.16: Boys' baseline anthropometric results for the EG and CG

Z score	Classification	EG: Boys (n=40)		CG: Boys (n=18)	
Height for age:		**24-47 months (n=21) % (n)**	**48-60 months (n=19) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=11) % (n)**
>-2 SD to <+3SD	Normal height for age	95.2 (20)	89.5 (17)	100 (7)	63.6 (7)
<-2SD to >-3SD	Stunted	0 (0)	10.5 (2)	0 (0)	36.4 (4)
<-3SD	Severely stunted	4.8 (1)	0 (0)	0 (0)	0 (0)
Weight for height:		**24-47 months (n=21) % (n)**	**48-60 months (n=19) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=11) % (n)**
>+3SD	Obese	0 (0)	0 (0)	28.6 (2)	0 (0)
>+2SD to <+3SD	Overweight	9.5 (2)	10.5 (2)	42.8 (3)	27.3 (3)
>+1 SD to<+2 SD	Possible risk of overweight	33.3 (7)	21.1 (4)	14.3 (1)	36.3 (4)
>-2 SD to <+1SD	Normal weight for height	57.2 (12)	63.1 (12)	14.3 (1)	36.4 (4)
<-2SD to >-3SD	Wasted	0 (0)	5.3 (1)	0 (0)	0 (0)
<-3SD	Severely wasted	0 (0)	0 (0)	0 (0)	0 (0)
Weight for age:		**24-47 months (n=21) % (n)**	**48-60 months (n=19) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=11) % (n)**
<-2SD to >-3SD	Underweight	0 (0)	0 (0)	0 (0)	0 (0)
<-3SD	Severely underweight	0 (0)	0 (0)	0 (0)	0 (0)

5.4.3 Baseline combined graphs for EG and CG

Figure 5.9 shows the height for age distribution curves for the EG at baseline. The blue growth distribution curve for boys and pink curve for girls in the EG were both below the ideal green curve as per the WHO growth standard curve for height for age (WHO 2017b). The mean z-score for girls was -0.32, and the mean z-score for boys was -0.08.

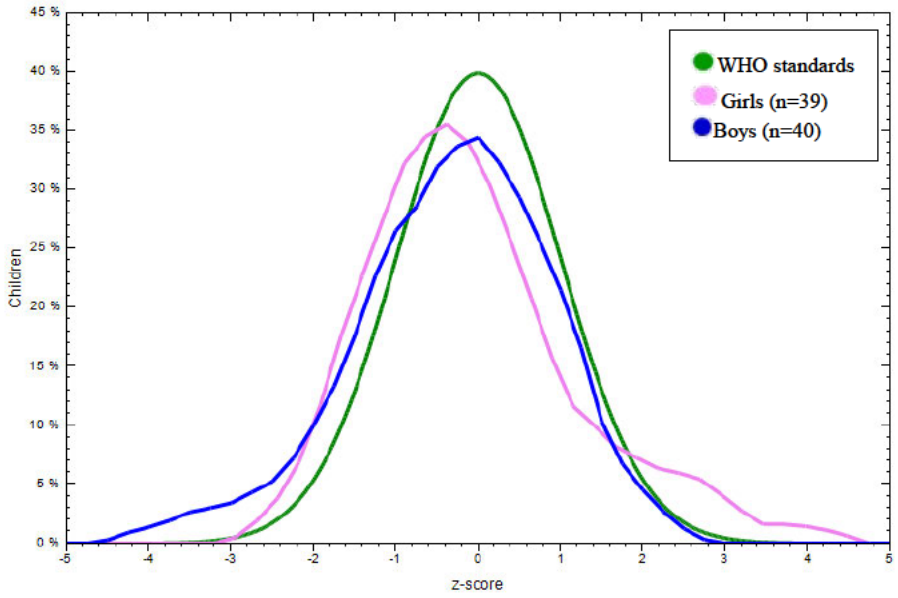

Figure 5.9: Height for age z-scores for the EG at baseline

Figure 5.10 shows that both CG boys and girls height for age distribution curves were skewed to the left and not aligned with the green WHO recommended curve (WHO 2017b), with a mean z-score of -0.23 and -0.87 for girls and boys, respectively.

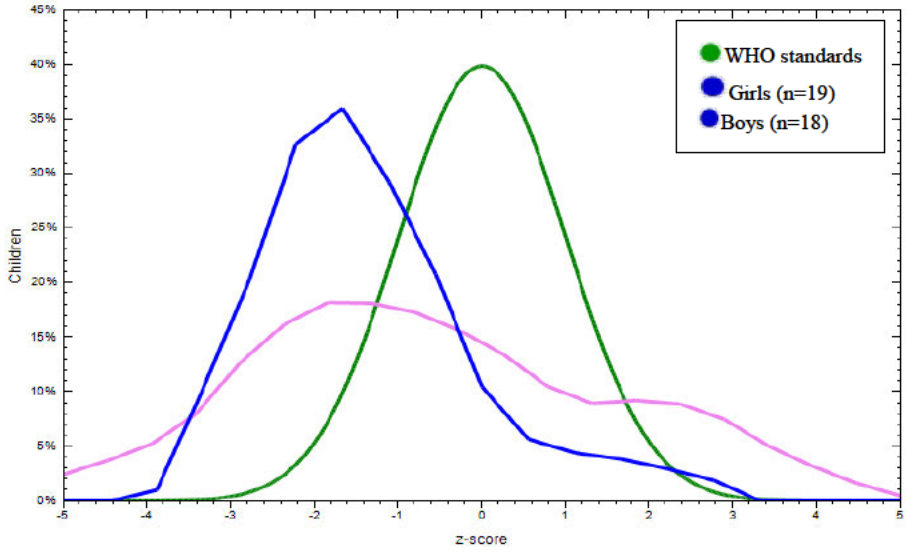

Figure 5.10: Height for age z-scores for the CG at baseline

In Figure 5.11 the weight for height distribution curves for the participants in the EG were skewed towards the right and not in alignment with the green WHO recommended curve in both groups (WHO 2017b). The mean z-score for the EG was 0.79 for girls and 0.76 for boys.

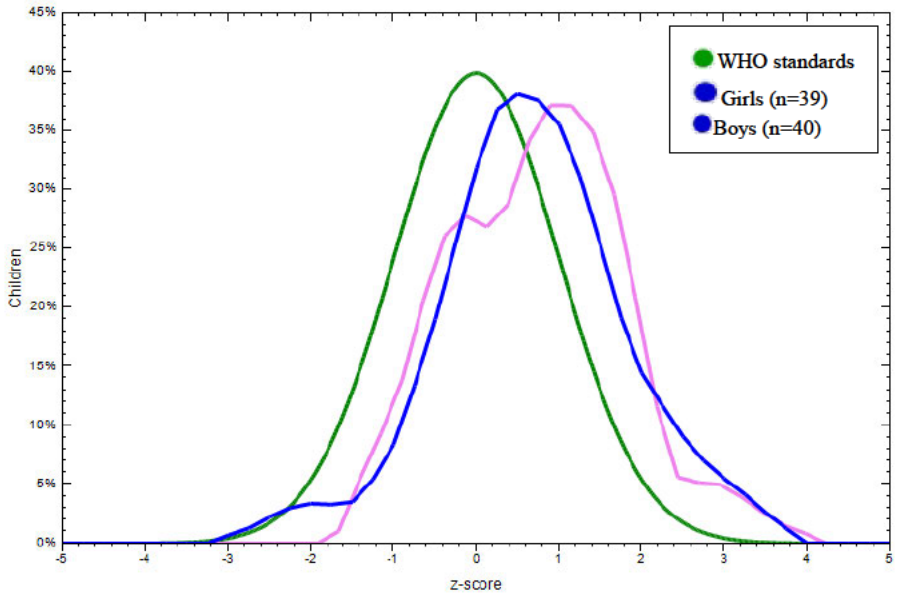

Figure 5.11: Weight for height z-scores for the EG at baseline

In Figure 5.12, both CG girls' and boys' weight for height distribution curves were skewed towards the right and not aligned with the green WHO curve (WHO 2017b). The mean z-score for the CG girls was 2.23 and 1.93 for the boys.

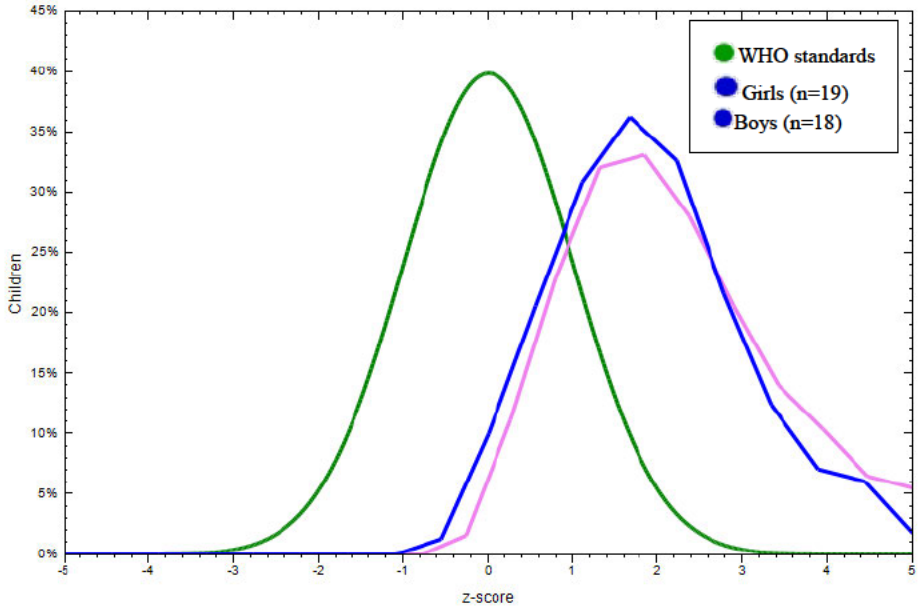

Figure 5.12: Weight for height z-scores for the CG at baseline

Figure 5.13 shows the weight for age distribution curve for the weight for age for the girls and boys in the EG. The pink curve for girls in the EG was noted to be above the ideal green WHO growth

curve with a mean z-score of 0.5, whereas the blue curve for boys was skewed towards the right of the WHO green curve, with a mean z-score of 0.31 (WHO 2017b).

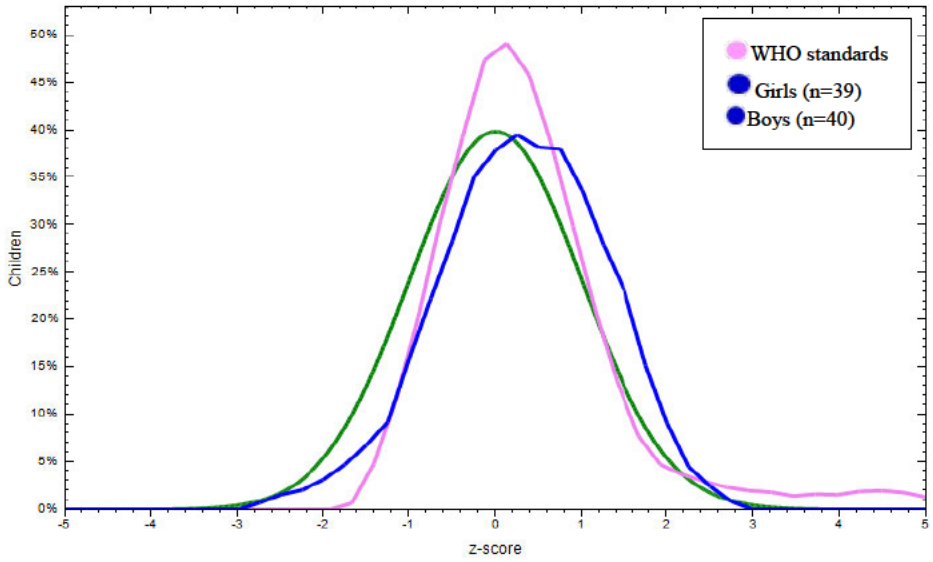

Figure 5.13: Weight for age z-scores for the EG at baseline

In Figure 5.14, the blue weight for age distribution curve for CG boys and the pink curve for CG girls were skewed toward the right side. Furthermore, the boys' growth curve was observed to be above the ideal green WHO growth curve (WHO 2017b) (mean z-score of -0.32), whereas the girls growth distribution curve was below the WHO curve (mean z-score of 0.76).

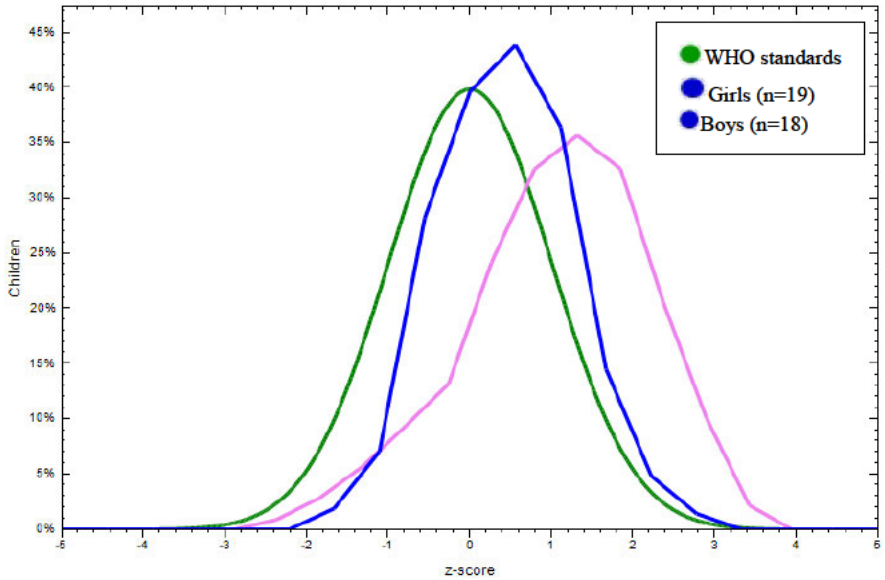

Figure 5.14: Weight for age z-scores for the CG at baseline

5.5 Dietary intake

5.5.1 Analysis of dietary intake

Table 5.17 shows that the daily mean energy intake for all the girls 24-47 months of age was higher than the EER for the age group. In contrast, the daily mean energy intake for all the girls 48-60 months of age was less than the EER for the age group. The CG had a higher daily mean energy intake (6432.76kJ) than the EG (5440.19kJ) (p=0.118). None of the girls consumed less than 100% of the RDA for protein (p=0.192 for girls 24-47 months of age and p=0.927 for girls 48-60 months of age) and the daily mean CHO intake exceeded the RDA for all girls (p=0.611 and p=0.000 for 24-47 months of age and for 48-60 months of age, respectively). With regard to the fibre intake, all the girls in both age groups consumed less than the AI of 19g and 25g per day for the 24-47 months age group (p=0.056) and 48-60 month age group (p=0.697), respectively. The daily mean calcium intake was lower than the AI for all girls in both groups (p=0.431 for girls 24-47 months of age and p=0.267 for girls 48-60 months of age). The daily mean intake of iron (p=0.063 for the 24-47 month age group and p=0.064 for the 48-60 month age group) and zinc (p=0.077 for the 24-47 month age group and p=0.156 for the 48-60 month age group) was higher than the RDA for all groups. None of the participants consumed less than 100% of the RDA for iron, whereas with zinc, although the daily mean intake was higher than the RDA, 6.2% of EG girls 48-60 months of age consumed less than 100% of the RDA. Furthermore, the daily mean intake for vitamin A was also higher than the RDA for all groups (p=0.421 and p=0.091 for girls 24-47 months of age and 48-60 months of age, respectively).

Table 5.17: Girls' analysis of nutrient intake at baseline

	Girls 24-47 months (n=30)						Girls 48 -60 months (n=28)					
	EG (n=23)			CG (n=7)			EG (n=16)			CG (n=12)		
Nutrient per day	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Energy (kJ)	5113.11 (1326.79)	86.9	4150	4699.30 (626.08)	10	.268	5440.19 (1236.35)	75	6870	6432.76 (1801.06)	58	.118
Protein (g)	35.26 (10.48)	0	**13**	31.11 (5.70)	0	.192	41.04 (12.14)	0	**19**	41.61 (18.32)	0	.927
Total fat (g)	37.99 (12.40)	-	-	32.89 (6.03)	-	-	41.91 (15.46)	-	-	43.72 (30.45)	-	-
CHO (g)	171.17 (44.29)	0	**130**	163.92 (27.77)	0	.611	175.54 (29.45)	0	**130**	226.65 (42.48)	0	**.000**
Total dietary fibre (g)	11.69 (3.568)	100	19 *	9.84 (1.45)	100	.056	12.24 (2.56)	100	25 *	15.01 (23.95)	100	.697
Calcium (mg)	262.94 (118.02)	95.6	500 *	233.68 (70.55)	100	.431	317.98 (88.46)	100	800 *	375.87 (156.61)	100	.267
Iron (mg)	9.11 (3.01)	0	**7.0**	7.69 (1.00)	0	.063	9.47 (2.85)	0	**10**	11.42 (2.47)	0	.064
Magnesium (mg)	139.50 (32.97)	0	**80**	119.07 (15.35)	0	.033	151.72 (33.27)	12.5	**130**	191.10 (90.18)	0	.173
Phosphorus (mg)	535.48 (144.63)	4.3	**460**	438.43 (55.15)	28.5	**.013**	599.93 (142.80)	12.5	**500**	610.05 (281.16)	8.3	.911
Potassium (mg)	989.63 (271.59)	0	3.0 *	822.68 (127.70)	0	**.035**	1113.58 (271.62)	0	3.8 *	1104.55 (496.00)	0	.955
Sodium (mg)	1109.28 (467.95)	0	1.0 *	946.82 (45.02)	0	.114	1124.48 (372.36)	0	1.2 *	1388.60 (746.17)	0	.278
Zinc (mg)	6.69 (2.09)	0	**3**	5.61 (1.01)	0	.077	7.47 (2.28)	6.2	**5**	8.79 (2.41)	0	.156
Selenium (mcg)	11.41 (6.53)	86.9	**20**	9.95 (4.12)	85.7	.490	14.28 (7.62)	87.5	**30**	9.34 (5.28)	100	**.054**
Iodine (mcg)	17.95 (11.11)	100	**90**	23.12 (10.19)	100	.275	21.76 (13.63)	100	**90**	28.82 (6.90)	100	.087
Vitamin A (mcg)	498.38 (323.45)	0	**300**	414.04 (202.89)	0	.421	513.69 (395.11)	18.7	**400**	703.88 (144.34)	0	.091
Thiamin (mg)	0.85 (0.31)	0	**0.5**	0.71 (0.07)	0	**.058**	0.90 (0.26)	0	**0.6**	0.97 (0.26)	0	.489
Riboflavin (mg)	1.63 (0.72)	0	**0.5**	1.58 (0.48)	0	.835	1.49 (0.56)	0	**0.6**	3.02 (3.60)	0	.172
Niacin (mg)	13.45 (4.33)	0	**6**	10.84 (1.64)	0	**.025**	15.05 (4.76)	0	**8**	18.31 (8.03)	0	.228

Table 5.17: Girls' analysis of nutrient intake at baseline

	Girls 24-47 months (n=30)						Girls 48 -60 months (n=28)					
	EG (n=23)			CG (n=7)			EG (n=16)			CG (n=12)		
Nutrient per day	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Vit B6 (mg)	1.93 (0.80)	0	**0.5**	1.69 (0.28)	0	.234	1.91 (0.79)	0	**0.6**	2.89 (0.90)	0	**.007**
Folate (mcg)	230.11 (81.11)	8.6	**150**	184.26 (24.68)	0	**.025**	234.00 (103.15)	25	**200**	269.75 (82.76)	0	.319
Vit B12 (mcg)	2.92 (14.18)	0	**0.9**	1.97 (0.38)	0	.751	3.36 (1.75)	0	**1.2**	2.30 (1.06)	16.6	**.058**
Pantothenate (mg)	2.86 (0.92)	21.7	2.0 *	2.24 (0.74)	28.5	.094	3.46 (1.70)	50	3.0 *	3.13 (1.19)	41.6	.552
Biotin (mcg)	18.99 (15.21)	8.6	8.0 *	14.14 (5.53)	0	0.213	19.07 (14.62)	50	12 *	18.04 (5.73)	8.3	.869
Vitamin C (mg)	37.96 (21.55)	4.3	**15**	39.87 (22.61)	0	.682	38.13 (16.04)	0	**25**	80.90 (28.87)	0	**.000**
Vitamin D (mcg)	3.72 (1.50)	91.3	5 *	3.72 (1.15)	71.4	1.000	3.70 (1.87)	87.5	5 *	5.86 (1.31)	8.3	**.001**
Vitamin E (mg)	7.95 (2.63)	4.3	**6**	8.11 (2.83)	014 2	.897	8.40 (3.24)	12.5	7	9.69 (4.36)	16.6	.400
Vitamin K (mcg)	22.03 (24.03)	82.6	30 *	17.17 (9.74)	85.7	.442	24.95 (29.51)	87.5	55 *	71.20 (66.53)	58.33	**.041**

Institute of Medicine 2001; SD: standard deviation; RDA: Recommended Dietary Allowance in bold; AI*: adequate intake; No AI/RDA set for fat as there is no defined level of fat intake at which inadequacy or prevention of disease occurs; *p*-values given in bold font indicate that the mean nutrient intake is significantly different between the two groups. *P*-value of <0.05 shows statistical significance, CHO: carbohydrates

Table 5.18 shows that in both groups, all boys 24-47 months of age and all boys 48-60 months of age had a daily mean energy intake that was more than 100% of the EER for energy (p=0.047 and p=0.137, respectively). In the EG, the daily mean protein intake was higher in boys 24-47 months of age (p=0.046), whereas in the CG, the daily mean intake of protein was higher among boys 48-60 months of age in both groups (p=0.659). In both groups, all boys 48-60 months of age consumed less than 100% of the AI of 25g per day for dietary fibre. In boys 24-47 months of age, 76.19% in the EG and 100% in the CG consumed less than 100% of the AI of 19g per day. The results also show that the daily mean intake of calcium was low for boys in both age groups in the EG and CG. For boys 24-47 months of age, 85.7% did not meet 100% of the AI in both groups (p=0.888). With regards to vitamin A intake, 19.0% of boys 24-47 months of age and 47.3% of boys 48-60 months of age in the EG consumed less than 100% of the RDA (p=0.345 and p=0.000, respectively). Similar trends were also noted with vitamin C intake in the same group, as 14.2% of boys 24-47 months of age (p=0.240) and 66.6% of boys 48-60 months of age (p=0.002) also consumed less than 100% of the RDA for vitamin C

Table 5.18: Boys' analysis of nutrient intake at baseline

	Boys 24-47 months (n=28)						Boys 48 -60 months (n=30)					
	EG (=21)			CG n=7)			EG (n=19)			CG (n=11)		
Nutrient	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Energy (kJ)	5517 57 (1018.51)	100	4376	4778.42 (688.48)	100	**.047**	5380.88 (799.84)	100	7289	5861.52 (832.02)	100	.137
Protein (g)	39.80 (9.41)	0	**13**	33.74 (5.22)	0	**.046**	38.60 (8.56)	0	**19**	39.91 (7.22)	0	.659
Total fat (g)	37.48 (9.14)	-	-	32.33 (10.31)	-	-	37.86 (8.54)	-	-	38.83 (10.42)	-	-
CHO (g)	188.79 (34 10)	0	**130**	164.59 (17.65)	0	**.025**	182.41 (25.13)	0	**130**	204.72 (29.79)	0	**.051**
Total dietary fibre (g)	14.42 (4.54)	76.19	19 *	12.41 (2.23)	100	.137	13.16 (3.44)	100	25 *	15.66 (2.91)	100	**.045**
Calcium (mg)	312.58 (145.44)	85.7	500 *	301.77 (178.88)	85.7	.888	37.06 (22.41)	100	800 *	445.43 (193.22)	90.9	**.000**
Iron (mg)	10.64 (3.30)	0	**7.0**	9.25 (1.19)	0	.114	9.76 (2.70)	0	**10**	11.46 (1.81)	0	**.049**
Magnesium (mg)	156.20 (39.48)	0	**80**	140.72 (27.36)	0	.268	151.01 (35.93)	5.2	**130**	181.22 (25.38)	0	**.012**
Phosphorus (mg)	607.68 (167.73)	0	**460**	505.42 (123.55)	14.2	.107	587.04 (141.40)	5.2	**500**	652.82 (131.13)	0	.212
Potassium (mg)	1096 28 (294.46)	0	3.0 *	847.28 (195.18)	0	-	1089.78 (220.07)	0	3.8 *	1190.34 (296.24)	0	-
Sodium (mg)	11.52.89 (332.04)	0	1.0 *	1246 (409.36)	0	-	1034.10 (302.25)	0	1.2 *	1326.19 (641.90)	0	-
Zinc (mg)	7.70 (2.07)	0	**3**	7.80 (1.16)	0	.876	7.05 (2.21)	0	**5**	8.84 (2.34)	0	**.053**
Selenium (mcg)	12.78 (6.59)	76.1	**20**	11.16 (4.91)	85.7	.501	12.74 (6.05)	89.4	**30**	13.64 (8.92)	90.9	.770
Iodine (mcg)	20.55 (10.89)	100	**90**	21.84 (5.50)	100	.687	16.83 (12.18)	100	**90**	31.98 (13.53)	100	**.006**
Vitamin A (mcg)	490.94 (282.27)	19.0	**300**	611.68 (278.60)	0	.345	374.75 (268.10)	47.3	**400**	673.86 (113.25)	0	**.000**
Thiamin (mg)	1 10 (0.33)	0	**0.5**	0.85 (0.11)	0	**.007**	0.98 (0.27)	0	**0.6**	1.07 (0.16)	0	.265
Riboflavin (mg)	1 5 (0.774)	0	**0.5**	1.44 (0.34)	0	.611	1.74 (0.39)	0	**0.6**	2.44 (1.32)	0	.114
Niacin (mg)	15.78 (4.63)	0	**6**	14.08 (2.16)	0	.204	14.02 (3.66)	0	**8**	17.36 (3.83)	0	**.030**
Vitamin B6 (mg)	2 22 (0.70)	0	**0.5**	2.40 (0.46)	0	.449	1.87 (0.56)	0	**0.6**	2.89 (1.01)	0	**.008**
Folate (mcg)	270.37 (81.80)	0	**150**	241.76 (41.08)	0	.240	265.28 (75.78)	0	**200**	280.72 (60.50)	0	.546
Vit B12 (mcg)	3.03 (1.70)	0	**0.9**	2.31 (1.45)	0	.298	2.77 (1.39)	0	**1.2**	2.17 (0.60)	0	.113

Table 5.18: Boys' analysis of nutrient intake at baseline

	Boys 24-47 months (n=28)						Boys 48 -60 months (n=30)					
	EG (=21)			CG n=7)			EG (n=19)			CG (n=11)		
Nutrient	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean nutrient intake (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Pantothenate (mg)	3.08 (1.11)	19.0	2.0 *	2.55 (0.80)	28.5	**.000**	3.01 (0.66)	42.1	3.0 *	3.56 (0.97)	27.2	.115
Biotin (mcg)	17.24 (10 25)	4.7	8.0 *	18.48 (9.42)	0	.774	16.23 (9.22)	66.6	12 *	22.27 (5.18)	0	**.029**
Vitamin C (mg)	41.21 (25.70)	14.2	**15**	57.36 (30.59)	0	.240	34.00 (18.11)	66.6	**25**	68.68 (27.92)	0	**.002**
Vitamin D (mcg)	3.75 (1.95)	80.9	5 *	4.06 (1.149)	28.5	.616	2.80 (1.55)	84.2	5 *	5.17 (2.18)	45.4	**.006**
Vitamin E (mg)	8.05 (2.35)	0	**6**	6.98 (2.08)	14.2	.277	7.07 (2.14)	31.5	7	9.27 (2.64)	9.0	**.030**
Vitamin K (mcg)	50.22 (94.80)	61.9	30 *	46.27 (13.92)	14.2	.855	22.03 (22.44)	94.7	55 *	23.57 (6.03)	100	.780

Institute of Medicine 2001; SD: standard deviation; RDA: Recommended Dietary Allowance in bold; AI*: adequate intake; No AI/RDA set for fat as there is no defined level of fat intake at which inadequacy or prevention of disease occurs; *p*-values given in bold font indicate that the mean nutrient intake is significantly different between the two groups. *P*-value of <0.05 shows statistical significance, CHO: carbohydrates

5.5.2 Top 10 foods consumed by EG and CG girls and boys 24-47 months of age at baseline

Table 5.19 shows that the top three food items consumed by EG girls 24-47 months of age were maize meal (with a daily mean intake of 3986.00g and 173.30g per capita intake), white rice (with a daily mean intake of 2454.00g and 106.70g per capita intake) and diluted squash drink (with a daily mean intake of 2308.33ml and 100.36ml per capita intake). Apple (with a daily mean intake of 590.00g and 25.65g per capita intake) was the only fruit that appeared on the top ten list for girls in EG. In the CG, the top three items were diluted squash drink (with a daily mean intake of 1083.33ml and 154.76ml per capita intake), maize meal (with a daily mean intake was 996.33g and 142.33g per capita intake) and instant vanilla porridge (with a daily mean intake of 554.67g and 79.24g per capita intake). Banana (with a daily mean intake of 200.00g and 28.57g per capita intake) was the only fruit that appeared in the top ten list for girls in the CG.

Table 5.19 further shows that the top three food items consumed by EG boys 24-47 months of age were maize meal (with a daily mean intake of 4284.67g and 204.03g per capita intake), diluted squash drink (with a daily mean intake of 2375.00ml and 113.10ml per capita intake) and white rice (with a daily mean intake of 2325.00g and 110.71g per capita intake). Apple (with a daily mean intake of 740.00g and 35.24g per capita intake) was the only fruit that appeared in the top ten list for boys in the EG. In the CG, the top three items were diluted squash drink (with a daily mean intake of 933.33ml and 133.33ml per capita intake), maize meal (with a daily mean intake was 870.67g and 124.38g per capita intake) and instant vanilla porridge (with a daily mean intake of 752.00g and 107.43g per capita intake). Two fruits that appeared in the top ten list for boys in the CG were apple at number nine (with a daily mean intake of 120.00g and 17.14g per capita intake) and banana at number ten (with a daily mean intake of 100.00g and 14.29g per capita intake).

Table 5.19: Top 10 food items consumed by EG and CG girls and boys 24-47 months of age at baseline

EG girls (n=23)				CG girls (n=7)				EG boys (n=21)				CG boys (n=7)			
No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)	No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)	No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)	No.	Item	Mean intake 1 day (g/ml	Per capita intake 1 day (g/ml)
1	Maize meal	3986.00	173.30	1	Diluted squash drink	1083.33	154.76	1	Maize meal	4284.67	204.03	1	Diluted squash drink	933.33	133.33
2	White rice	2454.00	106.70	2	Maize meal	996.33	142.33	2	Diluted squash drink	2375.00	113.10	2	Maize meal	870.67	124.38
3	Diluted squash drink	2308.33	100.36	3	Instant vanilla porridge	554.67	79.24	3	White rice	2325.00	110.71	3	Instant vanilla porridge	752.00	107.43
4	Instant vanilla Porridge	1330.00	57.83	4	Tea, brewed	500.00	71.43	4	Milk	1556.67	74.13	4	Bread	533.33	76.19
5	Bread	1080.00	46.96	5	White rice	482.67	68.95	5	Bread	1196.67	56.98	5	White rice	491.33	70.19
6	Milk	911.67	39.64	6	Bread	303.33	43.33	6	Instant vanilla porridge	1076.67	51.27	6	*Phuthu* and *maas*	312.00	44.57
7	Tea, brewed	808.33	35.14	7	Steamed bread	213.33	30.48	7	Tea, brewed	968.33	46.11	7	Milk	165.00	23.57
8	Crèche pilchard curry	617.00	26.83	8	Banana	200.00	28.57	8	Apple	740.00	35.24	8	Oats	153.33	21.90
9	Apple	590.00	25.65	9	Crèche sausage curry	180.00	25.71	9	Crèche pilchard curry	486.00	23.14	9	Apple	120.00	17.14
10	Crèche sausage curry	570.00	24.78	10	Milk	166.67	23.81	10	Crèche sausage curry	450.00	21.43	10	Banana	100.00	14.29

5.5.3 Top 10 foods consumed by EG and CG girls and boys 48-60 months of age at baseline

Table 5.20 shows that maize meal was the most consumed food items in the EG girls, with a daily mean intake of 2359.67 g and a per capita intake of 147.47g. White rice followed at number two with a daily mean intake of 2093.33g and a per capita intake of 130.83g. In the CG girls, however, instant vanilla porridge was at number one (with a daily mean intake of 2022.67g and a per capita intake of 168.56g) followed by maize meal at number two (with a daily mean intake of 1943.00g and a per capita intake of 161.92g). Diluted squash drink was at number three in both groups, with a daily mean intake of 1566.67ml and a per capita intake of 97.91ml for girls in the EG, and a daily mean intake of 1527.33ml and a per capita intake of 127.28ml for girls in the CG.

For boys in the EG, maize meal (with a daily mean intake of 4940.00g and a per capita intake of 260.00g), white rice (with a daily mean intake of 2774.50g and a per capita intake of 146.03g) and diluted squash drink (with a daily mean intake of 1745.00ml and a per capita intake of 91.84ml) were the top three items consumed. Protein-rich sources that appeared in the top ten included pilchard curry (with a daily mean intake of 505.33g and a per capita intake of 26.60g) at number nine and chicken curry (with a daily mean intake of 446.00 g and a per capita intake of 23.47g) at number ten. The most consumed items among boys in the CG were instant vanilla porridge (with a daily mean intake of 1484.67g and a per capita intake of 134.97g), maize meal (with a daily mean intake of 1232.33g and a per capita intake of 112.03g) and diluted squash drink (with a daily mean intake of 1166.67ml and a per capita intake of 106.06ml).

Table 5.20: Top 10 foods consumed by EG and CG girls and boys 48-60 months of age at baseline

EG girls (n=16)				CG girls (n=12)				EG boys (n=19)				CG boys (n=11)			
No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)	No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)	No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)	No.	Item	Mean intake 1 day (g/ml)	Per capita intake 1 day (g/ml)
1	Maize meal	2359.67	147.47	1	Instant vanilla porridge	2022.67	168 56	1	Maize meal	4940.00	260.00	1	Instant vanilla porridge	1484.67	134 97
2	White rice	2093.33	130.83	2	Maize meal	1943.00	161 92	2	White rice	2774.50	146.03	2	Maize meal	1232.33	112.03
3	Diluted squash drink	1566.67	97.91	3	Diluted squash drink	1527.33	127 28	3	Diluted squash drink	1745.00	91.84	3	Diluted squash drink	1166.67	106.06
4	Milk	986.67	61.66	4	White rice	1058.67	88.22	4	Milk	1350.00	71.05	4	*Phuthu* and *maas*	850.67	77.33
5	Instant vanilla porridge	886.67	55.41	5	Bread	863.33	71.94	5	Bread	690.00	36.32	5	Milk	833.33	75.76
6	Bread	666.67	41.66	6	Banana	496.33	41.36	6	Apple	610.00	32.11	6	White rice	767.33	69.76
7	Apple	486.67	30.41	7	Tea, brewed	483.33	40.28	7	Instant vanilla porridge	570.00	30.00	7	Apple	625.00	56.82
8	Crèche sausage curry	411.67	25.72	8	Milk	463.33	38.61	8	Tea, brewed	566.67	29.80	8	Orange	330.00	30.00
9	Chicken curry	403.33	25.20	9	Apple	427.33	35.61	9	Pilchard curry	505.33	26.60	9	Potato stew	285.67	25.97
10	Crèche pilchard curry	393.33	24.58	10	Savoury snack	351.00	29.25	10	Chicken curry	446.00	23.47	10	Savoury snack	219.33	19.94

5.5.4 Macronutrient distribution range at baseline

Table 5.21 indicates that for fat, the mean percentage energy contribution for girls 24-47 months of age was below the recommended 30-40% (IOM 2001: 769). The boys in this age group were also below the recommended 30-40% (IOM 2001: 769). With regards to the contribution of protein to total energy, the mean percentage energy contribution was within the recommended amounts (between 5%-20%) (IOM 2001: 769) for both genders in both groups in this age category. In both groups, the mean percentage contribution of carbohydrates to total energy for boys in both groups was within the recommended 45-65% (IOM 2001: 769).

Table 5.21: Macronutrient distribution range for girls and boys 24-47 months of age at baseline (IOM 2001: 769)

	EG (n-44)				CG (n=14)				
	Girls (n=23)		Boys (n=21)		Girls (n=7)		Boys (n=7)		
Macronutrients	**Mean (SD)**	**Mean % Energy**	**Mean (SD)**	**Mean % Energy**	**Mean (SD)**	**Mean % Energy**	**Mean (SD)**	**Mean % Energy**	**IOM recommendation**
Total fat (g)	37.9 (12.40)	27.4	37.4 (9.14)	25.1	32.8 (6.02)	25.9	32.3 (10.31)	25.0	30-40%
Protein (g)	35.2 (10.48)	11.7	39.8 (9.40)	12.2	31.1 (5.70)	11.2	33.7 (5.22)	12.0	5-20%
Carbohydrates and fibre (g)	182.8 (47.86)	60.8	203.2 (38.64)	62.6	173.7 (29.21)	62.8	177.0 (19.88)	62.9	45-65%

Table 5.22 shows the macronutrient distribution range for girls and boys between 48-60 months. In this age group, the mean percentage energy contribution of fat for boys in the CG (24.5%) was slightly below the recommended 25-35% (IOM 2001: 769). The other groups were within the recommended range (IOM 2001: 769), with boys in the EG having 26.0% contribution of energy from fat, and girls at 28.5% and 25.1% in the EG and CG, respectively. The contribution of protein was within the recommended 10-30% for both groups (IOM 2001: 769).

Table 5.22: Macronutrient distribution range for girls and boys 48-60 months of age at baseline (IOM 2001: 769)

	EG (n=36)				CG (n=23)				
	Girls (n=16)		Boys (n=19)		Girls (n=12)		Boys (n=11)		
Macronutrients	**Mean (SD)**	**Mean % Energy**	**Mean (SD)**	**Mean % Energy**	**Mean (SD)**	**Mean % Energy**	**Mean (SD)**	**Mean % Energy**	**IOM recommendation**
Total fat (g)	41.9 (15.46)	28.5	37.8 (8.53)	26.0	43.7 (30.45)	25.1	38.8 (10.42)	24.5	25-35%
Protein (g)	41.0 (12.14)	12.8	38.6 (8.56)	12.2	41.6 (18.32)	11.0	39.9 (7.22)	11.5	10-30%
Carbohydrates and fibre (g)	187.7 (32.00)	58.6	195.5 (28.57)	61.7	241.6 (46.42)	63.8	220.3 (32.70)	63.9	45-65%

5.5.5 Fruit and vegetable intake at baseline

WHO promotes a regular intake of fruit and vegetables as part of a healthy eating plan for individuals of all ages (WHO 2019d). Table 5.23 indicates that the daily mean intake of fruit and vegetables for girls 24-47 months of age was 64.57g and 83.57g for the EG and CG, respectively. For girls 48-60 months of age, there was a significant difference (p=0.000) in the daily mean fruit and vegetable intake between the EG (69.22g) and the CG (168.26g). For boys 48-60 months of age, Anova tests show a significant difference in the daily mean fruit and vegetable intake (p=0.005). These results show for girls and boys, the daily mean fruit and vegetable intake was below the recommended daily intake of 320g to 480g per day (Naude 2013: S50).

Table 5.23: Mean fruit and vegetable intake for girls and boys at baseline

Girls 24-47 months			Girls 48-60 months		
EG (n=23) Mean (g) (SD)	**CG (n=7) Mean (g) (SD)**	**ANOVA *p*-value**	**EG (n=16) Mean (g) (SD)**	**CG (=12) Mean (g) (SD)**	**ANOVA *p*-value**
64.57 (50.91)	83.57 (32.22)	0.362	69.22 (43.44)	168.26 (66.08)	**0.000**
Boys 24-47 months			**Boys 48-60 months**		
EG (n=21) Mean (g) (SD)	**CG (n=7) Mean (g) (SD)**	**ANOVA *p*-value**	**EG (n=19) Mean (g) (SD)**	**CG (=11) Mean (g) (SD)**	**ANOVA *p*-value**
80.75 (50.44)	68.33 (42.78)	0.565	61.05 (41.99)	127.88 (60.45)	**0.005**

P-value of <0.05 shows statistical significance

5.5.6 Food variety and food group diversity scores at baseline

The Food Frequency questionnaire data was used to determine the FVS and FGDS (Matla 2008). The former score indicates the number of foods consumed within the nine food groups, whereas the latter score indicates the number of food groups an individual consumed over a seven-day period (Matla 2008) (Table 4.1 in Chapter Four).

A summary of the food group diversity for the EG and CG is presented in Table 5.24. A mean FVS of 40.48 and 32.27 (for EG and CG, respectively) was observed for all food consumed form all the food groups over the seven-day period and therefore indicated that the EG and CG had a medium FVS.

Table 5.24: Summary of the FVS for the EG and CG at baseline (n=79)

	EG			CG		
Food Group	**Mean of each food group**	**(SD)**	**Range of scores**	**Mean of each food group**	**(SD)**	**Range of scores**
Meat, poultry and fish	6.12	2.44	0-12	4.95	2.48	1-13
Eggs	1.00	0.00	0-1	1.00	0.00	0-1
Dairy	3.72	1.63	0-8	2.81	1.26	1-6
Cereals, roots and tubers	7.03	1.40	0-10	6.43	1.59	3-9
Legumes and nuts	1.97	0.94	0-5	1.71	0.86	0-4
Vitamin A rich fruit and vegetables	3.93	1.80	0-8	2.38	1.30	0-7
Other fruit	6.78	2.77	0-13	5.49	2.76	1-16
Other vegetables	7.27	2.61	0-13	4.97	2.63	0-13
Fats and oils	4.01	1.22	0-6	3.43	1.24	0-5
Total number of food items	40.48	12.100	11-64	32.27	11.17	11-67

Low food variety=0-3 food groups or <30 individual foods; Medium food variety=4-5 food groups or 30-60 individual foods; High food variety=6-9 food groups or >60 individual foods (Matla 2008)

Table 5.25 indicates that the majority (68.4%; n=54) of participants in the EG ate from nine food groups, whereas in the CG, 62.2% (n=23) ate from the nine food groups. Twenty-one point five percent (n=17) and 24.3% (n=9) of participants ate from eight food groups in the EG and CG, respectively. Furthermore, 7.6% (n=6) and 10.8% (n=4) of participants in the EG and CG respectively, ate from seven food groups.

Table 5.25: FGDS of EG and CG participants at baseline

Number of food groups	EG (n=79) % (n)	CG (n=37) % (n)
3	1.3 (1)	0 (0)
6	1.3 (1)	2.7 (1)
7	7.6 (6)	10.8 (4)
8	21.5 (17)	24.3 (9)
9	68.4 (54)	62.2 (23)

Low food variety=0-3 food groups; Medium food variety=4-5 food groups; High food variety=6-9 food groups (Matla 2008)

5.5.7 Mean nutrient adequacy ratio for nutrients for all girls and boys at baseline

This section presents the NAR of selected nutrients closes to 100% at baseline. ANOVA tests show that with increased food group diversity from seven to eight food groups, there was a significant increase in the NAR for energy for EG girls 48-60 months of age (p=0.000). For EG and CG boys 48-60 months of age, an increase in FGDS from eight to nine food groups showed a significant increase in the NAR (p=0.007 and p=0.000, respectively). Even though an increase in FGDS showed an increase in the NAR for calcium for most groups, no significant differences were noted. With increased food group diversity from eight to nine food groups, there was a significant increase in the NAR for vitamin A for EG boys 24-47 months (p=0.014) (Table 5.26).

Table 5.26: The mean NAR for energy and calcium at different levels of FGDS for EG and CG girls and boys at baseline

Group	Age in months (n=)	FGDS	Mean NAR % for Energy (SD)	ANOVA *p*-value	Mean NAR % for Calcium (SD)	ANOVA *p*-value	Mean NAR % for vitamin A (SD)	ANOVA *p*-value	Mean NAR % for vitamin C (SD)	ANOVA *p*-value
Girls	EG Girls 24-47 months (n=23)	8	101.93 (21.48)	.721	93.54 (33.55)	.438	72.32 (11.48)	**.026**	73.43 (42.70)	.007
		9	104.46 (25.96)		103.34 (49.66)		109 26 (73.54)		117.50 (61 29	
	CG Girls 24-47 months (n=7)	6	61.52 (61.52)	.753	35.93 (35.93)	.415	166 98 (166.98)	.647	211.62 (211.62)	.317
		9	69.26 (9.41)		48.54 (14.54)		202 19 (104.82)		322.55 (184.94)	
	EG Girls 48-60 months (n=16)	7	59.43 (3.43)	**.000**	35.16 (2.06)	.097	157.48 (22.74)	.295	142.78 (49.74)	.137
		8	81.67 (17.41)		40.40 (11.70)		190 98 (153.71)		177.66 (76.03)	
	CG Girls 48-60 months (n12)	7	102.58 (36.20)	.232	55.15 (21.62)	.135	262.63 (26.39)	.617	381.40 (137.20)	.822
		8	88.24 (16.80)		42.41 (18.48)		251.08 (73.66)		368.17 (147.05)	
Boys	EG Boys 24-47 months (n=21)	8	75.90 (13.51)	.934	60.78 (34.39)	.772	173 14 (63.19)	**.014**	246.35 (112.20)	.056
		9	76.26 (14.42)		63.41 (22.70)		254.06 (127.52)		347.50 (204.50)	
	CG Boys24-47 months (n=7)	8	69.46 (16.64)	.506	87.33 (69.54)	.168	312.78 (43.45)	.606	613.92 (439.20)	.185
		9	64.63 (7.89)		45.79 (13.16)		274 26 (183.48)		359.31 (132.38)	
	EG Boys 48-60 months (n=19)	8	66.91 (5.98)	**.007**	4.97 (5.17)	.903	155.89 (178.35)	.676	118.65 (64.66)	**.033**
		9	76.18 (12.37)		4.81 (2.25)		136 97 (78.66)		175.93 (91.97)	
	CG Boys 48-60 months (n=11)	8	71.02 (7.69)	**.000**	51.23 (16.37)	.509	236.41 (19.50)	.295	495.20 (53.60)	**.000**
		9	86.60 (8.06)		58.16 (29.76)		252.82 (45.95)		269.02 (110.75)	

P-value of <0.05 shows statistical significance

5.6 Baseline blood results for serum retinol and Hb

Out of the 79 participants that were part of the baseline in the EG, only 73 blood samples were obtained due to absenteeism. The serum retinol could not be detected in eight of those blood samples and Hb values were detected in all blood samples obtained. In the CG, 28 blood samples were obtained, as nine participants were absent. From the 28 blood samples collected the serum retinol could not be detected in three samples. As the cut off points for VAD (<0.70 µmol/L, WHO 2009: para. 2 line 7) and Hb (<11.0 g/dL, WHO 2011: 3) are the same for girls and boys in both age categories the participants were grouped and results were presented as EG and CG. Results in Table 5.27 indicate that low iron levels were found in 19.2% (n=14) and 32.1% (n=9) of the participants in the EG and CG, respectively. The majority of participants had normal iron levels in both groups (80.8%; n=59) in the EG and 67.9% (n=19) in the CG. Low serum retinol levels

were found in 2.7% (n=2) of participants in the EG and 14.3% (n=4) in the CG. Serum retinol levels were not detected in 11% (n=8) and 10.7% (n=3) of samples in the EG and CG, respectively.

Table 5.27: Baseline blood results for serum retinol and Hb

Baseline blood results						
Variables	**EG (n=73)**			**CG (n=28)**		
	Low % (n)	**Normal % (n)**	**Not detected % (n)**	**Low % (n)**	**Normal % (n)**	**Not detected % (n)**
Serum retinol (µmol/L)	2.7 (2)	86.3 (63)	11 (8)	14.3 (4)	75 (21)	10.7 (3)
Hb (g/dL)	19.2 (14)	80.8 (59)	0 (0)	32.1 (9)	67.9 (19)	0 (0)

5.7 Comparison of baseline results between EG and CG

ANOVA tests in Table 5.28 show that EG boys 24-47 months of age had a significantly higher daily mean energy intake (5517.17kJ) than CG boys (4778.42kJ) (p=0.043).

Table 5.28: Baseline p-values for energy for EG and CG

		Energy (kJ)	
Gender	**Group and age in months (n)**	**Mean (SD)**	**ANOVA p-value**
Girls	**EG 24-47 (n=23)**	5113.11 (1326.79)	.268
	CG 24-47 (n=7)	4699.30 (626.09)	
	EG 48-60 (n=16)	5440.19 (1236.35)	.118
	CG 48-60 (n=12)	6432.76 (1801.06)	
Boys	**EG 24-47 (n=21)**	5517.17 (1018.51)	**.043**
	CG 24-47 (n=7)	4778.42 (668.48)	
	EG 48-60 (n=19)	5380.88 (799.84)	.137
	CG 48-60 (11)	5861.52 (832.02)	

P-value of <0.05 shows statistical significance

ANOVA tests in Table 5.29 show that at baseline, EG boys 24-47 months of age had a significantly higher daily mean protein intake (39.80g) compared to EG boys of the same age group (33.74g) (p=**0.046**) whereas EG boys 48-60 months of age had a significantly lower daily mean intake of calcium (37.06mg) (p=**0.000**), vitamin A (374.75mcg) (p=**0.000**), and vitamin B6 (1.87mg) (p=**0.008**) compared to CG boys of the same age group (445.43mg, 673.86mcg and 2.89mg, respectively).

Table 5.29: Means for protein intake and other micronutrients for EG and CG at baseline

		Protein (g)		Calcium (mg)		Iron (mg)		Zinc (mg)		Vitamin A (mcg)		Riboflavin (mg)		Vitamin B6 (mg)		Folate (mcg)		Vitamin C (mg)	
Gender	**Group and Age in months (n=)**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**
Girls	**EG 24-47 (n=23)**	35 23 (10 48)	195	262 94 (118 02)	059	9 11 (3 01)	063	6 69 (2 09)	076	498 38 (323 44)	421	1 63 (0 72)	833	1 93 (0 80)	230	230 11 (81 11)	**.025**	37 96 (21 55)	847
	CG 24-47 (n=7)	31 11 (5 70)		233 68 (70 55)		7 69 (1 00)		5 61 (1 01		414 04 (202 88)		1 58 (0 47)		1 69 (0 27)		184 26 (24 67)		39 87 (22 61)	
	EG 48-60 (n=16)	41 04 (12 14)	927	317 98 (88 46)	267	9 47 (2 84)	063	7 47 (2 27)	155	513 99 (395 10)	092	1 49 (0 56)	172	1 91 (0 78)	**.006**	234 00 (103 15)	319	38 13 (16 04)	**.000**
	CG 48-60 (n=12)	41 61 (18 32)		375 87 (156 60)		11 42 (2 46)		8 79 (2 41)		703 88 (144 34)		3 02 (3 60)		2 89 (0 90)		269 75 (82 76)		80 90 (28 86)	
Boys	**EG 24-47 (n=21)**	39 80 (9 40)	**.046**	312 68 (145 44)	887	10 64 (3 30)	114	7 70 (2 06)	875	490 94 (282 26)	345	1 55 (0 77)	608	2 22 (0 70)	442	270 37 (81 80)	240	41 21 (25 69)	240
	CG 24-47 (n=7)	33 74 (5 22)		301 77 (178 70)		9 25 (1 19)		7 80 (1 16)		611 68 (278 59)		1 44 (0 34)		2 40 (0 45)		241 76 (41 08)		57 36 (30 59)	
	EG 48-60 (n=19)	38 60 (8 56)	659	37 06 (22 41)	**.000**	9 76 (2 69)	638	7 05 (2 21)	052	374 75 (268 10)	**.000**	1 74 (0 39)	114	1 87 (0 56)	**.008**	265 28 (75 78)	546	34 00 (18 11)	**.002**
	CG 48-60 (n=11)	39 91 (7 22)		445 43 (193 21)		11 46 (1 80)		8 84 (2 33)		673 86 (113 25)		2 44 (1 32)		2 89 (1 00)		280 72 (60 50)		68 68 (27 92)	

P-value of <0.05 shows statistical significance

5.8 Discussion of results

5.8.1 Discussion of socio-demographic results

Like many semi-rural communities in SA, the housing structures were mainly built with bricks (91.1% in EG and 91.9% in CG), with the exception of a few that were made with mud or clay. Some participants lived in overcrowded households with between five and seven members in both groups (34.2 % in EG and 32.4% in CG), and some households had between eight to ten household members (15.2% and 13.5% in EG and CG, respectively). These results are consistent with findings by Hall *et al.* (2019: 250), who reported that 21% of children under six years reside in overcrowded households. Hall *et al*. (2019: 250) mentioned that overcrowding is more common among African and coloured children (19% and 21%, respectively), compared to Indian and white children (less than one percent). The authors also mentioned that children from poor socio-economic backgrounds are more likely to live in these conditions compared to children from affluent households (Hall *et al.* 2019: 250). The WHO (2018: 3) stated that children who live in overcrowded households are at a higher risk of contracting communicable diseases. A report by Statistics SA (2020: xv) found higher rates of child poverty in households with many children, households with seven or more members or in households where there were low levels of education.

The Constitution of SA in section 27 (1) (b) states that everyone has the right to have access to sufficient water (SA, Department of Justice 1996). This is, however, not the case for many South Africans and in this particular study, access to sanitation and essential services was inadequate. Regarding access to running water, less than half of the participants had a tap inside the house (45.6% in the EG and 32.4% in the CG). Most households in both groups had a tap outside the house, within the yard. Hall *et al.* (2019: 253) mentioned that just over half of children from the poorest households had access to safe water. This is highly concerning as children are susceptible to diseases such as diarrhoea and gastro-intestinal infections, which are linked to poor water quality (WHO 2018: xv). Furthermore, lack of access to safe water may result in poor sanitation and hygiene practices (WHO 2018: xv). Pests were common in many households and these included cockroaches, ants, flies and mosquitoes. Cockroaches and flies are often associated with poor hygiene conditions, especially waste removal or waste handling practices in the household (Donkor 2020: 5).

Haywood *et al*. (2021: 1) stated that a sanitary environment is essential for good health and may prevent the spread of communicable diseases. The authors also mentioned that adequate toilet facilities include flush/sewage toilets and well-ventilated pit latrines that are kept clean and disposal of waste safely with a minimum smell (Haywood *et al.* 2001: 1). Access to a flush toilet was very limited in both groups, as less than half of participants had a flush toilet (39.2% and 40.5% in EG and CG, respectively) and more than half of the participants had a pit latrine (60.8% in the EG and 59.5% in the CG). A higher percentage of households in the EG had access to waste removal services (75.9%) than in the CG (48.6%). Overall, this essential service was inadequately rendered to this community. This is a common problem in many communities in SA (Haywood *et al.* 2021: 2). Findings by Hall *et al.* (2019: 253) showed that in 2018, 78.6% of children in South Africa lived in households with basic sanitation. More than 95% of Indian, white and coloured children had access to adequate toilets, while only 76% of African children had access to adequate toilets. In KZN, the percentage was slightly lower at 76.2%. The statistics were worse in provinces like Limpopo and Mpumalanga (57.0% and 63.4%, respectively). Poor sanitation undermines children's health, safety and dignity and it is one of the indicators of inequality (Haywood *et al*. 2021: 1). Children residing in poorer households are most affected by poor sanitation (Statistics SA 2020: 28).

In both groups, the highest level of education in the household of most participants was Grade 12 and, in some households, the highest education level in the household was a college qualification, with a few Technikon or university qualifications. There was a high prevalence of unemployment in both groups. Most participants had been unemployed for longer than a year. This was not surprising as the unemployment rate in SA was very high at 30.8% in 2020 (Statistics SA 2020: 1). Furthermore, a low level of education is associated with a higher risk of poverty and low income (Wanka 2014: 68). This study predominantly consisted of low-income households as 11.5% and 20% of households in EG and CG, respectively, had an income that was less than R2000 per month. 44% of households in the EG and 13.5% in the CG had an income between R3501 and R6000 per month. A few households had over R6000 per month (10.8% in EG and 27% in the CG).

Many participants in the current study who reported that sometimes there was insufficient money for food in the household and some participants in the CG indicated that they always lacked money to purchase food. The percentage was higher in the EG than in the CG. Furthermore, the amount of money spent on food per month was significantly different between the two groups. These results are consistent with findings by Sambu (2019: 234), who reported that over 2.1 million

children in SA experienced hunger and 36% of them were from KZN. The author further stated that among racial groups, a higher percentage of African children live in households that experience hunger, compared to coloured, Indian and white children. Sambu (2019: 234) also stated that children who live in households that experience hunger are at increased risk of malnutrition. However, it is important to also note that hunger alone is not an indicator of food insecurity as dietary diversity, and consumption of nutrient-dense foods are also important. The findings from the SANHANES-1 study also showed that 28.3% of households in SA were at risk of hunger and 26.0% experienced hunger. KZN had the highest prevalence of households at risk of hunger (34.4%) (Shisana *et al.* 2013: 146).

A report by Statistics SA (2020: 16) stated that nationally, 62.1% of children between 0-17 years were multi-dimensionally poor, having at least three deprivations in any three dimensions. The levels of multi-dimensional poverty experienced by children in the current study population was not surprising, as KZN is in the top three leading provinces with high levels of multi-dimensionally poor children; eThekwini municipality is among the metropolitan municipalities with the highest prevalence of multi-dimensional child poverty (Statistics SA 2020: 17). This current study was conducted in a semi-rural area, and both groups were multi-dimensionally poor. These findings are in alignment with Statistics SA (2020: 13), who reported that the multidimensional poverty rate for children in SA is driven by children who reside in rural areas as they are more likely to be multidimensionally poor compared to children from urban areas. All the participants in the current study were back African children, therefore the findings indicating high levels of multidimensional poverty among this population group are similar to the report by Statistics SA (2020: 42), which showed that the percentage of children (between zero to four years of age and between five to twelve years of age) who are multidimensionally poor is higher among black African children than other population groups.

The largest contributor to multidimensional poverty in the current study was a lack of assets and a lack of sanitation. Similarly, Statistics SA (2020: 43) identified inadequate waste disposal services as one of the key drivers of multidimensional poverty as 94% of rural children between zero to four years were deprived of access to a drinking water source, sanitation and waste disposal (WASH). Additionally, the WHO (2018: 3) stated that inadequate access to safe, clean water and sanitation facilities affects personal hygiene and food safety, therefore increasing the risk of various infections. In the current study, most participants lived in sub-standard types of shelter, with houses that were small in size, some with floors made with cement or a carpet and some with leaking roofs.

The WHO (2018: xv) stated poor housing conditions is one of the characteristics of social and environmental inequality and may translate to health inequality. Furthermore, improving housing conditions can prevent diseases, reduce poverty and improve the quality of lives.

According to Statistics SA (2020: 18), a low level of education of the household head is also associated with a higher level of deprivation. The level of education of the head of households in the current study is unclear as the questionnaire asked the highest level of qualification of the adult respondent who answered the socio-demographic questionnaire on behalf of the child participant, who may not have been the household head. Statistics SA (2020: 42) stated that the poverty rate was higher in larger households with seven or more members. Crowded housing also increases the risk of exposure to infectious diseases (WHO 2018: 3). The prevalence of multidimensional poverty experienced in the current study could also possibly be linked to household size as many households had between five to seven and some between eight to ten household members in both groups. Furthermore, Statistics SA (2020: 42) reported that child multidimensional poverty was higher in households where no adult was employed and in households where only one adult was employed. In the current study, the high prevalence of unemployment in both groups contributed to poverty and food insecurity.

5.8.2 Discussion of anthropometric results

Anthropometric results show that over and undernutrition co-exist in the current study population, reflecting trends in developing countries (Abdullah 2015). The prevalence of stunting, overweight and obesity was high among the participants in the current study. The prevalence of stunting in the current study is similar to global trends as 21.9% of children are stunted globally (United Nations 2020b) and national findings from the SADHS (SA DOH *et al*. 2019: 179) indicated that in SA, stunting is the most common form of malnutrition in children below five years. Stunting was reported to be higher among boys than girls (30% and 25%, respectively). The prevalence was higher in rural areas (29%) compared to urban areas (26%). Shisana *et al*. (2013: 206) also reported that nationally, 26.9% of boys and 25.9% of girls below three years were stunted. Boys from rural informal areas had a significantly higher rate of stunting (23.2%), compared to urban formal areas (13.6%), whereas girls from urban informal areas had a higher prevalence compared to urban formal (20.9% and 10.4%, respectively). Moreover, a study conducted in eThekwini by Nzama (2015: 109) also showed among the two to three-year olds, 6.8% of girls and 10.9% of boys were stunted. Severe stunting in this age group was noted in 6.5% of boys. In children between four

and five years, 1.9% of girls and 2.1% of boys were stunted. Severe stunting was found in 1.9% of girls. Furthermore, the results in the current study are also similar to findings by Mwadiwa *et al*. (2016: 5), who conducted a study among pre-school children in Empangeni. The authors found that 4.8% of boys and 2.4 % of girls were stunted (Mwadiwa *et al*. 2016: 5).

In the 2020 Global Nutrition Report, stunting was also reported to be higher among children in rural areas whose mothers were less educated. Furthermore, stunting was also found to be higher in children from the poorest households (United Nations 2020b). Demographics showed that most participants in the current study were of low socio-economic status as results showed that many participants had low income, low level of education and poor housing. This could possibly be linked to the findings on stunting in the current study. Stunting is an indicator of chronic malnutrition compromising children's cognitive development, education, employment prospects and increasing risk of overweight and obesity (Shung-King *et al.* 2019).

Some participants in the current study were wasted. These findings are in alignment with global trends, as wasting reported in 7.3% of children below five years (Global Nutrition Report 2020). Likewise, Shisana *et al*. (2013: 206) found wasting in 3.4% of children under three years living in rural informal areas, 2.8% from rural formal areas and 0.6% from urban informal areas. The prevalence of wasting was reported to be higher among 10-14 year old girls and boys. According to findings by Mwadiwa *et al.* (2016: 5), wasting was higher in girls (7.1%) compared to boys (2.4%).

In the current study, none of the participants were underweight however overweight and obesity were prevalent. The prevalence of risk of overweight was higher among girls and boys in the EG than in the CG. The world is not on course in the global targets to reduce overweight in children and 5.9% of children below five years are overweight (United Nations 2020a). Overweight and obesity were also prevalent in boys and girls in the current study. Among boys, overweight was found in both groups, with a higher percentage in the CG. These results on overweight and obesity are comparable to findings by Sambu (2019: 237), who indicated that about 13% of South African children below five years are overweight and more boys were overweight (15%) than girls (11%). Nzama (2015: 109) also found a high prevalence of risk of overweight (42.3% and 32.6% of girls and boys between two and three years of age, respectively, and 29.4% of girls and 31.9% of boys between four to five years of age). The authors reported that 10.2% of girls and 24% of boys between two to three years of age were overweight, whereas among the four to five year olds, overweight was found in 11.7% and 10.6% of girls and boys, respectively. More girls were obese

than boys (5.1% compared to 4.3%). Furthermore, Mwadiwa *et al*. (2016: 5) reported that 4.8% of girls were at risk of overweight, 2.4% of boys were overweight and more girls were underweight (7.1%) than boys (4.8%).

According to the 2020 Global Nutrition Report, stunting and overweight can coexist in the same child simultaneously (United Nations 2020a). In the current study, micronutrient deficiencies, stunting, overweight and obesity co-existed in the study population. To actively direct public health initiatives, an understanding of the long-term dynamics of stunting in the South African context is required, in conjunction with the interplay of the obesogenic food environment (Makanjana and Naicker 2021: 10).

5.8.3 Discussion of food intake results

The energy intake of some participants in the current study was less than the EER, whereas for others, the energy intake exceeded the EER. The Centres for Disease Control and Prevention (CDC) linked an excessive energy intake with the development of overweight and obesity (CDC 2021: para. 2 line 2). This could possibly be a contributing factor the prevalence of overweight and obesity in the current study. According to CDC, childhood obesity reduces the quality of life, contributes the high incidence of being bullied, may result in anxiety and depression and increases the risk of health conditions in adulthood (CDC 2021: para. 7 line 6). The contribution of fat to total energy was below the recommended 30-40% for girls and boys between 24-47 months. For protein and carbohydrates, the contribution to total energy was within the Acceptable Macronutrient Distribution Range (AMDR) range recommended by IOM for all age groups. These results are consistent with Nzama and Napier (2017: 81), who reported that menus offered at selected childcare facilities did not meet the EER for energy for children between two and five years. The authors also reported that the menus did not provide adequate fibre and calcium. Similar results were reported by Mwadiwa *et al.* (2016: 7), who stated that the energy contribution of cycle menus offered to children between 12-36 months of age in an ECD centre was less than that the recommended amount, whereas in the second ECD it was slightly above the EER. In the current study, the daily mean intake of fibre was lower than the RDA for all groups and most participants consumed less than the RDA for fibre and calcium. Calcium deficiency reduces bone strength and may lead to osteoporosis and rickets (National Institutes of Health 2019a: 2). Although the mean intake of zinc was higher than the RDA for all girls in the current study, some girls in the 48-60

month age group did not meet the recommended intake for zinc. None of the participants consumed less than the RDA for iron. Similarly, Nzama and Napier (2017: 81) reported that in the two to three-year age group, 50% of the childcare facilities provided menus with adequate zinc and iron. In the current study, all girls met the RDA for vitamin A, whereas some EG boys 24-47 months of age consumed less than 100% of the RDA. Nzama and Napier (2017: 81) also reported that that in the three to five-year old age group, only 30% of the childcare facilities offered menus with adequate vitamin A. Results by Mwadiwa *et al.* (2016: 7) also indicated that the mean vitamin A intake of participants between two and three years of age was lower than the RDA for that age group. Early childhood is characterised by rapid growth; therefore, it is essential that the diet of young children supplies all the required nutrients in adequate amounts (Savarino *et al*. 2021: 11). Inadequate intake of nutrients increases the risk of the development of deficiencies and may impact growth negatively if interventions are not implemented timeously and effectively (Savarino *et al*. 2021: 11). Results in the current study also showed a low iodine intake among the participants in both age groups. This is surprising as salt is iodised in South Africa and this does not correlate with other studies conducted in children of the same group.

It has been well established that adequate fruit and vegetable consumption is crucial for the health of children (WHO 2019d: para. line 1). Globally and nationally, most children do not meet the recommended daily intake of fruit and vegetables (UNICEF 2019: 9). The results from the current study are no different. The daily mean fruit and vegetable intake was less than the recommended 320 g to 480 g per day for the 24-47 month age group and 400 g to 480 g for the 48-60 month age group and there was low variety in both groups. These findings compare with the global trends as 44% of children between six and 23 months are not fed fruit or vegetables (UNICEF 2019). Low fruit and vegetable intake was reported in South African studies such as the SANHANES-1 study by Shisana *et al.* (2013), Okop *et al.* (2019: 9), Nzama (2015: 117); and Mwadiwa *et al.* (2016: 6).

The mean FVS was 40.48 for the EG and 32.27 for CG. This indicated medium and low FVS for the EG and CG, respectively. Most participants in the current study consumed a lower variety of foods within a specific food group. A large percentage of participants consumed no legumes in a seven-day period (21.5% and 16.2% in EG and CG, respectively) and some consumed one type of legume (29.0% and 43% in EG and CG, respectively). This may explain the low fibre intake as presented in Tables 5.21 and 5.22. There was low variety regarding the consumption of vitamin A rich foods, as some participants did not consume any food items from this group and others between one and two vitamin A rich foods in seven days. These findings compare with global trends (United

Nations 2020a; UNICEF 2019). Cost is a major constraint contributing to low daily consumption of fruit and vegetables (Faber *et al.* 2001). Given that 65% of young children in SA live below the poverty line, affordability is related to the low consumption of fruit and vegetables (Hall *et al.* 2019; Naude 2013: S50). Moreover, the dislike of fruit and vegetables among children and the habit of not eating fruits and vegetables at an early age is another possible reason (Ragelienė 2021: 11). This could possibly be one of the reasons for low consumption of fruit and vegetables among the participants in the current study. According to Raggio and Gambaro (2018: 8), the sensory characteristics of vegetables and the habits of consumption in the family environment also play an important role in the acceptance or rejection of vegetables by children.

5.8.4 Discussion of blood results for serum retinol and Hb

Various programmes and strategies have been implemented in an effort to improve vitamin A intake and vitamin A status of children in SA. These include vitamin A supplementation for children between six months and five years, food fortification, implementation of home, school and community gardens and various nutrition education programmes targeting various groups **(**Laurie *et al*. 2008; Low *et al.* 2007; Van Jaarsveld *et al.* 2005; Van Jaarsveld *et al*. 2006). According to the SANHANES-1 study, approximately 44% of children in SA had VAD. The statistics were higher in boys than girls (49% and 39%, respectively). This showed a decrease when compared to previous findings by Labadarios *et al.* (2008) and Shisana *et al*. (2013). Statistics SA (2018) also reported that 61% of children below five years had anaemia. The incidence was higher among children from poor households. Findings from the current research study are consistent with these reports as low serum retinol and low Hb levels were found among the participants in the current study. In the CG, 14.3% of the participants had low serum retinol compared to 2.7% of participants in the EG. Moreover, the percentage of participants with low Hb levels was also higher in the CG (32.1%), compared to the EG (19.2%).

Assessing vitamin A status among this age group was very challenging. The blood samples in the current study were not collected using venipuncture as that would be invasive for children. The blood samples were drawn using a finger prick as detailed in Chapter Four. Specialised skills were required to conduct the blood analysis and due to the limited amount of blood obtained from a finger prick, serum retinol levels were undetected in some of the blood samples. This posed a major limitation to this study and is reported in Chapter seven as a limitation.

According to Abbaspour *et al.* (2014: 170), iron deficiency may be caused by inadequate dietary intake, reduced absorption and or utilization of iron, increased requirements or due to blood loss as a result of parasitic infections. Shisana *et al*. (2013: 217) indicated that nationally, 10.7% of children under five years had anaemia. This reflects a significant improvement from 28.9% as reported in the NFCS in 2005 (Labadarios *et al*. 2008). In the current study, despite the mean dietary intake of iron seeming adequate for all the participants, low Hb levels was found in 19.2% of participants in the EG and 32.1% in the CG. This prevalence is higher than findings from the SANHANES-1 study (Shisana *et al.* 2013). This suggests that there could be inaccurate reporting of food intake or possible issues related to iron absorption or utilisation. Co-morbid anaemia and stunting among children are highly prevalent in low- and middle-income countries (Tran *et al.* 2018: 35). Hence a syndemic framework approach is encouraged integrating the co-occurrence of health problems with social and environmental factors (Tran *et al*. 2018: 38).

5.9 Discussion of compared results

Most of the differences in energy intake between the EG and CG were not significant except for boys 24-47 months of age. Regarding other nutrients, the CG had a significantly higher mean for vitamin B6, calcium, vitamin A and vitamin C. This could possibly be linked to the CG having more fruit and vegetables compared to the EG and the CG having a higher mean fruit and vegetable intake than the EG.

5.10 Conclusion

It is important for more interventions to be implemented to address vitamin A and iron deficiency in children particularly due to the effects of these deficiencies on growth and immune function, as discussed in Chapter Two. As discussed in this chapter, various studies in different regions in SA show that some children under the age of five years are still consuming diets that lack essential nutrients and that malnutrition, in its various forms, is still prevalent among this group. Even though SA produces adequate food, there is a high prevalence of food insecurity at the household level. A high number of households, (particularly among black Africans and coloureds) are at risk of hunger. Food insecurity contributes to poor health and malnutrition, especially in vulnerable groups like children. As presented in this chapter, some participants have poor nutritional status. This therefore, highlights a need for more contextualised interventions to address food insecurity and malnutrition. The next chapter explains how the intervention was conducted.

CHAPTER 6: ENDLINE RESULTS AND DISCUSSION OF COMPARED RESULTS BETWEEN BASELINE AND ENDLINE

6.1 Introduction

The methodology used at endline was explained in Chapter 4 as all measurements used were the same at baseline and at endline, with the exception of the socio-demographic questionnaire which was not repeated at endline. This chapter will focus on presenting endline results and comparing baseline and endline data. The results that will be presented and compared include anthropometric results, dietary intake and results on vitamin A and iron levels. Dietary intake questionnaires and anthropometric measurements were conducted during the last week of October 2017. Due to logistical challenges with the team responsible for taking blood samples, the blood samples were taken in the second week of November 2017. The reader is to note differences in the sample size between baseline and endline due to loss to follow-up (Figure 6.1). The endline sample size for anthropometric measurements and dietary intake (n=70 for EG and n=37 for CG) differs from the sample size of the biochemical measurements (serum retinol and Hb) due to the inability to detect serum retinol A and Hb (n=54 for EG and n=22 for CG) in some of the samples, as explained in section 6.3.8.

The consort flow diagram for this research study is presented in Figure 6.1.

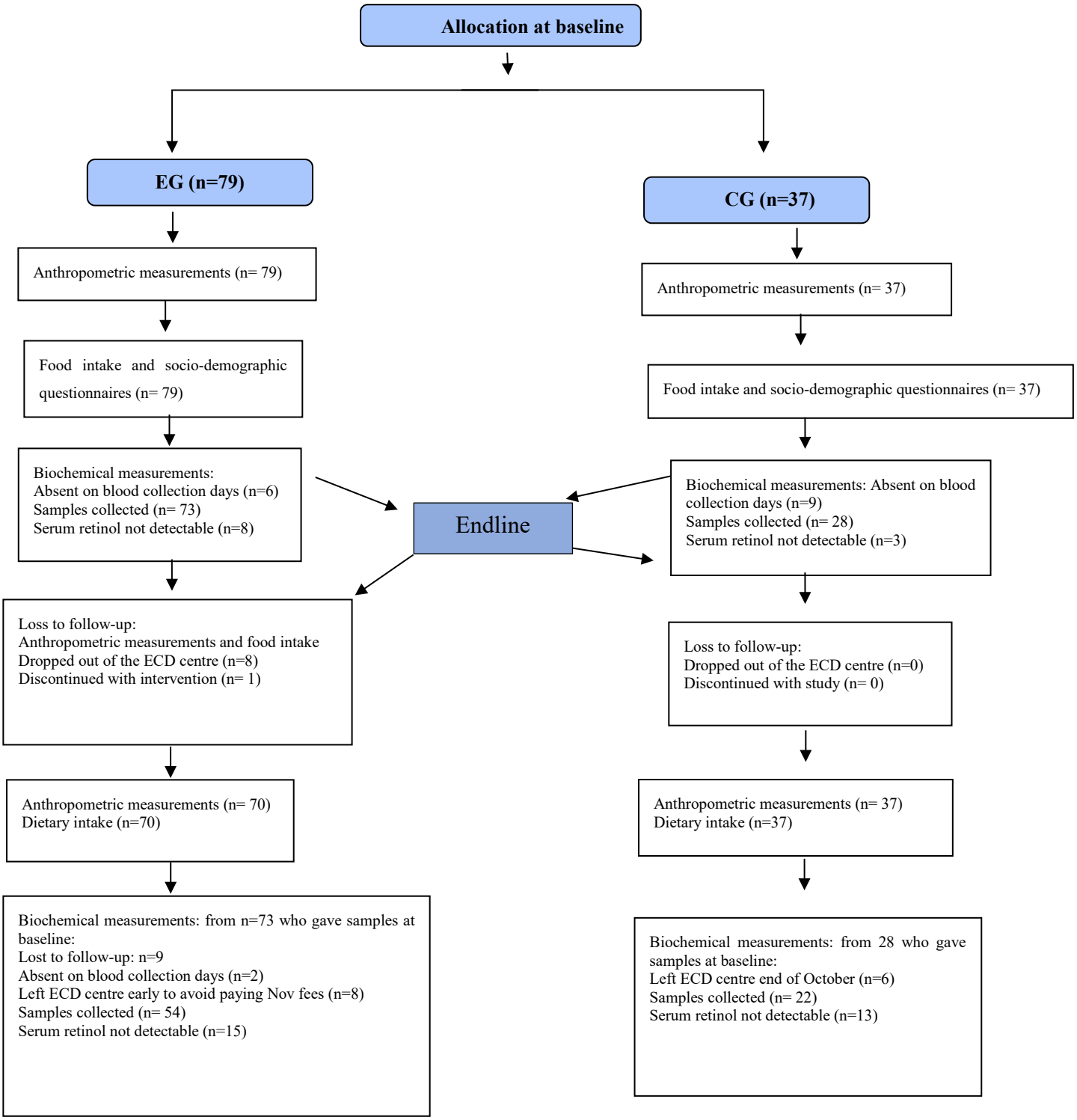

Figure 6.1: Consort flow diagram

6.2 Participant numbers for anthropometric results at endline

In the EG, the sample size at endline was less than at baseline due to loss to follow-up. In total, there were 31 girls in the EG (n=20 for 24-47 months of age and n=11 for 48-60 months of age) and 39 boys (n=20 for 24-47 months of age and n=19 for 48-60 months of age). There were no participants lost to follow-up in the CG; therefore, the sample size remained the same (n=37). Out of the 19 girls, seven were 24-47 months of age and 12 were 48-60 months of age. From the total of 18 boys, seven were 24-47 months of age and 11 were 48-60 months of age.

Table 6.1: Participant numbers for anthropometric results at endline

	EG (n=70)		CG (n=37)	
Gender	**24-47 months (n=40) % (n)**	**48-60 months (n=30) %(n)**	**24-47 months (n=14) % (n)**	**48-60 months (n=23) %(n)**
Girls	28.6 (20)	15.7 (11)	18.9 (7)	32.4 (12)
Boys	28.6 (20)	27.1(19)	18.9 (7)	29.7 (11)

6.3 Anthropometric results at endline

6.3.1 Girls' anthropometric results at endline

Table 6.2 shows that stunting was noted in 5% (n=1) of girls 24-47 months of age in the EG and in the CG 16.6% (n=2) of girls 48-60 months of age were stunted. Furthermore, 16.7% (n=2) of girls 48-60 months of age in the CG were severely stunted. In the EG, obesity was noted among 10% (n=2) of girls 24-47 months of age, whereas in the CG, it was noted in both age categories (14.3%; n=1 in girls 24-47 months of age and 41.7%; n=5 in girls 48-60 months of age). Similarly, overweight in the EG was found in 5% (n=1), whereas in the CG, it was found in both age groups (28.6%; n=2 in girls 24-47 months and 8.3%; n=1 girl between 48-60 months). In the 24-47 month of age group, more girls in the EG were at risk of overweight (45%; n=9) than the CG (28.6%; n=2). In the 48-60 months age group, 18.2% (n=2) of girls in the EG and 41.7% (n=5) in the CG were at risk of overweight.

Table 6.2: Girls' anthropometric results for EG and CG at endline

Z score	Classification	EG: Girls (n=31)		CG: Girls (n=19)	
Height for age:		**24-47 months (n=20) % (n)**	**48-60 months(n=11) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=12) % (n)**
>-2 SD to <+3SD	Normal height for age	95.0 (19)	100 (11)	100 (7)	66.7 (8)
<-2SD to >-3SD	Stunted	5.0 (1)	0	0	16.6 (2)
<-3SD	Severely stunted	0	0	0	16.7 (2)
Weight for height:		**24-47 months (n=20) % (n)**	**48-60 months months(n=11) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=12) % (n)**
>+3SD	Obese	10.0 (2)	0	14.3 (1)	41.7 (5)
>+2SD to <+3SD	Overweight	5.0 (1)	0	28.6 (2)	8.3 (1)
>+1 SD to<+2 SD	Possible risk of overweight	45.0 (9)	18.2 (2)	28.6 (2)	41.7 (5)
>-2 SD to <+1SD	Normal weight for height	40.0 (8)	81.8 (9)	28.6 (2)	8.3 (1)
<-2SD to >-3SD	Wasted	0	0	0	0
<-3SD	Severely wasted	0	0	0	0
Weight for age:		**24-47 months (n=20) % (n)**	**48-60 months months(n=11) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=12) % (n)**
<-2SD to >-3SD	Underweight	0	0	0	0
<-3SD	Severely underweight	0	0	0	0

6.3.2 Boys' anthropometric results at endline

Table 6.3 shows that stunting was only found in the CG as 14.3%; (n=1) of the younger boys were stunted and 36.4% (n=4) of the older boys were stunted. In the EG, 8.3% (n=1) boy was severely stunted among boys 24-47 months of age. Furthermore, obesity was found in 28.6% (n=2) of boys 24-47 months of age in the CG. Overweight was lower in the EG (5.0%; n=1 and 10.7%; n=2 in the EG in boys 24-47 months of age and 48-60 months of age, respectively) than in the CG (42.3%; n=3 among boys 24-47 months of age and 27.3%; n=3 among boys 48-60 months of age). In the EG, the risk of overweight was observed in 15.0% (n=3) and in 15.7% (n=3) of boys 24-47 months of age and 48-60 months of age, respectively. In the CG, 14.3% (n=1) of boys 24-47 months of age and 54.5% (n=6) of boys 48-60 months of age were at risk of overweight. Wasting was observed in one boy (5.0%) 24-47 months of age in the EG.

Table 6.3: Boys' anthropometric results for EG and CG at endline

Z score	Classification	EG: Boys (n=39)		CG: Boys (n=18)	
Height for age:		**24-47 months (n=20) % (n)**	**48-60 months (n=19) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=11) % (n)**
>-2 SD to <+3SD	Normal height for age	95.0 (19)	100 (19)	85.7 (6)	63.6 (7)
<-2SD to >-3SD	Stunted	0	0	14.3 (1)	36.4 (4)
<-3SD	Severely stunted	5.0 (1)	0	0	0
Weight for height:		**24-47 months (n=20) % (n)**	**48-60 months (n=19) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=11) % (n)**
>+3SD	Obese	0	0	28.6 (2)	0
>+2SD to <+3SD	Overweight	5.0 (1)	10.7 (2)	42.8 (3)	27.3 (3)
>+1 SD to<+2 SD	Possible risk of overweight	15.0 (3)	15.7 (3)	14.3 (1)	54.5 (6)
>-2 SD to <+1SD	Normal weight for height	75 (15)	73.6 (14)	14.3 (1)	18.2 (2)
<-2SD to >-3SD	Wasted	5.0 (1)	0	0	0
<-3SD	Severely wasted	0	0	0	0
Weight for age:		**24-47 months (n=20) % (n)**	**48-60 months (n=19) % (n)**	**24-47 months (n=7) % (n)**	**48-60 months (n=11) % (n)**
<-2SD to >-3SD	Underweight	0	0	0	0
<-3SD	Severely underweight	0	0	0	0

6.3.3 Combined anthropometric graphs for EG and CG at endline

The green growth standard distribution curve shows the ideal distribution for height for age, weight for height and weight for age per age group of the participants as per the WHO standards for growth indicators (WHO 2017b). Figure 6.2 shows that the height for age distribution curves for EG girls and boys were not in alignment with the WHO standards (WHO 2017b) as it showed stunting. The girls' pink distribution curve shows stunting as it falls below the green curve and is skewed more towards the right (mean z-score=0.25). The blue distribution curve for boys was above the ideal green curve (mean z-score=-0.19), indicating that there was no stunting in most of EG boys.

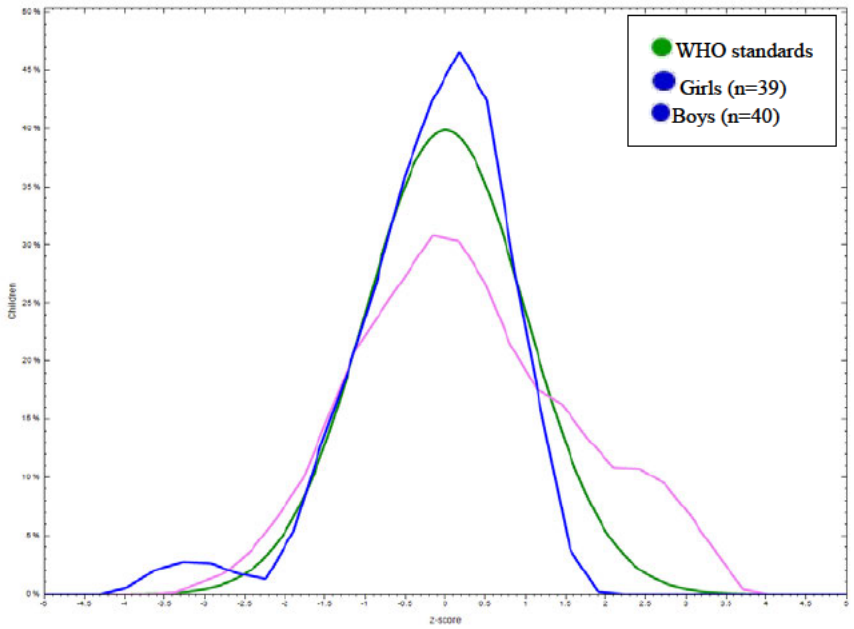

Figure 6.2: Height and age z-scores for the EG at endline

Figure 6.3 shows that there was stunting in the CG as the girls' and boys' CG height for age distribution curves were not in alignment with the WHO recommended green curve (WHO 2017b). Both were skewed more towards the left with a mean z-score of -0.33 for girls and a mean z-score of -1 for boys.

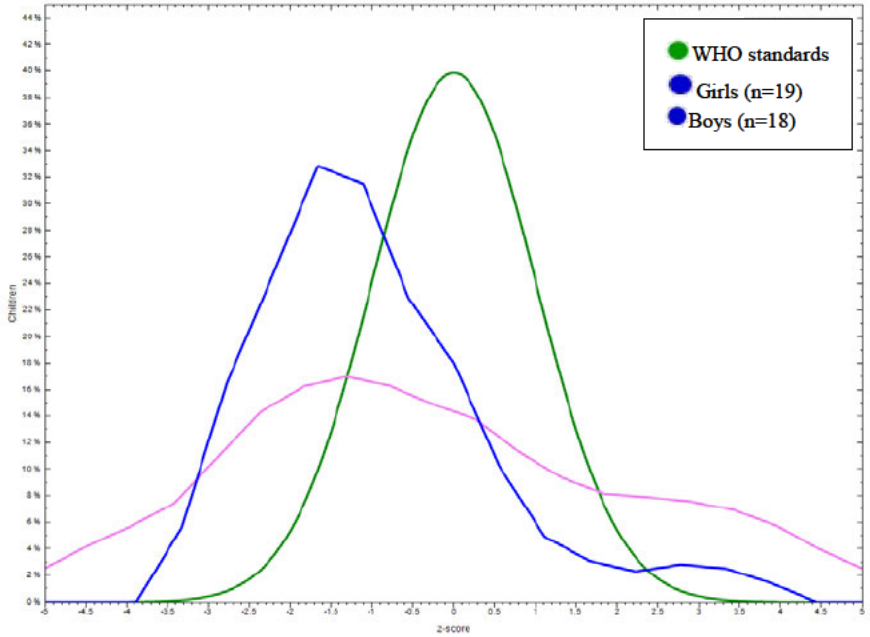

Figure 6.3: Height for age z-scores for the CG at endline

Figure 6.4 shows that the weight for height distribution curves for girls and boys in the EG fell below the WHO recommended green distribution curve (WHO 2017b) and the curves were skewed towards the right. The mean z-score was 0.70 for girls and 0.55 for boys.

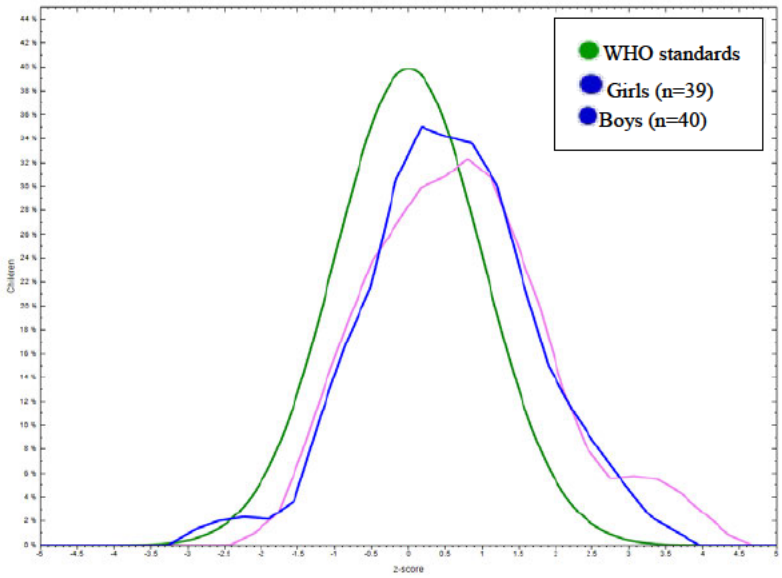

Figure 6.4: Weight for height z-scores for the EG at endline

Figure 6.5 shows that the weight for height distribution curves for girls and boys in the CG were not in alignment with the WHO green curve which indicates optimum weight for height for the age group (WHO 2017b). Both curves were skewed towards the right with a mean z-score of 2.18 and 1.79 for girls and boys, respectively.

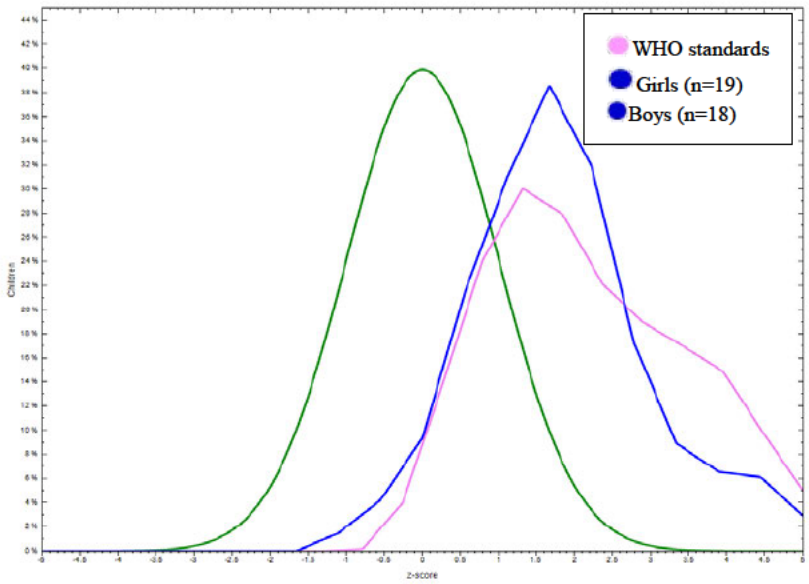

Figure 6.5: Weight for height z-scores for the CG at endline

Figure 6.6 shows that the weight for age distribution curves for girls and boys in both groups. Both the pink curve for girls (mean z-score= 0.65) and blue curve for boys (mean z-score=0.27) in the EG were noted to be above the ideal green WHO growth standard curve which indicates optimal weight for age (WHO 2017b). This indicates that some participants were overweight.

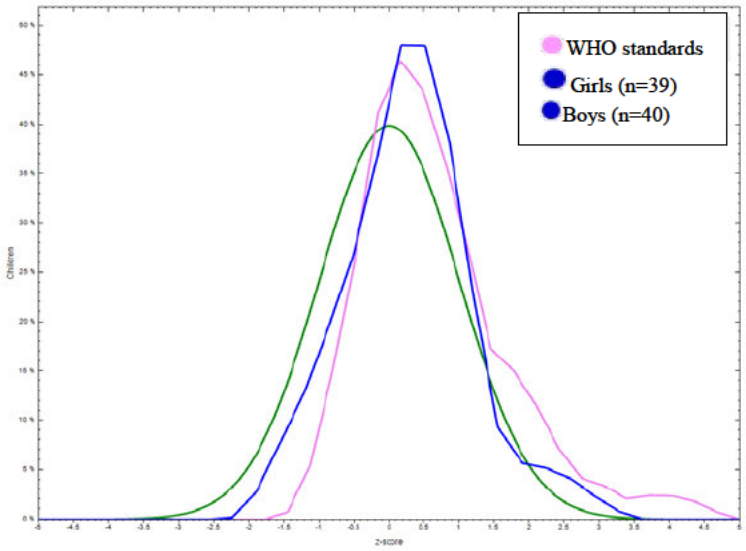

Figure 6.6: Weight for age z-scores for the EG at endline

Figure 6.7 indicates that the girls' pink distribution curve for weight for age (mean z-score=1.19) is below the recommended WHO green distribution curve, whereas the blue weight for age distribution curve for boys (mean z-score=0.59) was above the ideal green growth curve and the. Both curves were skewed more towards the right side of the WHO green growth distribution curve (WHO 2017b). This indicates that some participants were overweight.

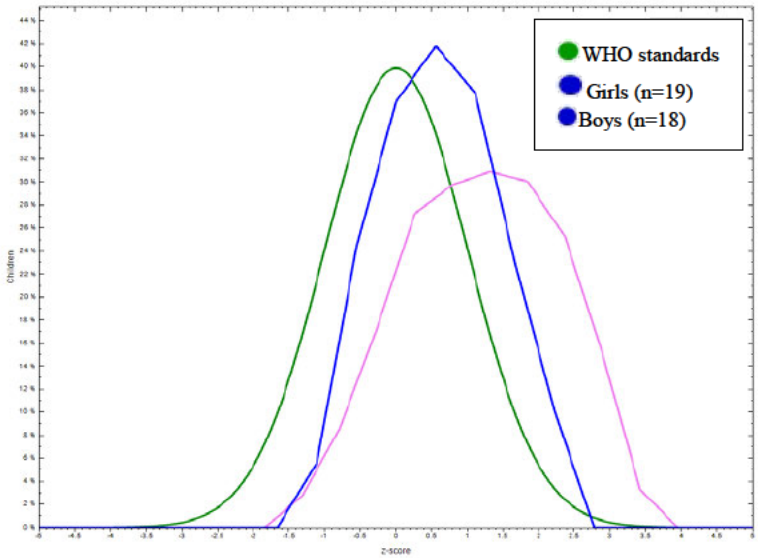

Figure 6.7: Weight for age z-scores for the CG at endline

6.4 Dietary intake

6.4.1 Analysis of dietary intake

Table 6.4 indicates that 50% (n=10) of girls in EG 24-47 months of age consumed less than 100% of EER for energy, and in the CG, all girls in this age group consumed less than the recommended 4150kJ for energy. The daily mean protein intake was higher than the recommended 13g per day in both groups in girls 24-47 months of age. Results also showed that in the age group, the daily mean intake of fibre was very low in both groups (9.37g in the EG and 8.33g for the CG) (p=0.173). Results also showed a low intake of calcium, with a daily mean intake of 202.41mg in the EG and 197.75mg in the CG (p=0.864). None of the girls met the AI intake of 500mg per day for calcium. Furthermore, 43% (n=3) of the girls consumed less than the RDA for vitamin A. For girls 48-60 months of age, the daily mean protein intake was higher than the RDA in the EG and CG. The daily mean intake of fibre was low in the EG and CG and in both groups, the mean calcium intake was lower than the AI. Furthermore, all girls in the EG and CG has a low iodine intake.

Table 6.4: Girls' analysis of nutrient intake at endline

	Girls 24-47 months of age (n=27)						Girls 48 -60 months of age (n=23					
	EG (n=20)			CG (n=7)			EG (n=11)			CG (n=12)		
Nutrient per day	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Energy (kJ)	4191.13 (817.48)	50	4150	3620.97 (296.68)	100	**.014**	4754.99 (1033.40)	91	6870	3340.85 (382.66)	100	**.001**
Protein (g)	33.01 (7.09)	0	**13**	23.25 (3.07)	0	**.000**	39.52 (7.86)	0	**19**	23.00 (5.10)	25	**.000**
Total fat (g)	26.31 (15.71)	-	-	28.30 (2.49)	-	.590	37.25 (14.77)		-	27.22 (6.012	-	**.000**
CHO (g)	139.88 (28.85)	10	**130**	119.82 (12.50)	14	**.019**	148.17 (25.31)	0	**130**	106.86 (10.27)	17	**.000**
Total dietary fibre (g)	9.37 (2.40)	100	19 *	8.33 (1.33)	100	.173	10.95 (2.61)	100	25 *	7.42 (2.01)	100	**.002**
Calcium (mg)	202.41 (102.33)	100	500 *	197.75 (37.94)	100	.864	234.65 (143.58)	100	800 *	178.44 (53.11)	100	.244
Iron (mg)	7.31 (1.79)	5	**7.0**	6.10 (1.11)	0	**.052**	8.43 (1.57)	0	**10**	5.48 (0.80)	0	**.000**
Magnesium (mg)	117.42 (31.16)	5	**80**	88.24 (10.09)	0	**.001**	129.79 (41.03)	45	**130**	80.43 (11.72)	100	**.003**
Phosphorus (mg)	457.76 (112.40)	15	**460**	373.13 (44.55)	71	**.010**	521.26 (154.66)	9	**500**	350.29 (53.88)	83	**.004**
Potassium (mg)	914.01 (317.15)	0	3.0 *	652.04 (81.89)	0	**.002**	993.97 (440.79)	0	3.8 *	607.68 (108.91)	0	**.016**
Sodium (mg)	917.17 (233.22)	0	1.0 *	602.88 (178.44)	0	**.003**	1167.68 (417.35)	0	1.2 *	653.09 (230.03)	0	**.002**
Zinc (mg)	6.13 (1.67)	0	**3**	4.24 (0.77)	0	**.001**	7.70 (1.76)	0	**5**	3.80 (0.47)	75	**.000**
Selenium (mcg)	13.34 (6.29)	70	**20**	10.91 (4.88)	86	.313	15.45 (5.20)	91	**30**	10.55 (5.11)	100	**.034**
Iodine (mcg)	17.22 (9.19)	100	**90**	10.66 (2.99)	100	**.010**	19.11 (11.58)	100	**90**	10.61 (6.53)	100	**.048**
Vitamin A (mcg)	477.67 (366.66)	20	**300**	712.48 (765.78)	43	.461	693.19 (956.23)	55	**400**	470.33 (584.25)	75	.514
Thiamin (mg)	0.70 (0.17)	5	**0.5**	0.54 (0.09)	0	**.005**	0.88 (0.21)	0	**0.6**	0.51 (0.09)	50	**.000**
Riboflavin (mg)	1.40 (0.67)	0	**0.5**	1.40 (0.35)	0	.000	1.61 (0.56)	0	**0.6**	1.07 (0.36)	0	**.015**
Niacin (mg)	11.76 (2.91)	0	**6**	7.35 (1.02)	0	**.000**	15.49 (3.02)	0	**8**	7.26 (1.62)	25	**.000**
Vitamin B6 (mg)	1.97 (0.65)	0	**0.5**	1.11 (0.31)	0	**.000**	2.50 (0.89)	0	**0.6**	0.98 (0.31)	0	**.000**

Table 6.4: Girls' analysis of nutrient intake at endline

	Girls 24-47 months of age (n=27)						Girls 48 -60 months of age (n=23					
	EG (n=20)			CG (n=7)			EG (n=11)			CG (n=12)		
Nutrient per day	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Folate (mcg)	206.17 (77.08)	5	**150**	220.78 (120.59)	14	.772	208.27 (51.27)	9	**200**	175.18 (91.22)	58	.293
Vit B12 (mcg)	2.83 (1.58)	10	**0.9**	3.08 (2.82)	14	.830	4.68 (9.23)	9	**1.2**	2.55 (2.29)	42	.472
Pantothenate (mg)	2.86 (0.84)	15	2.0 *	2.04 (0.82)	43	**.045**	3.60 (0.79)	27	3.0 *	1.80 (0.89)	92	**.002**
Biotin mcg	23.72 (16.01)	5	8.0 *	32.34 (29.58)	0	.486	20.15 (8.87)	9	12 *	22.02 (22.76)	58	.796
Vitamin C (mg)	28.12 (41.04)	5	**15**	17.32 (9.30)	29	.283	28.98 (40.36)	73	**25**	12.31 (3.79)	100	.202
Vitamin D (mcg)	1.94 (1.24)	95	5 *	1.41 (1.10)	100	.310	1.48 (1.32)	100	5 *	1.52 (0.96)	100	.935
Vitamin E (mg)	6.44 (2.39)	35	**6**	7.40 (2.09)	14	.335	6.93 (2.24)	36	**7**	5.87 (2.29)	67	.275
Vitamin K (mcg)	22.42 (27.37)	80	30 *	32.50 (14.31)	57	.231	27.46 (39.12)	91	55 *	37.15 (30.70)	83	.519

Institute of Medicine 2001; SD: standard deviation; RDA: Recommended Dietary Allowance in bold; AI*: adequate intake; p values given in bold font indicate that the mean nutrient intake is significantly different between the two groups. *P*-value of <0.05 shows statistical significance, CHO: carbohydrates

Table 6.5 shows that the daily mean energy intake for EG boys 24-47 months of age was 4420.41kJ and therefore higher than the EER, whereas in the CG, the daily mean energy intake (3677.57kJ) was lower than the EER (4376kJ) (p=0.011). The recommended fibre intake was not met in both groups (9.11g in the EG and 7.55g in the EG) (p=0.083). The calcium intake was inadequate among all the boys in this age group, and all consumed less than the recommended AI of 500mg per day. Even though the daily mean vitamin A intake was higher than the RDA in both groups in boys 24-47 months of age (415.00mcg in the EG and 204.03mcg in the CG) (p=0.015), some participants consumed less than the RDA of 300 mcg per day. For boys between 48-60 months, all participants from both groups also consumed less that the recommended energy intake of 7289kJ per day. With regard to protein intake, even though the daily mean intake was higher than the RDA of 19g per day (mean 33.87g in the EG and 21.13g in the CG) (p=0.000), 27% (n=3) of the boys in the CG consumed less than 100% of the RDA for protein. All boys in this age group consumed less than 100% of the RDA and AI for fibre and calcium, respectively. Furthermore, the 63% (n=12) of EG boys and 91% (n=10) of CG boys aged 48-60 months consumed less than the daily recommended RDA for vitamin A. All boys between 24/47 months of age and 48-60 months of age in the EG and CG consumed less that the RDA for iodine.

Table 6.5: Boys' analysis of nutrient intake at endline

	Boys 24-47 months of age (n=27)						Boys 48-60 months of age (n=30					
	EG (n=20)			CG (n=7)			EG (n=19)			CG (n=11)		
Nutrient per day	Mean (SD)	% of children consuming <100% of DRI	EER/ RDA/AI* per day	Mean (SD)	% of children consuming <100% of DRI	ANOVA *p*-value	Mean (SD)	% of children consuming <100% of DRI	EER/ RDA/AI* per day	Mean (SD)	% of children consuming <100% of DRI	ANOVA *p*-value
Energy (kJ)	4420.41 (753.21)	55	4376	3677.57 (518.54)	86	**.011**	4433.90 (661.29)	100	7289	3149 90 (406 22)	100	**.000**
Protein (g)	35.42 (0.57)	0	**13**	24.34 (4.42)	0	**.001**	33.87 (5.55)	0	**19**	21.13 (3.16)	27	**.000**
Total fat (g)	34.46 (10.55)		-	30.93 (6.45)	-	.312	30.81 (7.71)		-	26.17 (4.52)		**.000**
CHO (g)	140.48 (21.92)	0	**130**	117.21 (16.56)	14	.011	150.48 (21.33)	0	**130**	100.43 (13.85)	54	**.000**
Total dietary fibre (g)	9.11 (2.07)	100	19 *	7.55 (1.81)	100	.083	9.46 (1.52)	100	25 *	6.78 (1.29)	100	**.000**
Calcium (mg)	212.36 (119.33)	100	500 *	180.63 (37.75)	100	.304	236.42 (96.98)	100	800 *	164.15 (47.76)	100	**.000**
Iron (mg)	7.22 (1.21)	0	**7.0**	5.44 (1.18)	0	**.006**	7.20 (1.36)	0	**10**	4.70 (0.77)	9	**.000**
Magnesium (mg)	112.20 (20.43)	0	**80**	83.11 (15.64)	14	**.002**	117.44 (22.30)	36.8	**130**	71.28 (11.21)	100	**.000**
Phosphorus (mg)	473.81 (91.60)	0	**460**	358.09 (48.25)	14	**.000**	484.38 (95.42)	21	**500**	323.08 (54.34)	91	**.000**
Potassium (mg)	984.17 (274.45)		3.0 *	644.60 (97.90)	-	**.000**	922.97 (157.25)		3.8 *	545.63 (94.19)	-	**.000**
Sodium (mg)	972.08 (318.80)		1.0 *	630.03 (174.17)	-	**.002**	938.46 (394.51)		1.2 *	503.77 (147 54)	-	**.000**
Zinc (mg)	6.13 (1.10)	0	**3**	3.85 (0.67)	0	**.000**	5.90 (1.391)	5	**5**	3 36 (0.61)	82	**.000**
Selenium (mcg)	13.17 (3.80)	80	**20**	9.85 (3.66)	100	.066	11.47 (4.10)	100	**30**	8.05 (3.05)	100	**.000**
Iodine (mcg)	15.20 (5.59)	100	**90**	11.36 (4.97)	10	.115	13.30 (6.48)	100	**90**	7 25 (4.03)	0	**.000**
Vitamin A (mcg)	415.00 (347.47)	40	**300**	204.03 (45.65)	57	**.015**	394.37 (392.15)	63	**400**	250.75 (290.88)	91	**.000**
Thiamin (mg)	0.69 (0.13)	0	**0.5**	0.51 (0.11)	0	**.005**	0.71 (0.15)	10	**0.6**	0.47 (0.07)	9	**.000**
Riboflavin (mg)	1.15 (0.42)	5	**0.5**	1.05 (0.30)	0	.510	1.46 (0.58)	5	**0.6**	1.03 (0.38)	27	**.000**
Niacin (mg)	11.57 (2.05)	0	**6**	7.93 (1.76)	0	**.001**	11.52 (2.91)	0	**8**	7.03 (1.73)	18	**.000**
Vitamin B6 (mg)	1.91 (0.51)	0	**0.5**	1.01 (0.34)	0	**.000**	1.84 (0.73)	0	**0.6**	0.74 (0.29)	9	**.000**
Folate (mcg)	182.46 (68.26)	20	**150**	132.79 (19.69)	14	**.007**	184.21 (65.37)	47	**200**	132.25 (49.63)	91	**.000**

Table 6.5: Boys' analysis of nutrient intake at endline

	Boys 24-47 months of age (n=27)						Boys 48-60 months of age (n=30					
	EG (n=20)			CG (n=7)			EG (n=19)			CG (n=11)		
Nutrient per day	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**	**Mean (SD)**	**% of children consuming <100% of DRI**	**EER/ RDA/AI* per day**	**Mean (SD)**	**% of children consuming <100% of DRI**	**ANOVA *p*-value**
Vit B12 (mcg)	2.40 (1.27)	0	**0.9**	1.57 (0.98)	14	.098	2.51 (1.86)	15.7	**1.2**	1.72 (1.52)	55	**.000**
Pantothenate (mg)	2.85 (0.66)	5	2.0 *	2.13 (1.00)	43	.115	2.83 (0.68)	47	3.0 *	1 97 (0.84)	91	**.000**
Biotin (mcg)	20.24 (13.49)	0	8.0 *	10.81 (2.49)	14	**.007**	20.92 (16.78)	15.7	12 *	13.07 (11.81)	91	**.000**
Vitamin C (mg)	29.16 (30.30)	15	**15**	15.38 (8.36)	43	.077	38.75 (31.71)	52.6	**25**	12.25 (4.43)	100	**.000**
Vitamin D (mcg)	1.79 (1.02)	100	5 *	1.84 (0.95)	100	.909	1.47 (0.78)	100	5 *	1 24 (1.07)	100	**.000**
Vitamin E (mg)	6.51 (2.71)	35	**6**	7.63 (2.88)	28	.389	5.99 (2.60)	57.8	**7**	6 19 (1.83)	55	**.000**
Vitamin K (mcg)	29.16 (42.65)	75	30 *	52.20 (56.77)	71	.354	15.57 (14.98)	100	55 *	26.60 (7.86)	100	**.000**

Institute of Medicine 2001; SD: standard deviation; RDA: Recommended Dietary Allowance in bold; AI*: adequate intake; p values given in bold font indicate that the mean nutrient intake is significantly different between the two groups. *P*-value of <0.05 shows statistical significance, CHO: carbohydrates

6.4.2 Top 10 foods consumed by EG and CG girls and boys 24-47 months of age at endline

Table 6.6 shows that the top three food items consumed by EG girls 24-47 months of age were white rice (with a daily mean intake of 2178.67g and 108.93g per capita intake), maize meal (with a daily mean intake of 2173.33g and 108.67g per capita intake) and diluted squash drink (with a daily mean intake of 1641.67ml and 82.08ml per capita intake). Milk was the only dairy product appearing at number five, with a daily mean intake of 1263.3ml and 63.17ml per capita intake. In the CG, the top three items were maize meal (with a daily mean intake was 1069.33g and 97.21g per capita intake), diluted squash drink (with a daily mean intake of 833.33ml and 75.76ml per capita intake), and *phuthu* and *maas* (with a daily mean intake of 333.33g and 30.30g per capita intake).

The table further shows that the top three food items consumed by EG boys 24-47 months of age were maize meal (with a daily mean intake of 2455.33g and 122.77g per capita intake), white rice (with a daily mean intake of 2094.00g and 104.70g per capita intake) and diluted squash drink (with a daily mean intake of 1233.33ml and 61.67ml per capita intake). In the CG, the top three items were maize meal (with a daily mean intake was 1140.00g and 162.86g per capita intake), diluted squash drink (with a daily mean intake of 500.00ml and 71.43ml per capita intake), and *phuthu* and *maas* (with a daily mean intake of 291.67g and 41.67g per capita intake).

Table 6.6: Top 10 foods consumed by EG and CG girls and boys 24-47 months of age at endline

EG girls (n=20)				CG girls (n=7)				EG boys (n=20)				CG boys (n=7)			
No.	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**	**No.**	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**	**No.**	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**	**No.**	**Item**	**Mean intake 1 day(g/ml)**	**Per capita intake 1 day (g/ml)**
1	White rice	2178.67	108.93	1	Maize meal	1069.33	97.21	1	Maize meal	2455.33	122.77	1	Maize meal	1140.00	162.86
2	Maize meal	2173.33	108.67	2	Diluted squash drink	833.33	75.76	2	White rice	2094.00	104.70	2	Diluted squash drink	500.00	71.43
3	Diluted squash drink	1641.67	82.08	3	*Phuthu* and *maas*	333.33	30.30	3	Diluted squash drink	1233.33	61.67	3	*Phuthu* and *maas*	291.67	41.67
4	Tea, brewed	1356.67	67.83	4	Tea, brewed	266.67	24.24	4	Bread/ Rolls	1186.67	59.33	4	Tea, brewed	216.67	30.95
5	Milk	1263.33	63.17	5	Milk	229.00	20.82	5	Milk	920.00	46.00	5	Banana	175.00	25.00
6	Bread/ Rolls	1186.67	59.33	6	Banana	200.00	18.18	6	Chicken curry	590.00	29.50	6	Bread/Rolls	173.33	24.76
7	Chicken curry	476.00	23.80	7	Bread/Rolls	173.33	15.76	7	Beef mince	416.67	20.83	7	*Vetkoek*	160.00	22.86
8	Beef mince	353.33	17.67	8	Cabbage curry	116.67	10.61	8	*Vetkoek*	320.00	16.00	8	Chicken curry	160.00	22.86
9	Banana	336.67	16.83	9	Steamed bread	100.00	9.09	9	Apple	325.00	16.25	9	Milk	133.33	19.05
10	Apple	340.00	17.00	10	White rice	78.67	7.15	10	Potato	283.33	14.17	10	Steamed bread	120.00	17.14

6.4.3 Top 10 foods consumed by EG and CG girls and boys 48-60 months of age at endline

Table 6.7 shows that the top three food items consumed by EG girls 48-60 months of age were bread/rolls (with a daily mean intake of 880.00g and 80.00g per capita intake), white rice (with a daily mean intake of 839.33g and 76.30g per capita intake) and sugar (with a mean intake of 67.50g and 6.14g per capita intake. The top three items for CG girls 48-60 months of age were maize meal (with a daily mean intake was 1793.67g and 149.47g per capita intake), sugar (with a daily mean intake of 80.00g and 6.67g per capita intake) and margarine (with a daily mean intake of 45.00g and 3.75g per capita intake). Table 6.7 further shows that the top three food items consumed by EG boys 48-60 months of age were white rice (with a daily mean intake of 1924.67g and 101.30g per capita intake), baked bean curry (with a daily mean intake of 73.33g and 3.86g per capita intake) and sugar (with a mean intake of 109.17g and 5.75g per capita intake. In the CG, the top three foods were maize meal (with a daily mean intake of 1871.30g and 170.12g per capita intake), sugar (with a daily mean intake of 63.33 and 5.76g per capita intake) and margarine (with a daily mean intake of 46.67g and 4.24g per capita intake).

Table 6.7: Top 10 foods consumed by EG and CG girls and boys 48-60 months of age at endline

EG girls (n=11)				CG girls (n=12)				EG boys (n=19)				CG boys (n=11)			
No.	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**	**No.**	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**	**No.**	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**	**No.**	**Item**	**Mean intake 1 day (g/ml)**	**Per capita intake 1 day (g/ml)**
1	Bread/ Rolls	880.00	80.00	1	Maize meal	1793.64	149.47	1	White rice	1924.67	101.30	1	Maize meal	1871.30	170.12
2	White rice	839.33	76.30	2	Sugar	80.00	6.67	2	Baked bean curry	73.33	3.86	2	Sugar	63.33	5.76
3	Sugar	67.50	6.14	3	Margarine	45.00	3.75	3	Sugar	109.17	5.75	3	Margarine	46.67	4.24
4	Maize meal	985.00	89.55	4	Savoury Snack	104.67	8.72	4	Potato boiled	311.67	16.40	4	Savoury Snack	109.33	9.94
5	Savoury Snack	158.00	14.36	5	Cabbage curry	176.67	14.72	5	Mixed vegetables	91.33	4.81	5	White rice	200.00	18.18
6	Chicken Stew	504.83	45.89	6	Diluted squash drink	100.00	83.33	6	Maize meal	1910.00	100.53	6	Chicken curry	285.00	25.91
7	Mixed vegetables	92.33	8.39	7	*Phuthu and maas*	500.00	41.67	7	Milk	1261.67	66.40	7	Cabbage curry	166.67	15.15
8	Milk	598.33	54.39	8	Bread/Rolls	280.00	23.33	8	Savoury Snack	251.67	13.25	8	Soup powder	43.33	3.94
9	Diluted squash drink	150.00	104.55	9	White rice	175.00	14.58	9	Bread/Rolls	1040.00	54.74	9	Diluted squash drink	875.00	79.55
10	Potato boiled	120.00	10.91	10	Steamed bread	200.00	16.67	10	Chicken curry	583.33	30.70	10	*Phuthu and maas*	44.67	40.61

6.4.4 Macronutrient distribution range at endline

The results of the energy distribution of macronutrients from the average of three 24-hour recalls were compared to IOM recommendations (IOM 2001: 769). The fat intake was below the recommended 30-40% for the girls 24-47 months of age in both groups (IOM 2001: 769). The contribution of protein was within the recommended 5-20% for girls and boys (IOM 2001: 769). The contribution of carbohydrates towards the total energy intake was within the 45-65% recommendation for girls and boys in this age group (IOM 2001: 769) (Table 6.8).

Table 6.8: Macronutrient distribution range for girls and boys 24-47 months of age at endline (IOM 2001: 769)

	EG				CG				
	Girls (n=20)		Boys (n=20)		Girls (n=7)		Boys (n=7)		
Macronutrients	Mean (SD)	Mean % Energy	Mean (SD)	Mean % Energy	Mean (SD)	Mean % Energy	Mean (SD)	Mean % Energy	IOM recommendation
Total fat (g)	29.54 (7.77)	26.08	34.46 (10.55)	28.84	28.30 (2.49)	28.92	30.93 (6.45)	31.12	30-40%
Protein (g)	33.01 (7.09)	13.39	35.42 (4.57)	13.62	23.25 (3.07)	10.92	24.34 (4.42)	11.25	5-20%
Carbohydrates and fibre (g)	149.26 (31.24)	60.54	149.59 (23.98)	57.53	128.14 (13.83)	60.16	124.67 (18.37)	57.63	45-65%

Table 6.9 summarises the macronutrient distribution range for boys and girls 48-60 months of age. In this age group, the contribution of fat to the total energy was within the recommended 25-35% in both groups (IOM 2001: 769). The contribution of protein towards the total energy was slightly higher in the EG than in the CG. Carbohydrates were the main source of energy and the contribution towards the total energy intake was within the 45-65% IOM recommendation in both groups (IOM 2001: 769).

Table 6.9: Macronutrient distribution range for girls and boys 48-60 months of age at endline (IOM 2001: 769)

	EG				CG				
	Girls (n=11)		Boys (n=19)		Girls (n=12)		Boys (n=11)		
Macro-nutrients	Mean (SD)	Mean % Energy	Mean (SD)	Mean % Energy	Mean (SD)	Mean % Energy	Mean (SD)	Mean % Energy	IOM recommendation
Total fat (g)	37.25 (14.80)	28.98	30.81 (7.71)	25.71	27.22 (6.01)	30.14	26.17 (4.52)	30.73	25-35%
Protein (g)	39.52 (7.861)	14.13	33.87 (5.55)	12.99	23.00 (5.10)	11.71	21.13 (3.13)	11.40	10-30%
Carbohydrates and fibre (g)	159.12 (27.92)	56.89	159.94 (22.84)	61.32	114.28 (12.29)	58.15	107.21 (15.13)	57.86	45-65%

6.4.5 Fruit and vegetable intake at endline

Table 6.10 shows that EG girls 24-47 months of age had a lower daily mean intake of fruit and vegetable (69.12g) than CG girls 24-47 months (78.33g). ANOVA tests showed that the difference between the two groups was not significant (p=0.538). EG girls 48-60 months of age also had a lower intake (63.70g) than CG girls (66.39g). The differences in this age group were also not significant (p=0.862). The mean fruit and vegetable intake of EG and CG boys between 24-47 months was 72.20g and 71.10g, respectively. EG boys 48-60 months of age had a higher intake (67.96g) than CG boys of the same age group (48.86g); however, the difference was not significant (p=0.117).

Table 6.10: Mean fruit and vegetable intake for girls and boys at endline

Girls 24-47 months			**Girls 48-60 months**		
EG (n=20) Mean (g) (SD)	**CG (n=7) Mean (g) (SD)**	**ANOVA *p*-value**	**EG (n=11) Mean (g) (SD)**	**CG (n=12) Mean (g) (SD)**	**ANOVA *p*-value**
69.12 (31.82)	78.33 (38.78)	0.538	63.70 (38.84)	66.39 (34.99)	0.862
Boys 24-47 months			**Boys 48-60 months**		
EG (n=20) Mean (g) (SD)	**CG (n=7) Mean (g) (SD)**	**ANOVA *p*-value**	**EG (n=19) Mean (g) (SD)**	**CG (n=11) Mean (g) (SD)**	**ANOVA *p*-value**
72.20g (36.49)	71.10g (32.22)	0.948	67.96g (32.55)	48.86g (28.67)	0.117

P-value of <0.05 shows statistical significance

6.4.6 Food variety and food group diversity scores at endline

Table 6.11 presents the summary of food group variety for the EG at endline. The mean for the EG was 40.79 and 41.86 for the CG for all the food consumed from all food groups within the seven-day period. This indicated medium food variety for both groups, as the mean was between 30 and 60 (Matla 2008).

Table 6.11: Summary of FVS within the food groups for the EG and CG at endline (n=70)

	EG (n=70)			CG (n=37)		
Food Group	**Mean of each food group**	**SD**	**Range of scores**	**Mean of each food group**	**SD**	**Range of scores**
Meat, poultry and fish	6.66	2.41	0-11	7.11	2.28	0-11
Eggs	1.00	0.00	0-1	1.00	0.00	0-1
Dairy products	4.10	1.68	0-7	4.56	1.48	0-6
Cereals, roots and tubers	6.80	1.80	0-10	6.81	1.67	0-10
Legumes and nuts	1.52	0.84	0-4	1.36	0.66	0-3
Vitamin A rich fruit and vegetables	4.10	2.29	0-8	4.32	2.26	0-8
Other fruit	7.33	3.65	0-16	7.62	3.65	0-15
Other vegetables	5.99	3.03	0-14	5.62	2.59	0-11
Fats and oils	3.94	1.45	0-8	3.95	1.54	0-8
Total number of food items	40.79	13.21	19-64	41.68	12.35	19-66

Table 6.12 indicates that in the CG as the majority of participants in the CG (59.5%; n=22) ate from nine food groups, 37.8% (n=14) ate from eight food groups and 2.7% (n=1) ate from seven food groups.

Table 6.12: FGDS of the EG and CG participants from diverse food groups at endline

Number of food groups	EG % (n=70)	CG % (n=37)
7	2.9 (2)	2.7 (1)
8	32.9 (23)	37.8 (14)
9	64.3 (45)	59.5 (22)

6.4.7 The mean NAR for energy and other nutrients for all girls and boys at endline

Table 16.13 indicates that for EG girls 24-47 and 48-60 months of age, and CG boys 24-47 months of age, the relationship between FGDS and the NAR for energy showed an increased NAR with increased FGDS from eight to nine food groups. ANOVA tests showed that the increase was only significant in EG girls 48-60 months of age (p=0.014). In other groups, the NAR for energy decreased with increased FGDS and a significant difference was only noted in CG girls 24-47 months of age (p=0.001). A significant increase in the NAR for calcium with increased FGDS from eight to nine food groups was only noted in CG girls 48-60 months of age (p=0.001).

Table 6.13: The mean NAR for energy and calcium at different levels of FGDS for EG and CG girls and boys at endline

Group	Age in months (n=)	FGDS	Mean NAR % for Energy (SD)	ANOVA *p*-value	Mean NAR % for Calcium (SD)	ANOVA *p*-value	Mean NAR % for vitamin A (SD)	ANOVA *p*-value	Mean NAR % for vitamin C (SD)	ANOVA *p*-value
Girls	EG Girls 24-47 months (n=23)	8	56.32 (10.19)	.063	34.54 (20.95)	.172	289.33 (214.78)	.118	132.45 (50.09)	.142
		9	62.70 (12.34)		43.03 (20.49)		200.95 (155.84)		252.26 (374.18)	
	CG Girls 24-47 months (n=7)	8	55.26 (3.46)	**.001**	35.53 (5.98)	.056	314.01 (472.32)	.352	163.85 (83.61)	**.090**
		9	48.04 (0.96)		44.49 (9.247)		499.86 (142.56)		98.82 (28.24)	
	EG Girls 48-60 months (n=16)	8	62.42 (3.52)	**.014**	26.64 (13.23)	.332	75.37 (18.27)	**.035**	58.13 (26.13)	.110
		9	73.12 (15.10)		32.40 (19.22)		306.35 (399.32)		149.87 (214.63)	
	CG Girls 48-60 months (n=12)	8	49.18 (9.35)	.784	15.27 (0.80)	**.001**	226.56 (248.54)	.479	61.29 (2.44)	.267
		9	48.30 (5.27)		23.71 (6.37)		159.92 (202.22)		54.88 (18.86)	
Boys	EG Boys 24-47 months (n=21)	8	61.99 (14.02)	.318	46.48 (29.60)	.450	123.03 (36.83)	**.027**	309.50 (341.64)	.090
		9	58.51 (7.09)		40.43 (20.95)		216.99 (177.45)		171.42 (107.94)	
	CG Boys24-47 months (n=7)	8	48.30 (9.23)	.243	35.43 (8.68)	.713	106.55 (24.85)	.062	130.32 (87.26)	.434
		9	52.89 (2.15)		37.06 (7.44)		84.64 (8.93)		102.24 (17.69)	
	EG Boys 48-60 months (n=19)	8	64.21 (3.78)	.048	28.76 (6.38)	.749	213.72 (156.85)	**.034**	199.24 (169.06)	.504
		9	58.94 (10.34)		29.92 (14.24)		110.96 (128.98)		165.46 (137.36)	
	CG Boys 48-60 months (n=11)	8	43.20 (5.21)	.925	16.54 (3.05)	**.009**	58.48 (18.65)	.228	53.47 (16.95)	.689
		9	42.97 (6.14)		22.79 (6.17)		109.86 (131.73)		56.97 (22.96)	

P-value of <0.05 shows statistical significance

6.4.8 Endline blood results for serum retinol and Hb

The attrition rate was very high at endline. Some participants had left the ECD centre as explained under 4.10. Efforts to arrange for the children to come just for blood collection were futile. For biochemical measurements, only participants that provided a sample at baseline were included at endline. From the 73 that provided blood samples at baseline in the EG, two participants were absent on all blood collection days, nine were lost to follow-up (eight dropped out of the ECD centre and one dropped out of the study) and eight left the ECD centre a month earlier than expected, assumingly to avoid paying fees for November and were expected to return the following year. This resulted in a sample size of n=54 for biochemical results. Serum retinol was not detected in 15 blood samples. In the CG, from the 28 participants eligible for blood samples to be drawn from, six participants left the ECD centre at the end of October, resulting in a samples size of 22.

As the cut off points are the same for girls and boys in both age categories, the participants were grouped and were presented as EG and CG. Results in Table 6.14 indicate that 37.03% (n=20) of the participants in the EG and 27.27% (n=6) of participants in the CG had low serum retinol levels. Serum retinol was not detected in 27.77% (n=15) and 59.09% (n=13) of participants in the EG and CG, respectively. Low Hb levels were found in 62.96% (n=34) of participants in the EG and 45.45% (n=10) of participants in the CG.

Table 6.14: Endline blood results for serum retinol and Hb

	EG (n=54)			CG(n=22)		
Variables	**Low (%) (n)**	**Normal (%) (n)**	**Not detected (%) (n)**	**Low (%) (n)**	**Normal (%) (n)**	**Not detected (%) (n)**
Serum retinol (µmol/L)	37.03 (20)	35.18 (19)	27.77 (15)	27.27 (6)	13.63 (3)	59.09 (13)
Hb (g/dL)	62.96 (34)	37.03 (20)	0 (0)	45.45 (10)	54.54 (12)	0 (0)

6.5 Comparison of results

6.5.1 Comparison of endline nutrient intake results between EG and CG

ANOVA tests in Table 6.15 show that EG girls had a significantly higher daily mean energy intake compared to CG girls in both age groups (p=0.013 and p=0.001 for 24-47 months of age and 48-60 months of age, respectively). Similarly, EG boys also had a significantly higher daily mean energy intake than CG boys (p=0.011 for 24-47 months of age and p=0.000 for 48-60 months of age).

Table 6.15: Mean energy intake and Gender P-values for EG and CG at endline

		Energy (kJ)	
Gender	**Group and age in months (n)**	**Mean (SD)**	**ANOVA *p*-value**
Girls	**EG 24-47 (20)**	4191.13 (817.48)	**.013**
	CG 24-47 (7)	3620.97 (296.68)	
	EG 48-60 (11)	4754.99 (1033.40)	**.001**
	CG 48-60 (12)	3340.85 (382.66)	
Boys	**EG 24-47 (20)**	4420.41 (753.21)	**.011**
	CG 24-47 (7)	3677.57 (518.54)	
	EG 48-60 (19)	4433.90 (661.29)	**.000**
	CG 48-60 (11)	3149.90 (406.22)	

P-value of <0.05 shows statistical significance

ANOVA tests in Table 6.16 show that in both age groups, EG girls had a significantly higher daily mean protein intake than CG girls in both age groups (p=0.000). In boys 24-47 months of age, EG boys had a significantly higher daily mean intake for protein (p=0.000), iron (p=0.006), zinc (p=0.000) and vitamin A (p=0.015). EG boys 48-60 months of age had a significantly higher daily mean intake for protein (p=0.000), iron (p=0.000), and zinc (p=0.000) than CG boys of the same age group.

Table 6.16: Mean intake for protein and selected micronutrients for EG and CG at endline

		Protein (g)		Calcium (mg)		Iron (mg)		Zinc (mg)		Vitamin A (mcg)		Riboflavin (mg)		Vitamin B6 (mg)		Folate (mcg)		Vitamin C (mg)	
Gender	**Group and age in months (n)**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**
Girls	**EG 24-47 (n=20)**	33 01 (7 09)	**000**	202 41 (102 33)	864	7 31 (1 79)	052	6 13 (1 66)	**.001**	477 67 (366 65)	461	1 40 (0 677)	1 000	1 97 (0 64)	981	206 17 (77 08)	772	28 12 (41 03)	283
	CG 24-47 (n=7)	23 25 (3 06)		197 75 (37 93)		6 10 (1 11)		4 24 (0 76		712 48 (765 77)		1 40 (0 350)		1 11 90 30)		220 78 (120 58)		17 32 (9 30)	
	EG 48-60 (n=11)	39 52 (7 86)	**000**	234 65 (143 57)	244	8 43 (1 56)	**.000**	7 70 (1 75)	**.000**	693 19 (956 23)	508	1 61 (0 559)	**.015**	2 50 (0 88)	**.000**	208 27 (51 27)	293	28 98 (40 36)	202
	CG 48-60 (n=12)	23 00 (5 10)		178 44 (53 11)		5 48 (0 80)		3 80 (0 47)		470 33 (548 25)		1 07 (0 364)		0 98 (0 31)		175 18 (91 22)		12 31 (3 79)	
Boys	**EG 24-47 (n=20)**	35 42 (4 57)	**.000**	212 36 (119 32)	300	7 22 (1 21)	**.006**	6 13 (1 01)	**.000**	415 00 (347 46)	**.015**	1 15 (0 422)	510	1 91 (0 50)	**.000**	182 46 (68 25)	891	29 16 (30 30)	077
	CG 24-47 (n=7)	24 34 (4 41)		180 63 (37 74)		5 44 (1 17)		3 85 (0 66)		204 03 (45 65)		1 05 (0 302)		1 01 (0 34)		132 79 (919 69)		15 38 (8 36)	
	EG 48-60 (n=19)	33 87 (5 54)	**.000**	236 42 996 98)	756	7 20 (1 36)	**.000**	5 90 (1 39)	**.000**	394 37 (392 14)	263	1 46 (0 583)	263	1 84 (0 73)	**000**	184 21 (65 37)	**021**	38 75 (31 71)	**.002**
	CG 48-60 (n=11)	21 13 (3 13)		164 15 (47 75)		4 70 (0 76)		3 36 (0 61)		250 75 (290 88)		1 03 (0 384)		0 74 (0 29)		132 25 (49 62)		12 25 (4 43)	

P-value of <0.05 shows statistical significance

6.5.2 Comparison of baseline and endline nutrient intake results between EG and CG

When comparing baseline and endline nutrient intake between the age groups, ANOVA tests in Table 6.17 show that daily mean energy intake decreased significantly for girls 24-47 months of age in both groups (p=0.008 for the EG and p=0.003 for the CG). The daily mean iron intake decreased significantly in CG girls 48-60 months of age (p=0.000) and among boys 24-47 months of age in both groups (p=0.000 for EG and CG). There was also a significant decrease in the daily mean intake for vitamin A among CG boys 24-47 months of age and 48-60 months of age (p=0.008 and p=0.001, respectively).

Table 6.17: Comparison of mean intake of energy and selected nutrients at baseline and endline between EG and CG

			Energy (kJ)		Iron (mg)		Vitamin A (mcg)		Protein (g)	
Group	**Group and age in months**	**Phase (n=)**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**	**Mean (SD)**	**ANOVA *p*-value**
Girls	**EG 24-47 months**	Baseline (23)	5113.13 (1326.79)	**.008**	9.11 (3.01)	**.021**	498.38 (323.44)	.846	35.23 (10.48)	.416
		Endline (20)	4191.13 (817.48)		7.31 (1.79)		477.67 (366.65)		33.01 (7.09)	
	CG 24-47 months	Baseline (7)	4699.30 (626.09)	**.003**	7.69 (1.00)	**.016**	414.04 (202.88)	.353	31.11 (5.70)	**.010**
		Endline (7)	3620.97 (296.68)		6.10 (1.11)		712.48 (765.77)		23.25 (3.06)	
	EG 48-60 months	Baseline (16)	5440.19 (1236.35)	.132	9.47 (2.84)	.234	513.69 (395.10)	.566	41.04 (12.14)	.696
		Endline (11)	4754.99 (1033.40)		8.43 (1.56)		693.19 (956.23)		39.52 (7.86)	
	CG 48-60 months	Baseline (12)	6432.76 (1801.06)	**.000**	11.42 (2.46)	**.000**	703.88 (144.34)	.178	41.61 (18.32)	**.005**
		Endline (12)	3340.85 (382.66)		5.48 (0.80)		470.33 (548.25)		23.25 (5.10)	
Boys	**EG 24-47 months**	Baseline (21)	5517.17 (1018.51)	**.000**	10.64 (3.30)	**.000**	490.94 (282.26)	.449	39.80 (9.40)	.066
		Endline (20)	4420.41 (753.21)		7.22 (1.21)		415.00 (347.46)		35.42 (4.57)	
	CG 24-47 months	Baseline (7)	4778.42 (668.48)	**.005**	9.25 (1.19)	**.000**	611.68 (278.59)	**.008**	33.74 (5.22)	**.002**
		Endline (7)	3677.57 (518.54)		5.44 (1.17)		204.03 (45.65)		24.34 (4.41)	
	EG 48-60 months	Baseline (19)	5380.88 (799.84)	**.000**	9.76 (2.69)	.001	374.75 (268.10)	.823	38.60 (8.56)	.052
		Endline (19)	4433.90 (661.29)		7.20 (1.36)		394.37 (392.14)		33.87 (5.54)	
	CG 48-60 months	Baseline (11)	5861.52 (832.02)	**.000**	11.46 (1.80)	**.000**	673.86 (113.25)	**.001**	39.91 (7.72)	**.000**
		Endline (11)	3149.90 (406.22)		4.70 (0.76)		250.75 (290.88)		23.13 (3.13)	

P-value of <0.05 shows statistical significance

When comparing baseline and endline nutrient intake between the age groups, ANOVA tests in Table 6.18 show that for CG girls 48-60 months of age, there was a significant decrease in the daily mean intake of calcium and zinc (p=0.001 and p=0.000, respectively). For EG boys 24-47 months of age, there was a significant decrease in the daily mean intake of calcium and zinc from baseline to endline (p=0.020 and p=0.005, respectively). For EG boys 48-60 months of age, there was significant increase in the daily mean intake of calcium from baseline to endline (p=0.000) whereas, for CG boys 48-60 months of age, the daily mean intake of calcium decreased significantly (p=0.001).

Table 6.18: Comparison of baseline and endline mean intake for selected micronutrients for EG and CG

			Calcium (mg)		Zinc (mg)		Riboflavin (mg)		Vitamin B6 (mg)		Folate (mcg)		Vitamin C (mg)	
Gender	**Group and age in months**	**Phase (n)**	**Mean**	**ANOVA *p*-value**	**Mean**	**ANOVA *p*-value**	**Mean**	**ANOVA *p*-value**	**Mean**	**ANOVA *p*-value**	**Mean**	**ANOVA *p*-value**	**Mean**	**ANOVA *p*-value**
Girls	**EG 24-47 months**	Baseline (23)	262.94 (118.02)	.249	6.69 (2.09)	.335	1.63 (0.72)	.286	1.93 (0.80)	.857	230.11 (81.11)	.327	37.96 (21.55)	.344
		Endline (20)	202.41 (102.33)		6.13 (1.66)		1.40 (0.67)		1.97 (0.64)		206.17 (77.07)		28.12 (41.03)	
	CG 24-47 months	Baseline (7)	233.68 (70.55)	.265	5.61 (1.01)	**.016**	1.58 (0.47)	.439	1.69 (0.27)	**.003**	184.26 (24.67)	.460	39.78 (22.61)	**.041**
		Endline (7)	197.75 (37.93)		4.24 (0.76		1.40 (0.35)		1.11 (0.30)		220.78 (120.58)		17.32 (9.30)	
	EG 48-60 months	Baseline (16)	317.98 (88.46)	.107	7.47 (2.27)	.770	1.49 (0.56)	.590	1.91 (0.78)	.091	234.00 (103.55)	**.000**	38.13 (16.04)	.489
		Endline (11)	234.65 (143.57)		7.70 (1.75)		1.61 (0.55)		2.50 (0.88)		208.27 (51.27)		28.98 (40.36)	
	CG 48-60 months	Baseline (12)	375.87 (156.60)	**.001**	8.79 (2.41)	**.000**	3.02 (3.60)	.088	2.89 (0.90)	**.000**	269.75 (82.76)	**.014**	80.90 (28.86)	**.000**
		Endline (12)	178.44 (53.11)		3.80 (0.47		1.07 (0.36)		0.98 (0.31)		175.15 (91.22)		12.31 (3.79)	
Boys	**EG 24-47 months**	Baseline (21)	312.68 (145.55)	**.020**	7.70 (2.06)	**.005**	1.55 (0.77)	**.047**	2.22 (0.70)	.113	270.37 (81.80)	**.001**	41.21 (25.69)	.179
		Endline (20)	212.36 (119.32)		6.13 (1.10)		1.15 (0.42)		1.91 (0.50)		182.46 (68.25)		29.16 (30.30)	
	CG 24-47 months	Baseline (7)	301.77 (178.87)	.124	7.80 (1.16)	**.000**	1.44 (3.44)	**.026**	2.40 (0.45)	**.000**	241.76 (41.08)	**.000**	57.36 (30.59)	**.011**
		Endline (7)	180.63 (37.74)		3.85 (0.66		1.05 (0.30)		1.01 (0.34)		132.79 (19.69)		15.38 (8.36)	
	EG 48-60 months	Baseline (19)	37.06 (22.41)	**.000**	7.05 (2.21)	.064	1.74 (0.39)	.093	1.87 (0.56)	.888	265.28 (75.78)	**.001**	34.00 (18.11)	.575
		Endline (19)	236.42 (96.98)		5.90 (1.39)		1.46 (0.58)		1.84 (0.73)		184.21 (65.37)		38.75 (31.71)	
	CG 48-60 months	Baseline (11)	445.43 (193.21)	**.001**	8.84 (2.33)	**.000**	2.44 (1.31)	**.005**	2.89 (1.00)	**.000**	280.72 (60.50)	**.000**	68.68 (27.99)	**.000**
		Endline (11)	164.15 (47.75)		3.36 (0.61)		1.03 (0.38)		0.74 (0.29)		132.25 (49.62)		12.25 (4.43)	

P-value of <0.05 shows statistical significance

6.5.3 Correlation of variables

Partial Eta Squared values were used to indicate the significance of numerical dependent variables on independent variables of a categorical nature. Table 6.19 shows the correlation coefficients and the Partial Eta Squared values at baseline and endline. The household income had a large effect on the MPI score in both groups. The amount of money spent on food per month had a large effect on the FVS in both groups. Frequency of not having enough money to purchase food had a large effect in the EG in at baseline and endline, whereas it had a medium effect in the CG at baseline. The household income had a large effect on the FGDS at baseline and endline for both groups. At baseline, the frequency of not having enough money to purchase food had a medium effect on the FGDS for both groups.

Table 6.19: Correlation between income-related variables and FVS and FGDS

Partial Eta Squared					
Variable	**Variables**	**EG**		**CG**	
MPI Score	Household income	(0.395) **.195**		(0.412) **.412**	
Variable	**Variables**	**Baseline**		**Endline**	
		EG	**CG**	**EG**	**CG**
FVS	Household income	(0.581) **.294**	(0.799) **.418**	(0.514) **.356**	(0.247) **.660**
	How often the money for food was not enough	(0.034) **.170**	(0.902) **.059**	(0.517) **.142**	(0.570) **.192**
	Amount of money spent on food per month	(0.634) **.131**	(0.645) **.161**	(0.686) **.140**	(0.438) **.249**
FGDS	Household income	(0.794) **.228**	(0.000) **.974**	(0.017) **.636**	(0.416) **.555**
	How often the money for food was not enough	(0.680) **.092**	(0.848) **.082**	(0.011) **.480**	(0.416) **.260**
	Amount of money spent of food per month	(0.698) **.024**	(0.692) **.143**	(0.029) **.457**	(0.202) **.386**

Correlation coefficient values shown in ( ), Partial Eta Squared: 0.02 shows a small effect, 0.06 shows medium effect and 0.12 shows a large effect

Pearson's correlation tests were conducted to assess correlation of NARs and FVS and FGDS. Table 6.20 shows that the FVS had significant positive correlations with the NAR for energy (p=0.036), NAR for protein (p=0.028) and the NAR for vitamin B6 (p=0.003) at baseline in the EG. A significant negative correlation was observed between the FGDS and the NAR for zinc and the NAR for vitamin C in the CG at endline (p=0.048 and p=0.047, respectively).

Table 6.20: Correlation between FVS and FGDS and NAR for energy and selected nutrients

Variable	Variables	Baseline		Endline	
		EG	CG	EG	CG
FVS	Energy NAR	(0.236*) **.036**	(0.130) .442	(-0.008) .946	(0.072) .673
	Protein NAR	(0.247*) **.028**	(-0.013) .938	(0.143) .237	(0.085) .618
	Calcium NAR	(0.127) .263	(0.054) .752	(-0.029) .814	(0.111) .512
	Iron NAR	(0.211) .062	(-0.068) .687	(0.117) .335	(0.259) .122
	Zinc NAR	(0.179) .113	(-0.155) .360	(0.146) .228	(0.275) .099
	Vitamin A NAR	(0.074) .518	(-0.054) .752	(-0.143) .236	(-0.025) .882
	Riboflavin NAR	(0.078) .496	(-0.217) .197	(-0.020) .871	(0.151) .371
	Vitamin B6 NAR	(0.325**) **.003**	(0.022) .895	(0.177) .142	(0.307) .064
	Folate NAR	(0.121) .287	(0.049) .776	(-0.003) .980	(0.079) .640
	Vitamin C NAR	(0.122) .283	(0.069) .686	(0.010) .934	(0.082) .629
FGDS	Energy NAR	(0.246) .056	(-0.120) .479	(0.067) .580	(-0.148) .383
	Protein NAR	(0.165) .145	(-0.040) .814	(-0.125) .302	(-0.220) .191
	Calcium NAR	(0.057) .619	(-0.102) .547	(0.113) .351	(-0.142) .402
	Iron NAR	(0.0111) .328	(-0.205) .223	(-0.054) .659	(-0.148) .383
	Zinc NAR	(0.124) .278	(-0.115) .499	(-0.050) .680	(-0.328*) **.048**
	Vitamin A NAR	(0.097) .490	(-0.299) .072	(-0.029) .813	(0.008) .962
	Riboflavin NAR	(-0.179) .114	(0.022) .896	(0.011) .925	(0.085) .617
	Vitamin B6 NAR	(0.026) .820	(-0.165) .330	(-0.098) .418	(-0.267) .111
	Folate NAR	(0.0018) .877	(-0.143) .398	(-0.057) .639	(-0.086) .612
	Vitamin C NAR	(0.180) .113	(-0.144) .394	(0.030) 0.805	(-0.328*) **.047**

Correlation coefficient values shown in ( ), *P*-value of <0.05 shows statistical significance, significant relationships are indicated by * or **

Table 6.21 shows that positive correlations between biochemical measurements and FVS and FGDS were not statistically significant. Statistically significant negative correlations were noted at baseline in the CG between Hb and FVS (p=0.019). At endline, a statistically significant negative correlation was observed between the Hb and the FVS in the CG (p=0.006).

Table 6.21: Correlation between biochemical measurements and FVS and FGDS

Variable	Variables	Baseline		Endline	
		EG	CG	EG	CG
FVS	Serum retinol	(0.054) .671	(-0.021) .920	(0.071) .664	(0.317) .406
	Hb	(0.123) .299	(-0.442) **.019**	(0.036) .789	(-0.568**) **.006**
FGDS	Serum retinol	(0.027) .834	(-0.068) .747	(-0.043) .791	(0.424) .256
	Hb	(0.049) .680	(-0.215) .271	(-0.142) .291	(0.113) .617

Correlation coefficient values shown in ( ), P-values of <0.05 shows statistical significance, significant relationships are indicated by * or **

Partial Eta Squared values were used to indicate the significance of the highest level of education of the adult participant on weight for height, height for age and weight for age. The Partial Eta Squared values show that the education the level of education had a small effect on the weight for height in the EG (p=0.033) and a medium effect in the CG (p=0.110). The level of education also had a small effect on the height for age in the EG (p=0.042) and in the CG (p=0.016). In the post-test, the level of education was noted to have a large effect on weight for age in the EG (p=0.121) whereas in the CG, it had a medium effect (p=0.103) (Table 6.22).

Table 6.22: Correlation between highest level of the education of the adult participant and z-scores for weight for height, height for age and weight for age at baseline and endline

Variable	Variables	Partial Eta Squared			
		Baseline		Endline	
		EG	CG	EG	CG
Highest level of education of the adult participant	Weight for height	(0.778) **0.033**	(0.427) **0.110**	(0.789) **0.043**	(0.640) **0.074**
	Height for age	(0.668) **0.042**	(0.971) 0.016	(0.578) **0.066**	(0.918) **0.028**
	Weight for age	(0.462) **0.060**	(0.477) **0.101**	(0.209) **0.121**	(0.466) **0.103**

Correlation coefficient values shown in ( ), Partial Eta Squared: 0.02 shows a small effect, 0.06 shows medium effect and 0.12 shows a large effect

Bivariate correlation was also performed on the data. Positive values indicate a directly proportional relationship between the variables and a negative value indicates an inverse relationship. Table 6.23 shows a directly proportional relationship between height and weight (p=0.681** in the EG and p=0.511** in the CG at baseline) and p=0.679** and p=0.481** for EG and CG at endline). This shows that an increase in height resulted in an increase in weight. Furthermore, an increase in height resulted in increased z-score for height for age. Negative correlation values between height and weight for height were observed regarding baseline weight for height in both groups. This showed that as height increased, there was a decrease in the weight for height z-scores in both groups.

Table 6.23: Correlation between height and other z-scores at baseline and endline

Variables	Baseline Weight		Baseline Weight for Height		Baseline Height for Age	
	EG	CG	EG	CG	EG	CG
Baseline Height	(0.681**) **0.000**	(0.511**) **0.001**	(-0.238*) **0.035**	(-0.651**) **0.000**	(0.584**) **0.000**	(0.537**) **0.001**
	Endline weight		Endline Weight for Height		Endline Height for Age	
Endline Height	(0.679**) **0.000**	(0.481**) **0.003**	(-0.285*) **0.027**	(-0.719**) **0.000**	(0.714**) **0.000**	(0.575**) **0.000**

Correlation coefficient values shown in ( ), Partial Eta Squared: 0.02 shows a small effect, 0.06 shows medium effect and 0.12 shows a large effect, significant relationships are indicated by * or **

6.5.4 Discussion of compared baseline and endline results

At endline, the prevalence of risk of overweight in girls 24-47 months of age increased in both groups. The prevalence of obesity also increased in EG girls 24-47 months of age. Even though the mean energy intake was slightly less than the EER at endline, baseline mean energy intake exceeded the EER for this age group. The increase in overweight and obesity at endline was not surprising considering the diet of participants being starch-based as indicated in the top ten foods consumed. A study by Mushaphi *et al.* (2015: 99) conducted a nutrition education intervention programme for 12 months in rural villages in Limpopo. The study investigated infant feeding practices and assessed anthropometric and micronutrient status of three-to-five-year-old children prior to and post intervention. The caregivers of the participants in the experimental group received the nutrition education intervention (covering topics such as feeding guidelines for children three years and older, making starchy foods the basis of most meals and feeding children fruit and vegetables daily), whereas the participants in the control group received no intervention. Findings by Mushaphi *et al.* (2015:101) also showed no significant differences in anthropometric measurements of the children after a nutrition education intervention was implemented. Furthermore, other contributing factors could be the current food environment observed at both ECD centres, which promotes consumption of processed and starch-based foods and insufficient fruit and vegetables. The results in the current study support the view that food intake is not the only factor to be considered in the development of overweight and obesity. In addition to dietary intake, the CDC highlighted that an environment that does not promote young children becoming more physically active contributes to overweight and obesity (CDC 2021: para. 5 line 2). Exposure to an obesogenic environment could have possibly contributed to the high prevalence of risk of overweight and prevalence of overweight and obesity in the current study. Based on the observations made by the researcher and fieldworkers, the snacks consumed by the children were usually unhealthy. Scaglioni *et al.* (2018: 9) highlighted that diets high in convenience foods and

energy dense snacks, in combination with sedentary lifestyles contribute to overweight and obesity in children. Furthermore, the authors also mentioned that an increased energy intake compared to energy requirements also contribute to childhood obesity (Scaglioni *et al.* 2018: 9).

In the current study, some endline anthropometric findings such as the prevalence of stunting were similar to baseline. Stunting in the current study was higher among boys than girls. Likewise, Nithya and Bhavani (2017: 12) also reported a higher prevalence of stunting in boys compared to girls. Results in the current study are similar to findings by Saragih *et al.* (2017: 65), who found no significant change in nutritional status after a meal parenting intervention which was implemented over three months. In contrast, findings from a nutrition education intervention programme by (Ghoneim *et al.* 2004: 833) which evaluated the nutritional status and Hb levels of children aged two to five years showed a decrease in the prevalence of stunting in girls and boys after 12 months (from 4.6% to 2.3% and from 5.0% to 3.5% in girls and boys, respectively). The results on stunting in the current study suggest that the length of the intervention is crucial for improving the prevalence of stunting as shorter intervention studies seem to have low or no improvement in the rate of stunting compared to longer interventions. This comparison further highlights that the three-month intervention was too short to yield any major changes in anthropometric results post intervention.

When comparing baseline with endline results between 24-47 month and 48-60 month age group within the EG and CG, there was a decrease in the mean intake of energy and other nutrients such as iron, protein, calcium and zinc in all groups. Findings on food intake in the current study compare to a study by Mushaphi *et al.* (2017: 100), who investigated impact of a nutrition education programme on infant feeding practices of caregivers with children aged three to five years in rural villages in Limpopo. Mushaphi et al. (2017: 103) reported that the mean energy intake of children was below the estimated requirements at endline. The authors further reported that the energy and protein intake of the participants in the EG had not significantly changed at endline. Similar to this current study, Mushaphi *et al.* (2017: 107) reported that nutrients that were adequate were carbohydrates, zinc and iron.

When examining the top ten foods in both groups in the current study, it was not surprising that the calcium intake was low, as milk and and *maas* were the only foods appearing in the top 10 foods that were high in calcium. Even with these two foods, the per capita intake was generally low. Herber *et al.* (2020: 5) found that weight for height z-scores and weight for age z-scores were

positively associated with milk consumption in children six to 23 months. The authors concluded that regular milk consumption was beneficial for growth in children six to 59 months of age. With regard to dietary intake of vitamin A, a decrease was observed in the current study in some age groups, whereas in other groups there was an increase in vitamin A from baseline to endline. This suggests that the OFSP yoghurt positively influenced the vitamin A of some participants in the EG. The baseline was conducted during winter and endline was conducted towards the end of spring. The changes in nutrient intake in the current study could therefore be possibly linked to seasonal changes in food intake and the time of data collection as endline data was collected in the last week of October before some participants received their income. Findings by Waswa et *al.* (2021: 1) showed changes in the diet of children when comparing food intake during the harvest period and months after harvest. The changes were noted by the author to affect dietary diversity and nutrient adequacy. Belayneh *et al*. (2021: 54) also reported a decrease in the intake of fruits, vegetables and meat products during the pre-harvest season compared to post-harvest. Kucukerdonmez and Rakıcıoğlu (2018: 165) also reported that seasonal variations had a significant effect on food consumption, dietary habits and anthropometric measurements of university students. Abizari *et al*. (2017: 1) concurred that seasonality affects dietary diversity of children as participants consumed more vitamin A-rich fruits and vitamin A-rich dark green leafy vegetables during the rainy season compared to the dry season.

Household income is also one of the factors that may cause diet changes. The data collection in the current study was conducted before COVID-19 pandemic which greatly affected the income and food consumption habits of many households in SA (Naicker *et al.* 2021: 134). It is anticipated that in the current study, there were no major changes in income as the endline measurements were conducted three months after baseline. In other studies, the impact of family income on food intake, food security and nutritional status is well documented. Galgamuwa *et al*. (2017: 9) suggest that a high household income contributed to the provision of good quality food and low income was significantly associated with undernutrition among school children. A study by Tyagi and Sharma (2016: 365) concluded that there was a correlation between family income and the height and weight of six to 11 year old children. Furthermore, findings by Cheteni *et al.* (2020: 13) showed that income had a significant correlation with household food security.

Food preferences could have also been a contributor to changes in food intake of the participants. As children grow, their tendency to like other foods increases. Mazarello Paes *et al*. (2015: 4) stated that the taste preferences of children influence their diet, and some parents feed their children

what the child prefers to eat. Scaglioni *et al.* (2018: 8) mentioned that children usually prefer sweet and salty flavours. This may limit their eagerness to try out new foods or build preference towards familiar foods. Family influences also impacts on children's food intake. Children tend to imitate the behaviour of the adults around them (Scaglioni *et al*. (2018: 4). Mazarello Paes *et al*. (2015: 4) stated that older siblings also influenced young children's dietary behaviours, as they are often perceived by young children as role models. In the current study, exposure the food advertisements may have possibly contributed to the food intake. As toddlers grow, many watch television programmes which play food advertisements that may not necessarily be healthy and this may contribute to unhealthy food choices (Scaglioni 2018: 6).

At endline, serum retinol levels increased in 5.5% (n=3) participants in the EG and 4.5% (n=1) in the CG. Even though not to the same extent, results from this study are in alignment with findings reported by Hotz *et al.* (2012: 7), who reported an increase in serum retinol levels of children below five years after the implementation of a two-year long OFSP intervention programme. The increase in serum retinol in participants in the current study was not as high as results obtained by Van Jaarsveld *et al*. (2005: 1085) who reported an increase in vitamin A status or adequate vitamin A liver stores from 78% to 87% of participants who consumed 125g of boiled mashed sweet potatoes for 53 days. In the study by Van Jaarsveld *et al.* (2005), the amount of OFSP consumed by the participants was higher than in the current study. In the current study, the quantity of OFSP that could be used in the production of the yoghurt had to be in alignment with regulations stipulated in the agricultural product standards act number 119 of 1990 (DAFF 2019: 15). In the current study, more participants had low retinol levels at endline than at baseline, which could be linked to the decreased nutrient intake as explained under dietary intake in this chapter. This could possibly be attributed to seasonal dietary changes as there was a decrease in the intake of many nutrients at endline, as indicated under dietary intake. Furthermore, factors like bioavailability could also have contributed to the results. According to Melse-Boonstra (2020: 6) the ingestion of fat with carotenoids is essential to enhance the absorption of carotenoids and dietary fibre increases in the diet, it is associated with a decrease in absorption of β-carotene. Jamil *et al.* (2012: 1901) emphasized that adding dietary fat enhances optimal uptake of β-carotene. In the current study, the intake of fibre was low in all age groups in the EG and CG therefore indicating that a high fibre intake could not have been an inhibitor of bioavailability. At endline, Hb levels increased in 3.7% (n=2) and 9.0% (n=2) participants in the EG and CG, respectively. With regard to changes in iron levels, our findings are contrary to findings by Mushaphi *et al.* (2015: 100), who also reported no changes in iron status of children aged three to five years after conducting the intervention. Results

in the current study are contrary to findings by Ghoneim *et al*. (2004: 837), who reported a significant decrease in the prevalence of anaemia from 47.3% at baseline to 14.2% at endline after a 12 months intervention.

In the current study, it was not surprising that household income had a large effect on FVS and FGDS. Positive correlation between the NAR values of some nutrients indicated that as the FVS and FGDS increased, the NAR also increased. This suggests that strategies to improve income in this community would be beneficial to the health of children. French *et al.* (2019: 6) reported that low income households are less likely to have lower diet quality. In the current study, as the level of education increased, it had a significant effect on weight for age, height for age and weight for height. Similarly, Galgamuwa *et al*. (2017: 7) found that as the education of mothers increased, it resulted in a decline in the trend of malnutrition. Results in the current study are also similar to findings by Belayneh *et al*. 2021: 58) who reported that the prevalence of wasting was higher in children from households with less educated fathers and among food insecure households. The authors also reported a higher risk of stunting among children from poor households whose parents had no formal education (Belayneh *et al.* 2021: 59).

6.6 Conclusion

Baseline and endline anthropometric results remained fairly similar. There were no major changes in stunting levels among both groups. This was not unexpected as stunting is a long-term effect of malnutrition and the duration of this intervention was too short to cause a change in stunting levels. At endline, the risk of overweight and the prevalence of obesity increased among girls in most groups. Among boys, there was a decrease in the risk of overweight in boys in the EG, whereas in the CG, there was a noted increase among boys. Dietary changes included a general decrease in energy intake across the age groups in the EG and CG. There was also a decrease in the mean intake for iron in all groups and there was a decrease in the mean intake of vitamin A in most groups. The percentage of children with low vitamin A blood levels did not change to adequate levels, however, there was a noted increase in the serum retinol levels in some participants in the EG. This change suggests that the consumption of OFSP yoghurt may have had a positive impact on serum retinol levels in the EG. The next chapter will present overall conclusions from this study, study limitations and recommendations.

CHAPTER 7: CONCLUSIONS, STUDY LIMITATIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter draws conclusions from the main findings and makes contextualised recommendations. The purpose of this study was to develop and test the impact of the developed OFSP yoghurt on the nutritional status of pre-school children in Durban, KwaZulu-Natal, South Africa. A baseline survey was conducted to establish the socio-demographic profile of the households, assess the nutritional status and determine the dietary intake of the participants. A three month intervention was implemented and thereafter, impact on nutritional status was assessed at endline.

7.2 Conclusions

The socio-demographic profile indicated that participants were mostly from low-income households. The household characteristics of participants indicated that they were deprived of some essential sanitation services such as waste removal and flush/sewage toilets. Other issues in the current study population included overcrowding and high unemployment, and some households reported running out of money to buy food. Lack of facilities such as flush/sewage toilets and running water expose children to illnesses such as diarrhoea, which may lead to compromised nutritional status.

Stunting was higher among boys than girls, whereas obesity was higher among girls than boys. The risk of overweight was high in both girls and boys and no participants in the current study were underweight or severely underweight. The health of the participants is at risk, as stunting has long-term health effects that not only affect physical growth and development, but cognitive abilities and reduced levels of productivity in adulthood. Overweight and obesity also puts the participants at risk of NCDs such as hypertension, coronary heart disease, diabetes and other weight-related health problems. Malnutrition, in the form of micronutrient deficiencies, stunting, overweight and obesity, co-existed in the current study population. The diet of the participants was sub-optimal for optimum growth. There was low fibre intake and inadequate fruit and vegetable intake in both EG and CG at baseline and endline. Some participants did not consume any type of legume in seven days. The intake of some nutrients varied across the different age groups. The top five foods consumed in each group were predominantly starch-based and a diluted squash drink also made it

to the top five of some groups. Overall, the mean energy intake was lower from baseline to endline and the mean energy intake was mostly inadequate among the 24-47 month age group. The calcium and fibre intake among participants in the current study was inadequate as the AI for both nutrients was not met.

Even though more participants did not meet the DRI for vitamin A at endline compared to baseline, possibly due to seasonal variations on dietary intake as observed for other nutrients, there was an increase in the mean intake of vitamin A in girls and boys 48-60 months in the EG. Linked to the decrease in nutrient intake, more participants had low serum retinol levels and low Hb levels in EG and CG at endline compared to baseline. Even though children with low serum retinol levels did not change to adequate levels, there was a noted increase in the serum retinol levels in some participants in the EG, indicating a positive impact of the OFSP yoghurt on nutritional status.

Although an improvement in serum retinol was noted in a few participants, the OFSP yoghurt was not highly effective in improving serum retinol levels of all the participants; as retinol levels did not drastically improve, the iron levels also did not improve. In addition to the limitation posed by using dried blood spot to analyse serum retinol, yoghurt as a vehicle to introduce or increase the consumption of the OFSP was limiting due to the amount of OFSP that could be used in the developed yoghurt in alignment with regulations as stipulated in the agricultural product standards act number 119 of 1990. A different product where a higher amount of OFSP would be used could have perhaps achieved different results. Addressing VAD in children under five years requires a more holistic approach including a combination of interventions such as consumption of vitamin A-rich and fortified foods, vitamin A supplementation, multiple micronutrient powders and nutrition education. Nutrition sensitive agriculture should also be explored in addressing VAD in children.

7.3 Study limitations

The level of education of the head of households in the current study is unclear as the questionnaire asked the highest level of qualification of the adult respondent who answered the socio-demographic questionnaire on behalf of the child participant, who may not have been the household head. The blood samples were not collected using venipuncture as that would be too invasive for children 24-60 months of age. Therefore, this resulted in the use of the finger prick method. Using the finger prick posed a major limitation to the study as serum retinol could not be detected in some samples at baseline and at endline. There was no other test known by the research team that could

have been used as blood collection using venipuncture was ruled out as per the explanation above. Statistical significance of data is presented however, clinical significance could have also been explored. Reliance on expertise from outside the province to conduct the blood analysis was also a limitation due to logistical challenges, which caused many delays and ultimately led to the endline being conducted in November instead of October. This had negative implications as some participants were then lost to follow-up as explained in Chapter six. High absenteeism was also a factor as some participants were excluded due to being absent from the ECD centre on all data collection days.

The duration of the intervention was three months and therefore posed a limitation as it was too short to yield any major changes in anthropometric results post intervention. The sample size should have been calculated in consultation with a statistician to ensure accurate results and not decided by the researcher based on sample size of other intervention studies. The sub-group analysis according to age group of participants should have been anticipated and sample size should have been increased to make provision for this.

The calculation of the power of the sample size was not included in the presentation of the results, and will be considered for future publications. Due to the nature of the product developed, regulations on acceptable quantities of food ingredients to be added when flavouring yoghurt limited the amount of OFSP used in the manufacturing of the yoghurt, was another limitation. This is considered a limitation as other studies using a higher amount of OFSP in the yoghurt showed a higher impact.

Self-reported retrospective dietary intake was also a limitation, as some participants indicated that they were not with the child the previous morning and could not indicate accurately what the child ate and relied on what the minor child reported. This may have resulted in an inaccurate estimation of the portion sizes. Furthermore, the endline dietary intake take was conducted in the last week of the month, which may have impacted the amount of food eaten by the participants at endline compared to baseline as results showed that some participants reported running out of food.

7.4 Recommendations

7.4.1 Government level

Addressing nutrition problems requires a multisectoral and holistic approach. The Department of Basic Education, Department of Health and Department of Social Development should invest in

joint efforts to fight malnutrition and improve the living conditions in poor communities, such as the one where this research was conducted. Such efforts could include health and nutrition education programmes targeting younger children attending ECD centres and physical activity programmes as part of the curriculum. The government stated that ECD centres will be under the Department of Education in 2022 and therefore the children will benefit from the National School Nutrition Programme.

Essential municipal services such as waste removal and building toilets needs to be improved in this community as these are required for a healthy environment.

The government should consider job creation strategies or poverty alleviation strategies, as there was a high unemployment rate among adult participants in the current study. Graduate programmes or learnership programmes could also assist to improve employment prospects as they offer opportunities for community members to gain work experience.

7.4.2 Community and household level

A combination of home-based and school-based early interventions to address both under and overnutrition is required during the early childhood development period. Apart from inadequate food intake, the current study reported on other factors that contribute to malnutrition such as low income and limited access to resources. Therefore a participatory problem-solving approach should be used to investigate and address the root causes of poverty in this community, and in so doing reduce the prevalence of malnutrition in the community where the current study was conducted. This, therefore, highlights a need for partnerships with various organisations or stakeholders that play a role in community development projects.

Mothers and caregivers should be educated by healthcare workers about nutrition for the growing child and menu and meal planning. This could play a role in improving the food intake of the children.

There should be education programmes that also focus on overnutrition as it is evident that the risk commences very early in the life cycle. These could be implemented by non-government organisations that focus on improving lives of residents in the community where the current study was conducted. Based on the reported food intake, parents and caregivers should also be educated on healthy eating and healthy food preparation techniques.

7.4.3 ECD centres

The menus offered at the ECD centres should be reviewed by the person responsible for menu planning at the ECD centres and the menus should include more fruit and vegetables and unrefined carbohydrates.

Formal food gardens should be established at the ECD centres to increase access to vegetables.

7.4.4 Research

Future research should include a larger sample size. Studies should be conducted to draw a comparison of ECDs in urban and rural areas.

The use of the OFSP in product development should further be investigated in products that will not limit the amount to be used, such as in dairy products.

Interventions should also include addressing the causes of poor food intake; which should be contextualised considering the challenges encountered by the community.

The co-morbidity of anaemia and stunting in early childhood resource-constrained settings should be managed using a syndemic approach. Sustainable nutrition-sensitive interventions should be explored with the intent to support good health, proper nutrition and early learning at ECD centres towards the optimum development of human capital.

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APPENDICES

Appendix A

Food and Nutrition Consumer Sciences

SOCIO-DEMOGRAPHIC QUESTIONNAIRE

This questionnaire covers certain aspects of your life, including work and personal details, health and illness, lifestyle and social life that is relevant to health. The answers to these questions will be kept strictly confidential and the information will not be identifiable on any reports or publications.

1. GENERAL INFORMATION

Participant number:……..……. Date: ……

Fieldworker name: ……

Please answer all questions by marking the correct answer with **X,** except where otherwise indicated.

Where do you live?

.....

2. PERSONAL INFORMATION

2.1 Your role in the family

Mother	Grandmother	Father	Grandfather	Other, specify……..

2.2 When were you born? Year: Month: Day:

2.3 How old are you? _____years

2.4 Gender:

Male	Female

3. ACCOMMODATION AND FAMILY COMPOSITION

3.1 Do you live in?

Town/City	Farm	Squatter camp	Rural village	Hostel	Township	Other, specify……...

3.2 How are you currently living?

Homeless	
Living with relatives	
Living with friends	
Hostel accommodation	
Squatter home	
Rented house/flat	
Own house/flat	
Employees Properties	
Other, specify…….	

3.3 Do other people live in the house with you?

Yes	No

3.4 How many people are permanent residents living in the house with you? (Only if these people eat and sleep in this house at least 4 days a week?)

3.5 How long have you been staying permanent in this house?

< 1 year	1-5 years	>5 years

3.6 In what type of house are you staying?

Brick	Clay	Grass	Wood	Zinc/shack

3.7 How many rooms does your house have?

1 room	2 rooms	3 rooms	4 room	>5 rooms

3.8 Are there other houses/shacks within the same yard of the main house?

Yes	No

3.9 Do you have the following facilities/ services at home?

3.9.1 Water

Tap in the house	
Tap outside the house (in yard)	
Borehole	
Spring / river / dam water	
Fetch water from elsewhere	

3.9.2 Toilet facilities

None	
Pit latrine	
Flush / sewage	
Bucket system	
Other, specify…….	

Waste removal	Yes	No	3.9.3
Tarred road in front of house	Yes	No	3.9.4
Gravel road in front of house	Yes	No	3.9.5
Access to electricity	Yes	No	3.9.6

3.10 To what extent do you have problems with the state of your house (e.g. size, repairs, damp, etc.)?

……
……

3.11 Do you have problems with the following?

Mice/ Rats	
Cockroaches	
Ants	
Flees	
Mosquitoes	
Geckos	
Frogs	
Snakes	
Bed Bugs	

3.12. What is the floor inside your house made of?

Cement	
Tiles	
Carpet	
Dirt	
Sand/mud	
Dung	
Other, please state	

4. WORK STATUS AND INCOME

4.1. Are you currently employed?

Yes	No

If YES, go to Question 4.5.

4.2. If NO, how would you describe your current status (tick one box only)?

Unemployed	Retired	Housewife	Student	Other, specify……

4.3. Are you actively looking for paid employment at the moment?

Yes	No

4.4. How long have you been unemployed?

< 6 months	6-12 months	1-3 years	> 3 years

4.5. If YES (question 4.1) is your current job a:

Permanent position	Temporary position	Fixed term contract	Other, specify……..

4.6. Are you doing part time jobs as a second job on weekends and school vacations?

Yes	No

4.7 What is the exact title of your current job?
(Including self-employed)

4.8. What is the total income in the household per month?

R0- R500	R501-R1000	R1001-R1500	R1501-R2000	R2001-R2500	R2501-R3000
R3001-R3500	R3501-R4000	R4001-R4500	R4501-R5000	R5001-R6000	R6001

4.9. Please specify the monthly income in the household (if willing)……..

4.10 Do you receive any of the South African Government social grants?

Old age grant	Child grant	Disability grant	Foster grant

4.11. How often does it happen that you do not have enough money to buy food? for you and your family?

Always	Often	Sometimes	Seldom	Never

4.12. How many people e.g. partner, relatives & others (including yourself) contributed to your household income from any source, (including wages/salary from paid employment, money from second or odd jobs income from savings investments, pension, rent or property, benefits and or maintenance etc.) in the last 12 months?

People	0	1	2	3	4	5	6	7	8	9

4.13. How often do you buy food?

Every day	Once a week	Once a month	Other, specify……

4.14. Where do you buy food?

Tuck shop	Street vendor	Wholesalers	Supermarket	Other, specify……

4.15 What type of transport do you use to get around?

Taxi	
Bus	
Train	
Own car	
Bicycle/ Motorbike	
Other Specify	

4.16 How much money is spent on food PER MONTH? (Tick only one box)

R 0 – R 200	R 201 – R 300	R 301 – R 400	R 401 – R 500	R 501 – R 600	R 601 – R 700	R 701-R800	R801-1000
R1001-R1200	R1201-R1400	R1401-R1600	R1601-R1800	R1801-R2000	>R2001		

5 EDUCATION AND LANGUAGE

5.1. What is your highest education level?

None	Primary School	Standard 8	Standard 10	College/FET	Other post school

5.2 What language is spoken mostly in the house?

Zulu	Xhosa	English	Afrikaans	Other, specify……

5.3 How many children (in the household) have birth certificates?

None	1	2	3	4	5	6	7	8	All

5.4 How many children have completed their immunisation schedule?

None	1	2	3	4	5	6	7	8	All

5.5 Has any children in your household died in the past?

Yes	No

Reason: ……..

5.6 Number of children attending school

None	1	2	3	4	5	6	7	8	All

5.7 How do the children get to school?

Walk	Bus	Taxi	Parents car	Other, specify…….

Food practices in the household

Tick one block for every question:	Father	Mother	Sibling	Grandma	Grandpa	Aunt	Uncle	Cousin	Friend	Other
5.8 Who is mainly responsible for food preparation in the house?										
5.9 Who decides on what type of food is bought for the household?										
5.10 Who is mainly responsible for feeding/serving the children?										
5.11 Who is the head of this household?										
5.12 Who decides how much is spent on food?										

5.13 How many meals do you eat per day?

0	1	2	3	> 3

5.14 Where do you eat most of your meals?

Home	Friends	Work	School	Other, specify…….

5.15 Where do your children eat most of their meals?

Home	Friends	School	Other, specify…….

6. ASSETS

6.1 Does your home have the following items and how many?

	Yes
Electrical stove	
Gas stove	
Primus or paraffin stove	
Microwave	
Hot plate	
Radio	
Television	
Refrigerator	
Freezer	
Telephone/ Cell phone	
Bed with mattress	
Mattress only	
Lounge suite	
Dining room suite	
Electrical iron	
Electrical, kettle	
Car	
Bicycle	
Motorbike	

6.2 What type of fuel do you usually use for food preparation?

Wood fire	Paraffin	Electricity	Gas	Coal/Charcoal	Other, specify……

6.3 What type/s of material are your pots made off (tick all relevant options)?

Cast iron	Aluminium	Stainless steel	Clay	Other, specify……

Thank you very much for your co-operation. We appreciate the time.

Appendix B

DEPARTMENT OF FOOD AND NUTRITION CONSUMER SCIENCES

Anthropometric Measurements

Section A:

1. Number/Name of the subject..,.. ……..

2. Community:..... ... .

I 3. Date of birth I Year I Month I Day

I 4. Gender I Male I Female

Section B:

1. Body weight (kg)	1. Body weight (kq)	2. Height/Length (cm)	2. Height/Length (cm)
kq	kg	cm	cm

3. Waist circumference	3. Waist Circumference	4. Blood pressure	4. Blood pressure
cm	cm	/	/

Appendix C

24-HOUR RECALLS QUESTIONNAIRE

Subject ID number: _____ Interviewer: _____

Name: _____ Date: _____ / _____/ _____

Address: _____

Tick what the day was yesterday:

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday

Would you describe the food that you ate yesterday as typical of your habitual food intake?

Yes	1	No	2

If not, why? _____

I want to find out about everything you ate or drank yesterday, including food you pick from the veld. Please tell me everything you ate from the time you woke up to the time you went to sleep. I will also ask you where you ate the food and how much you ate.

Time (approximately)	Place (Home, school, etc)	Description of food and preparation method.	Amount	Amount in g (office use Only)	Code (office use only)
From waking up to going to work, or starting day's activities					

During the morning at work or at home					

Time (approximately	Place (Home, school, etc)	Description of food and Preparation method.	Amount	Amount in g (office use Only)	Code (office use only)
Middle of the day (Lunch time)					

During the afternoon					
At night (dinner time)					

Time (approximately	Place (Home, school, etc)	Description of food and preparation method.	Amount	Amount in g (office use Only)	Code (office use only)

After dinner, before going to sleep					
* Do you take any vitamins (tablets or syrup)		Yes	1	No	2
Give the brand name and dose of the vitamin/tonic:					

Appendix D

FOOD AND NUTRITION CONSUMER SCIENCES

FFQ LIST OF FOODS AND FOOD GROUPS DIVERSITY

PLEASE INDICATE THE FOOD YOU ATE DURING THE PAST SEVEN (7) DAYS BY AN (X)

GROUP 1: Flesh Foods (Meat, Poultry, Fish) Diversity	**Y**	**N**
Meat (Chicken)		
Meat (Beef)		
Meat (Mutton, Lamb)		
Meat (Pork)		
Meat (Goat)		
Dried Meat (Biltong)		
All Mince		
All Tribe/Offals/Runners and Heads		
Fish (fresh / whole)		
Tinned Fish (Pilchards/Tuna)		
Processed Meats (Viennas / Polony, Russians, Boerewors Sausage)		
Seafood (Prawns, Mussel's, Calamari, Crab, Shrimp, Crayfish)		
GROUP 2: Eggs Diversity	**Y**	**N**
Eggs		
GROUP 3: Dairy Products Diversity	**Y**	**N**
All Milk		
Evaporated milk (Unsweetened)		
Condensed milk		

Maas/ Inkomasi		
All Cheese		
Custard		
Ice Cream		
GROUP 4: Cereals, Roots and Tubers Diversity	**Y**	**N**
All Rice		
Maize (Pap, Mealie Rice, Mealie Meal, Samp, Porridge, Corn on the cob, Popcorn, Sweet Corn)		
Macaroni/Pasta/Spaghetti		
All Bread (White/ Brown/ Whole Wheat)		
Dumpling/Steamed Bread/Fat Koek		
Scones/Biscuits		
Mageu		
Breakfast Cereals (Corn Flakes, Oats, Weet Bix, Matabela)		
All Tubers/Roots (Amadumbe, Sweet Potato)	**Y**	**N**
Potatoes		
GROUP 5: Legumes and Nuts	**Y**	**N**
All Beans Dried		
Dried Peas		
Lentils		
Peanuts and Nuts		
Soya		
GROUP 6: Vitamin A Rich Fruits and Vegetables Diversity	**Y**	**N**
Pumpkin		
Carrots		
Wild Leafy Vegetables Fresh and Dried		
Spinach		
Butternut		

Apricots (Appelkoos)		
Peach (yellow cling)		
Mango		
GROUP 7: Other Fruits (and juices) Diversity	**Y**	**N**
Deciduous Fruits		
Apple		
Peaches		
Pear		
Grapes (black/green)		
Plum		
Sub – Tropical Fruit	**Y**	**N**
Lemon		
Orange		
Naartjie		
Banana		
Pineapple		
Avocado		
Kiwi fruit		
Watermelon		
Guava		
Paw- Paw		
Juices	**Y**	**N**
Juice (100% pure juice e.g. Ceres/Liquifruit)		
GROUP 8: Other Vegetables Diversity	**Y**	**N**
Onions		
Cabbage		
Beetroot		
Tomatoes	**Y**	**N**
Green beans (fresh)		
Peas (fresh)		

Cauliflower		
Chili (red/green)		
Lettuce		
Green\ Yellow\ Red Pepper		
Frozen Vegetables (Mixed)		
Ginger & Garlic (Fresh)		
GROUP 9: Oils and Fats Diversity	**Y**	**N**
Butter		
Sunflower oil		
Margarine		
Lard		
Salad dressing/oil		
Potato Crisps		
Coffee Creamer (Cremora, Ellis Brown)		

Appendix E

OFSP YOGHURT PRODUCTION CLEANING CHECKLIST

Date: _____

Use the checklist below to ensure cleaning is done before each production session

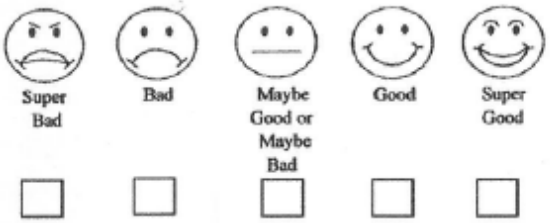
Step	Yes	No
Clean and sanitize all work surfaces		
Clean and sanitize yoghurt maker		
Clean and sanitize measuring cups and spoons		
Clean and sterilize glass jars and lids		
Clean yoghurt cups and lids		
Clean and sanitize cooler boxes to be used for transportation		

Appendix F

SAMPLE: _____

Please taste the sample and tick √ under the face that you think best describes the samples appearance aroma, taste and texture. You may taste the samples more than once.

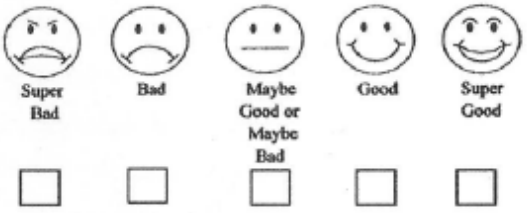
Appearance



Comments:

_____

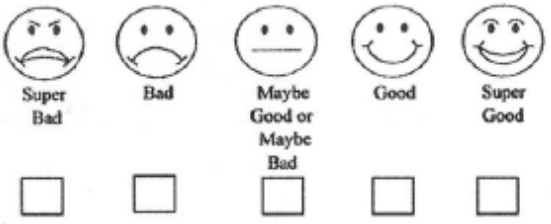
Aroma



Comments:

_____

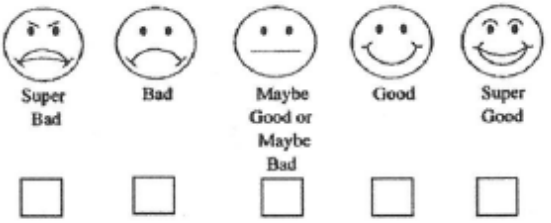
Taste



Comments

:_____

Texture



Comments:

_____

Please indicate which sample you prefer: _____

Thank you for your feedback

Appendix G

Sample A

Bad

Good

☐ ☐

Sample 1

Bad

Good

☐ ☐

Uthanda yiphi? _____

Appendix H

23 April 2018

Ms O Makanjana

C/o Department of Food and Nutrition S9 Level 3, Room 304

Steve Biko Campus DUT

Dear Ms Makanjana

The impact of an orange-fleshed sweet potato yoghurt on Vitamin A and iron status of pre-school children
Ethics Clearance Number: IREC O 19/ 13

The Institutional Research Ethics Committee acknowledges receipt of your Safety Monitoring and Annua l Recertification report.

I am pleased to inform you that the study has been approved to continue.

Please note that ethical approval has been extended till **25 March 2020,** if the research is not complete within this time, you will be required to apply for recertification three months before the expiry date.

Yours Sincerely

Professor J K Adam Chairperson: IREC

DURBAN

ZOM -0 - Z 3

INSITUTUTIONAL RESEARCH ETHICS COMMITTEEP

Appendix I

DURBAN UNIVERSITY OF TECHNOLOGY
INYUVESI YASETHEKWINI YEZOBUCHWEPHESHE
Department of Food and Nutrition Consumer Sciences
Tel. (031) 373-2334, Fax 086 557 2410

RE: LETTER REQUESTING PERMISSION TO CONDUCT STUDY

Dear Creche Manager

Your creche has been randomly selected from a list of creches in the Durban Area. I hereby request yourpermission to conduct a study at your creche. I require pre-school children to voluntarily participate the study titled "The impact of an orange-fleshed sweet potato yoghurt on Vitamin A and iron status of pre- school children in Durban".

For further details, an information letter regarding the project is attached.

Yours faithfully

0. Makanjana (Researcher)
Tel. 031 373 2334

I, _____ Id number _____ hereby give permission for the above- mentioned research project to be conducted in the creche premises.

Name of Creche: _____

Physical Address: _____

Creche Manager's Signature: Date:

Researchers' signature: Date:

Appendix J

Department of Food and Nutrition
Tel. (031) 373-2334, Fax 086 557 2410
P.O. Box 1334, Durban 4000

LETTER OF INFORMATION AND CONSENT

Dear Parent or Guardian,

Welcome and thank you for taking the time to read through this document. My name is Onwaba Makanjana and I work at Durban University of Technology. We are starting a research project in the crèche your child attends. We require pre-school children to voluntarily participate to make this project work.

Title of the Research Study: The impact of an orange-fleshed sweet potato yoghurt on Vitamin A and iron status of pre-school children

Principal Investigator/researcher: Onwaba Makanjana

Co-Investigators/Supervisors: Prof. Carin Napier and Dr. Ashika Naicker

Outline of the Procedures:

- Should you decide to allow your child to participate in the study, you will be required to sign a consent form. Your child will be required to indicate if he/ she agrees to participate in the research project.
- The child's height and weight will be measured. Please be present.
- Using the finger-prick method, blood samples will be taken to determine current levels of Vitamin A and iron status by a nursing sister. A few drops of blood will be collected by drawing blood from the child's finger. This process will be done twice within the duration of the research project, once at the beginning and again at the end of the study. **NO HIV OR AIDS** tests will be done on these blood samples.
- Your child will receive a fruit after the blood has been taken.
- Kindly tell us if your child is allergic to milk products
- Please keep in mind that your child does not have to take part in this study it is strictly on a voluntary basis.

Risks:

- Your child will not be exposed to any health risks by participating in the study.

Rights to withdraw and Reasons why a Child may be Withdrawn from the Study:

- Your child has the right to withdraw at any point, if they wish to do so and that decision will be respected.

Remuneration:

The participants will not receive any remuneration for participating in the project.

Costs of the Study:

The participants will not be expected to cover any costs towards the research project.

Confidentiality:

- When publishing results from the study, the names of those who participated will not be made public knowledge. The researcher will allocate reference numbers to all participants and names will not be used.
- During the project, questionnaires will be kept in a locked cupboard. The questionnaires will be shredded after the completion of the research project.

Research-related injury:

The research involves very minimal risk therefore no injury is anticipated, however, should there be any injury; the participants will be referred to a health professional.

Ethics:

Ethical approval will be obtained from the Institutional Research Ethics Committee before the research project begins.

Persons to Contact in the Event of Any Problems or Queries:

Should you have any queries, please do not hesitate to contact the following people:

Onwaba Makanjana (Researcher)
Tel.: 031 373 2334

Research co-supervisor:
Dr. Ashika Naicker
Tel.: 031 373 2333

Prof. Carin Napier (Research Supervisor
Tel.: 031 373 2326

Institutional Research Ethics Administrator
Tel.: 031 373 2900

Thank You,

Onwaba Makanjana (Researcher)

Statement of Agreement to Participate in the Research Study:

I, _____ (parents full name), _____ (ID number), have read this document in its entirety or have listened to an oral explanation and understand its contents. Where I have had any questions or queries, these have been explained to me by the researcher to my satisfaction. Furthermore, I fully understand that my child may withdraw from this study at any stage without any penalties and his/her future health care will not be compromised. I therefore, voluntarily agree for my child to participate in this study.

Parents Name _____ Child's name _____

Parent's Signature: _____ Date: _____

Researcher's Name: _____

Researcher's Signature: _____ Date: _____

Witness Name: _____

Witness Signature: _____ Date: _____

Appendix K

Department of Food and Nutrition
Tel. (031) 373-2334, Fax 086 557 2410
P.O. Box 1334, Durban 4000

Mzali

Ngiyabonga ngesikhathi sakho sokufunda lo mbhalo. lgama lami ngingu Onwaba Makanjana. Ngisebenza eDurban University of Technology. Siqala iproekthi yocwaningo enkulisa okufunda kuyo ingane yakho. Ngakho ke sicela ukuba uvumele ingane yakho ukuthi ibe yingxenye yalolucwaningo. Sidinga izingane zasenkulisa ezizoba ingxenye yomsebenzi wephrojekthi ngokuzithandela.

Kungani loluncwaningo lubalulekile:

Umnyango wezempilo usungule uhlelo lwa Vitamin A. Lolucwaningo luhambisana nezinhloso zomnyango wezempilo, onenhloso yokuthuthukisa izinga likaVitamin A ezinganeni ezincane

Isihloko socwaningo:

Umthelela weyogathi eyenziwe ngobhatata onesikhumba esiwolintshi uma kubhekwa ubungako buka Vitamin A ne-lron emzimbeni yezingane zasenkulisa.

Inhloso yalolu cwaningo ukuthola ulwazi ngesimo sikaVitamin A ne iron emzimbeni wezingane zasenkulisa. Emva kwalokho kuyobe sekwenziwa indlela yokungenelela bese kuhlolwa umthelela weyogahi eyenziwe ngobhatata onesikhumba esiwolintshi uma kubhekwa ubungako buka vitamin A ne-iron emzimbeni yezingane zasenkulisa eseThekwini eNingizimu Afrika.

Uhlelo:

- Sizocela uphendule imibuzo mayela nokudla okudliwe yingane yakho
- lsisindo nobude bengane buzokalwa
- Amaconsi egaza azothathwa emunweni wengane. **Kuzohlolwa uVitamin A ne iron KUPHELA.**
  lngane izonikwa isithelo emva kothathwa igazi.
- lngane izonikwa iyogathi izinyanga enthathu.
- Emva kwezinyanga ezine kuzogcwaliswa inhlovu kuphindwe kuthathwe amanye amaconsi egaziukuqathanisa izinga le vitamin A ne iron emva kokuba ingane ithole iyogathi

izinyanga ezintathu.

Uma uvuma ukuthi ingane yakho ibe yingxenye yalolu cwaningo uyacelwa ukuba usayine ifomu yokunika imvume ulibuyisele enkulisa. lngane yakho iyocelwa ukuba isho ukuthi iyavuma yini ukuba yingxenye yocwaningo.

Okungahle kufake ingane yakho engcupheni:

- lngane yakho ngeke ibe sengcupheni ngokwempilo ngokuba ingxenye yalolu cwaningo.

llungelo lokuhoxa kanye nezizathu ezingenza ukuthi ingane ihoxiswe kulolu cwaningo:

lngane yakho inelungelo lokuhoxa noma inini, uma kuyisifiso sayo, lokho kuyohlonishwa

Uma kunenkinga noma unombuzo ungathitha:

Onwaba Makanjana (Umcwaningi)
Tel.: 031 373 2334

Prof. Carin Napier (Suphavayza)
Tel.: 031 373 2326

Dr Ashika Naicker
(Suphavayza)
Tel.: 031 373 2333

Institutional Research Ethics Administrator
Tel.: 031 373 2900

Siyabonga,

Onwaba Makanjana (Umcwaningi)

Isivumelwano

Isivumelwano sokuba yingxenye yocwaningo:

Ngiyavuma ukuthi ngichazelwe ngalolucwaningo, nangayo yonke imininingwane yalo lolu cwaningo – Research Ethics Clearance Number : 019/13.

Ngiyavuma ukuthi ingane yami u _____ (igama lengane) ibeyingxenye yalolucwaningo.

_____	_____	_____
Igama lomzali	Usuku	Sayina
_____	_____	_____
Igama lomcwaningi	Usuku	Sayina
_____	_____	_____
Igama likafakizi	Usuku	Sayina

Appendix L

Fieldworker Training Manual

Welcome to the fieldwork training session.

Goal of training session:

The goal of this training session is to provide you with guidelines and equip you with the necessary knowledge to enable you to conduct research field work.

What is a fieldworker?

A fieldworker is an important team member of the research team. The role of the fieldworker is to assist in the collection of data. A fieldworker interviews the participants in the research project and documents the answers given by the participants. It is therefore important for all fieldworkers to be able to interact with others, record information accurately and pay attention to detail. Fieldworkers must be approachable and not intimidate the participants.

Code of conduct for fieldworkers:

Respect: All fieldworkers are to always treat all participants and other members of the research team with respect.

Honesty and integrity: All fieldworkers must be honest and trustworthy as they may handle personal information of participants

Patience: Fieldworkers must exercise patience with all participants. Some of the research participants may be elderly caregivers or young children. It is therefore essential to be patient in all activities e.g. during administration of questionnaires, weight and measuring height of children etc.

Punctuality: Fieldworkers must be punctual at all times. The research team has a schedule to follow and at times has appointments with participants or stakeholders. It is therefore essential to respect people and their time.

Humility: All fieldworkers need to be humble. Fieldworkers are not to undermine research participants

Attitude: All field workers need to have a positive attitude and not be judgmental.

Flexibility: Fieldworkers must be flexible and adapt to different circumstances that may arise during the fieldwork sessions.

Professionalism: Fieldworkers must be professional in their conduct and appearance. Remember, you are representing the research team and DUT

What is my dress code as a fieldworker?

You must be neat and wear clean clothes at all times. Fieldworkers are to dress as follows:

Comfortable shoes such as takkies or pumps

Jeans or Jeggings

DUT branded fieldworker T shirt (black or grey)

Jacket or jersey where necessary

What should I not wear as a fieldworker?

T shirts branded with information promoting political organisations

T shirts with offensive emblems or illustrations

How to conduct the interview with the participants?

- Greet the participant politely. Smile and be friendly.
- Make sure you have written the participant number.
- Ask which language the participant would like to communicate in.
- Explain what the interview is about. Allow the participant to ask questions.
- Reassure the participants that the information they give you will be treated confidentially. Put them at ease.
- Direct the questions to the participants as indicated in the questionnaire. If you are using a different language, ensure you don't lose meaning of what is being asked in the questionnaire
- Keep your tone soft and friendly throughout the interview. Do not appear shocked or disturbed by any response the participant gives.
- Ask the questions as they appear in the questionnaire and in the order presented in the questionnaire.
- Do not lead the response of the participants. Allow them to answer freely and openly and write down the responses. If you are not clear on what the participant said in response to a question, politely ask them to clarify so that you document accurate information.
- Be careful of your own body language. Avoid frowning and maintain a friendly facial expression.

- Keep your tone conversational and control the direction of the interview.
- Towards the end of the interview, make sure you have covered all questions.
- Indicate to the participant when the interview is over and thank them for their time.

How do I conduct weight and height measurements of the children?

Weight:

- Greet the child and be friendly.
- Make sure you have written the participant number and all necessary details.
- Explain that you will measure their weight.
- Assist the child to remove his or her shoes.
- Remove any heavy clothing.
- Make sure the scale is placed on a flat surface and it's on zero.
- Ask the child to step on the scale and record the weight on the anthro sheet provided.
- Ask the child to step off and repeat the process and record the weight for the second time in the slot provided

Height:

- Make sure the child shoes are off.
- Ask them to stand with their heels together with their hands hanging on the sides
- Make sure the child looks straight ahead without lifting up the head
- Record the height as indicated on the stadiometer
- Repeat the same process and record for the second time on the anthro sheet provided

Thank the child for their participation and cooperation

Data verification:

The researcher will verify and check the questionnaires for completeness at the end of each session.

Practice exercise:

Choose a partner.

One must be the participant and the other the fieldworker.

The fieldworker is to interview the participant using one of the questionnaires.

Weigh and measure the height of the participant.

The researcher will oversee this process and give you feedback and guidance.

Swop roles.

End of the training Session

Appendix M

Certificate from language editor

THE WRITING STUDIO
Writing and Editing Practice

Certificate 2721

TO WHOM IT MAY CONCERN

27 July 2021

This dissertation, entitled **The impact of orange fleshed sweet potato yoghurt on vitamin A and iron status of pre-school children in Durban South Africa,** by OZ Makanjana**,** has been edited and reviewed to ensure technically accurate and contextually appropriate use of language for research at this level of study.

Yours sincerely

CM ISRAEL, BA Hons (UDW) MA (UND) MA (US) PhD(UNH)
LANGUAGE EDITOR AND WRITING CONSULTANT
Connieisrael90@gmail.com Mobile 082 4988166

Appendix N

International Journal of
Environmental Research and Public Health

MDPI

Article

Nutritional Status of Children 24–60 Months Attending Early Child Development Centres in a Semi-Rural Community in South Africa

Onwaba Makanjana * and Ashika Naicker

Department of Consumer Sciences: Food and Nutrition, Durban University of Technology, 70 Steve Biko Road, Musgrave, Berea 4001, South Africa; ashikan@dut.ac.za
* Correspondence: onwabam@dut.ac.za; Tel.: +27-31-373-2334

Abstract: Despite the numerous efforts to improve the nutritional status of children, a high prevalence of malnutrition still exists in South Africa. This study aimed to determine the nutritional status of children attending Early Child Development centres in South Africa. In this baseline study, we randomly selected two Early Child Development centres comprising 116 children aged 24–60 months, separated into two cohorts, of 24–47 months and 48–60 months. Dietary intake was measured through the 24 hDR and analysed using Food Finder software. The food frequency questionnaire was used to calculate the food variety and food group diversity scores. Anthropometric measurements were taken and the WHO Anthro software was used to convert it to nutritional data indices. Blood samples were collected through dried blood spot cards in order to determine serum retinol and haemoglobin levels and they were assessed using WHO indicators. The findings showed that participants between 24 and 47 months had a high mean energy intake (4906.2 kJ and 4997.9 kJ for girls and boys, respectively). For the 48–60 months age group, energy intake was lower than the EER (5936.4 kJ and 5621.2 kJ; $p = 0.038$). There was low fruit and vegetable consumption (24–47 months; 63.8 g and 69.5 g ($p = 0.037$), 48–60 months; 68.3 g and 74.4 g ($p = 0.038$) and the top five foods consumed were carbohydrate rich foods for girls and boys, respectively. Stunting was noted in 7% and 20% (48–60 months) ($p = 0.012$) and overweight in 8% and 17% (24–47 months) and 17% and 13% (48–60 months) ($p = 0.041$) in girls and boys, respectively. Low serum retinol levels (<0.070 µmol/L) were found in 9.1% of boys (24–47 months), and 8% and 7.4% of girls and boys (48–60 months), respectively. Low haemoglobin levels (<11.0 g/dL) were found in 50.0% and 30.4% (24–47 months) and 8.6% and 39.3% (48–60 months) of girls and boys, respectively. Malnutrition, despite many national and provincial initiatives, still exists in Early Childhood Development centres in South Africa, calling for the application of contextualized nutrition interventions to suit resource-poor settings.

Keywords: nutritional status; Early Childhood Development; stunting

check for updates

Citation: Makanjana, O.; Naicker, A. Nutritional Status of Children 24–60 Months Attending Early Child Development Centres in a Semi-Rural Community in South Africa. *Int. J. Environ. Res. Public Health* **2021**, *18*, 261. https://doi.org/10.3390/ijerph18010261

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1. Introduction

The early childhood period is the most crucial developmental phase in life, and thus, the ultimate aim is for all children to be free of malnutrition in all forms. The six global targets set by the World Health Assembly in 2012 included a 40% reduction in the number of stunted children by 2025, no increase in childhood overweight and maintenance of the prevalence of wasting to less than 5% [1]. The global agenda to improve nutrition by 2030 aims to end all forms of malnutrition, reduce stunting by 50% and reduce childhood overweight and wasting numbers to less than 3% [2]. Globally in 2018, 821.6 million people were undernourished, of which 256.1 million were from Africa. Moreover, 9.2% of people worldwide experienced hunger and Africa accounted for the highest percentage (21.5%) of people experiencing severe food insecurity [3]. It has been well established that stunting is the devastating result of poor nutrition in-utero and early childhood. Even though progress has been made in various regions to reduce stunting, almost 149 million children below five

years of age are stunted [3]. As the emerging face of childhood malnutrition moves towards overweight and obesity conditions, the prevalence of overweight in children under five has increased dramatically with 40.1 million identified as overweight [3]. While wasting in children is seen as the life-threatening result of sub-optimal nutrient intake and/or disease, in 2019, wasting was prevalent among 49.5 million children [3].

Various studies show that the diet of the South African population, particularly children, is generally low in fruit and vegetables, and mostly consists of starch-based foods [4–6]. Despite numerous efforts to improve the nutritional status of South African children, stunting is the most common nutritional disorder similar to global trends in undernutrition [7]. Additionally, the South African National Health and Nutrition Examination Survey (SANHANES-1) showed that 43.6% of children under five years had vitamin A deficiency and 10.7% had anaemia in 2013; however a marked reduction of the prevalence of anaemia was noted from 2005 onwards [8]. Good nutrition in the first 1000 days allows children to survive, grow, develop, learn, play, participate and contribute to society. Notable among gaps in the achievement in the nutritional status of children in South Africa lies the potential to introduce contextualised interventions through a syndemic approach involving the interacting nature of nutritional status and the social and environmental factors that promote their negative relationship [9].

Interventions to improve the health and nutritional status of children need to be implemented as early as possible, to reduce the effects of malnutrition on growth and development of young children. The Department of Social Development (DSD) identified Early Childhood Development (ECD) centres as an ideal platform for implementing strategies aimed at reducing poverty in children below five years of age in South Africa. ECD centres are facilities designed to provide early childhood development services and programmes that include good health, proper nutrition and early learning through a holistic approach in promoting a healthy environment that is conducive for learning and development [10]. ECDs in South Africa are non-profit organizations that are funded by the department of social development and the department of education [11]. The General Household Survey by Statistics South Africa indicated that over 2 million children receive some form of ECD services. Of this number, 800,654 children are currently accessing registered ECD programmes by the Department of Social Development and 626,574 of these children receive a subsidy of R17 per child per day. There are currently 14,205 registered partial care facilities that operate as ECD centres while many remain unregistered as they do not comply with the minimum norms and standards set out in the Children's Act [12]. Given the strong subscription of ECDs in South Africa, ECDs are the perfect platform to continue support for the first 1000 days of life. The arguments in favour of promoting the development of children at a very young age are clear and compelling. Against this backdrop, the study aims to determine the nutritional status of 24–60 months old children attending ECD centres in South Africa for the purposes of planning robust and contextualised nutritional interventions suited to resource-poor settings.

2. Materials and Methods

2.1. Study Design and Sampling

This study formed part of a randomised control trial, of which the baseline results for the entire group are presented in this paper. Children between the ages of 24 to 60 months attending two registered ECD centres were eligible for the study. Simple random sampling techniques were used to select two ECD centres from a list of ECD centres in the Valley of a Thousand Hills in Durban. The Valley of Thousand Hills is a semi-rural area located 40 km from Durban in KwaZulu-Natal (KZN), South Africa. The population size of the area where the study was conducted was 815 (33.70 per km^2) [13]. The study sample consisted of 116 children between the ages of 24–60 months separated into two cohorts (24–47 and 48–60 months).

2.2. Dietary Intake

Dietary intake data was measured using a validated 24 h dietary recall questionnaire (administered three times: two weekdays and one weekend day) and a Food Frequency Questionnaire (FFQ) [14]. Trained fieldworkers administered the questionnaires to the parent or caregiver of the child. Food samples were used to aid portion size identification.

2.3. Anthropometric Measurements

Anthropometric measurements including height (up to the nearest 1 mm using the SECA stadiometer) and weight (up to the nearest gram using the SECA weighing scale, calibrated before weighing session) were taken using WHO standard indicators to assess wasting, stunting, underweight, overweight and obesity [15]. All measurements were recorded twice using standardised prescribed anthropometric measurement procedures [15].

2.4. Biochemical Measures

Using the finger-prick method, blood samples (50µL) were collected, and dried blood spots (DBS) were prepared by trained health professionals to determine biochemical indicators of vitamin A and haemoglobin (Hb) levels of the participants. The participants washed their hands and rubbed them together to generate warmth to promote blood circulation. A pea-size amount of a topical anaesthetic cream was applied to the fingertip 20 min before pricking. The fingertip was thereafter pricked with a sterile retractable lancet and blood drops were allowed to fall freely inside the pre-printed circles on labelled DBS cards. The DBS cards were then placed in drying racks and left to dry at room temperature. All safety protocols for blood collection were observed [16]. After drying, the DBS cards were placed inside Ziploc plastic bags from the DBS collection kit, and a desiccant sachet was placed inside the cooler boxes and transported to the laboratory in a temperature-controlled environment. The samples were thereafter stored at −80 °C until analysis [16]. Biochemical indicators of vitamin A were assessed using High Performance Liquid Chromatography (HPLC) and vitamin A levels < 0.070 µmol/L were considered as vitamin A deficiency [17]. Haemoglobin levels were measured using a haemoglobin meter and compared to prescribed cut-offs (<11.0 g/dL) for iron deficiency for the age group [18].

2.5. Ethics Approval and Consent to Participate

Ethical approval was granted by the Institutional Research Ethics Committee at Durban University of Technology (IREC no 019/13). Gatekeeper permission to conduct the research was sought from relevant stakeholders. A letter of information in English and in isiZulu (local language) was shared and explained to all internal gatekeepers, parents and caregivers. Written consent was obtained from the principals of the ECD centres to conduct the study at their facilities and from parents or caregivers of the child. All biomedical waste was disposed of using biomedical waste management rules [19].

2.6. Data Management and Analysis

Data from the 24hDR was captured and analysed using Food Finder Software (version 3) to determine mean nutrient intake and the top ten foods consumed [20]. The nutrient intake was compared to the Recommended Dietary allowance (RDA) and AI for the age group 24–47 months and 48–60 months (15). The FFQ data were used to determine the food variety score (FVS) and food group diversity scores (FGDS). The mean fruit and vegetable intake were compared to the South Africa Peaediatric guidelines for children aged 1–7 years [21]. Anthropometric data were analysed using the WHO Anthro software version 3.2.2 [22]. Stunting was defined as a low length/height-for-age z-score (<−2 for moderate or <−3 for severe), wasting as a low weight-for-height z-score (<−2 for moderate or <−3 for severe), and underweight as low weight-for-age z-score (<−2 for moderate or <−3 for severe). The data were analysed for descriptive statistics and independent *t*-tests using the Statistical Package for the Social Sciences SPSS® statistical software package

Version 24.0 (IBM SPSS Inc., Chicago, IL, USA) for analysis. p values <0.05 were considered statistically significant.

3. Results

3.1. Participant Profile

The sample size comprised of 116 children of which there were 58 children in 24–47 months category (girls $n = 30$, boys $n = 28$) and 58 children in the 48–60 months category (girls $n = 28$, boys $n = 30$).

3.2. Nutrient Intake

Table 1 illustrates that the mean energy intake for girls (4906.2 kJ) and boys (4997.9 kJ) between 24–47 months was above the estimated energy requirement (EER). In the 48–60 months age group, the mean energy intake was 5936.4 kJ for girls and 5621.2 kJ for boys ($p = 0.038$). The mean intake of protein was 33.1 g for girls and 36.7 g for boys between 24–47 months ($p < 0.001$) and was 41.3 g and 39.2 g for girls and boys, respectively, for the 48–60 months age group ($p < 0.001$). The mean intake of carbohydrates was significantly higher than the recommended amount for both age categories; 167.5 g and 176.9 g for girls and boys respectively between 24 and 47 months ($p = 0.011$) and 201.1 g for and 193.5 g for girls and boys between 48 and 60 months. The contribution of fat to total energy was 26.7% and 25.8% in girls and boys between 24 and 47 months respectively. In the 48–60 months age group, fat contributed 26.7% to total energy for girls and 25.2% for boys. In contrast, the mean dietary fibre intake was lower than the recommended amount; 10.7 g for girls and 13.4 g for boys between 48 and 60 months, 13.6 g for girls and 14.4 g for boys aged 40–60 months. Ninety-seven percent of girls and 86% of boys between 24 and 47 months did not meet the daily recommended amount for calcium, with the mean intake being lower in girls (248.3 mg) than boys (307.1 mg) ($p < 0.001$). The mean intake of calcium for participants between 48–60 months was also lower than the recommended intake, (346.9 mg for girls and 241.2 mg for boys ($p = 0.056$).

The results also show that the mean intake of vitamin A was higher than the recommended RDA for all participants between 24–47 months (456.2 µg and 551.3 µg for girls and boys respectively) ($p < 0.001$). A similar trend was observed in girls (608.7 µg) and boys (506.3 µg) between 48 and 60 months ($p = 0.019$). All boys between 24 and 47 months met the RDA for folate per day; however, 7% of girls in that age group consumed less than the recommended amount. In the 48–60 months age group, results show that even though the mean intake of folate was higher for girls (251.8 µg) compared to boys (273.0 µg), 11% of girls consumed less than the RDA ($p < 0.001$). This trend was also noted for vitamin B12 for participants aged 48–60 months where the mean intake was 2.8 µg for girls and 2.4 µg for boys ($p = 0.031$); however, 7% of girls consumed less than the RDA.

The results presented in Table 2 indicate that for the 24–47 months age group, the mean fruit and vegetable intake for girls was 63.8 g and 69.5 g for boys ($p = 0.037$). In the 48–60 months age group, the mean was 68.3 g for girls and 74.4 g for boys ($p = 0.038$). Results also showed that the mean FVS was 34 for participants between 24 to 47 months and 38 for participants between 48 to 60 months, indicating medium variety. The mean FGDS was 8.2 for the 24 to 47 month age group and 8.5 for 48 to 60 months age group.

Table 3 shows that maize meal was the most consumed item among girls and boys between 24–47 months (2491.1 g and 2577.6 g respectively), followed by diluted squash cold drink (1695.8 mL for girls and 1408.1 mL for boys) and rice at third place (1468.3 g and 860.8 g). A donated instant vanilla porridge was placed fourth for both groups (942.3 g for girls and 865.0 g for boys) and bread at number five (691.6 g and 1654.1 g for girls and boys respectively). The top three foods consumed by girls and boys between 48 and 60 months were maize meal (2151.3 g for girls and 3086.1 g for boys), rice (1576.0 g for girls and 1770.9 g for boys) and diluted squash (1547.0 mL and 1091.6 mL for girls and boys respectively).

Table 1. Mean dietary intake for girls and boys (n = 116) 24–60 months as measured by the 24 h food recall.

Nutrient	Girls and Boys 24–47 Months (n = 58)					Girls and Boys 48–60 Months (n = 58)				
	Girls Mean Nutrient Intake n = 30 (SD)	% Girls < 100% of DRI	Boys Mean Nutrient Intake n = 28 (SD)	% Boys < 100% of DRI	*p* Value	Girls Mean Nutrient Intake n = 28 (SD)	% Girls < 100% of DRI	Boys Mean Nutrient Intake n = 30 (SD)	% Boys < 100% of DRI	*p* Value
Energy kJ *	4906.2 (292.6)	40	4997.9 (734.7)	17.8	0.541	5936.4 (701.4)	82	5621.2 (339.8)	96.6	**0.038**
Protein (g) **	33.1 (2.9)	0	36.7 (4.2)	0	**0.001**	41.3(0.4)	0	39.2 (0.9)	0	**0.000**
CHO (g) **	167.5(5.1)	0	176.6(17.1)	0	**0.011**	201.1 (36.1)	0	193.5 (15.7)	0	0.316
Total fat (g)	35.4 (18.4)	-	34.9 (9.3)	-	0.842	42.8 (30.4)	-	38.3 (9.4)	-	0.342
Total dietary fibre (g) ***	10.7 (1.3)	100	13.4(1.4)	82	0.307	13.6 (1.9)	100	14.4(1.7)	100	0.118
Calcium (mg) ***	248.3 (20.6)	97	307.1 (7.6)	86	**0.000**	346.9 (40.9)	100	241.2 (288.7)	97	0.056
Iron (mg) **	8.4 (1.0)	0	9.9(0.9)	0	**0.000**	10.4 (1.3)	0	10.6(1.2)	0	0.641
Zinc (mg) **	6.15 (0.7)	0	7.7 (0.0)	0	**0.000**	8.1 (0.9)	0	7.9 (1.2)	0	0.538
Vitamin A (µg) **	456.2 (59.6)	0	551.3 (85.3)	14	**0.000**	608.7 (134.4)	11	506.3 (186.0)	23	**0.019**
Riboflavin (mg)	1.6 (0.0)	0	1.5 (0.0)	0	**0.000**	2.2 (1.0)	0	2.1 (0.4)	0	0.477
Vitamin B6 (mg) **	1.8 (0.1)	0	2.3 (0.1)	0	**0.000**	2.4 (0.6)	0	2.3 (0.7)	0	0.900
Folate (µg)	207.1 (32.4)	7	256.0 (20.2)	0	**0.000**	251.8 (25.2)	11	273.0 (10.9)	0	**0.000**
Vitamin B12 (µg) **	2.45(0.6)	0	2.6 (0.5)	0	0.164	2.8 (0.7)	7	2.4 (0.4)	0	**0.031**

[1] DRI for 24–47 months [23]; DRI for 48–60 months: [23], SD: standard deviation; * EER, ** RDA: Recommended dietary allowance; *** AI: adequate intake; *p* values given in bold font indicate that the mean nutrient intake is significantly different from the RDA/AI.

Table 2. Mean fruit and vegetable intake for all participants (n = 116).

	Girls 24–47 Months (n = 30)		Boys 24–47 Months (n = 28)		*p* Value	Girls 48–60 Months (n = 28)		Boys 48–60 Months (n = 30)		*p* Value
	Mean Intake (g) (SD)	Per Capita	Mean Intake (g) (SD)	Per Capita		Mean Intake (g) (SD)	Per Capita	Mean Intake (g) (SD)	Per Capita	
Fruit and vegetables	63.8 (13.2)	74.0	69.5 (5.4)	74.5	**0.037**	68.3 (8.4)	98.8	74.4 (13.0)	94.4	**0.038**

Table 3. Top 10 foods consumed by all girls and boys (n = 116) between 24 and 60 months as measured by the 24-h food recall.

Girls 24–47 Months (n = 30)			Boys 24–47 Months (n = 28)			Girls 48–60 Months (n = 28)			Boys 48–60 Months (n = 30)		
ITEM	Mean Intake (g) (SD)	Capita Intake (g)	ITEM	Mean Intake (g) (SD)	Capita Intake (g)	ITEM	Mean Intake (g) (SD)	Capita Intake (g)	ITEM	Mean Intake (g) (SD)	Capita Intake (g)
Matze meal	2491.1 (2114.0)	83	Matze meal	2577.6 (2414.0)	92	Matze meal	2151.3 (294.6)	77	Matze meal	3086.1 (2621.7)	103
Diluted squash cold drink	1695.8 (866.2)	56	Diluted squash cold drink	1408.1 (1019.4)	50	Rice	1576.0 (731.6)	56	Rice	1770.9 (1419.2)	59
Rice	1468.3 (1393.9)	48	Rice	860.8 (1296.6)	31	Diluted squash cold drink	1547 (−27.8)	55	Diluted squash cold drink	1091.6 (408.9)	36
Instant porridge	942.3 (−548.2)	31	Instant porridge	865 (−229.5)	31	Instant porridge	1454.6 (803.2)	52	Milk	1455.8 (365.3)	49
Bread	691.6 (549.1)	23	Bread	1654.1 (469.0)	59	Bread	765 (−139)	27	Instant porridge	1027.3 (646.7)	34
Tea	654.1 (218.0)	22	Milk	914.3 (−984)	33	Milk	725.0 (370.0)	26	Bread	617.5 (124.9)	21
Milk	538.83 (526.3)	18	Tea	484.1 (−684.7)	17	Apple	457.0 (41.9)	16	Apple	283.3 (10.6)	9
Pilchard curry	384.5 (328.8)	13	Apple	430 (−438.4)	15	Chicken curry	275.0 (181.4)	10	Phuthu and maas	778.3 (601.5)	26
Sausage curry	375.0 (275.7)	13	Pilchard curry	243 (−343.6)	9	Savoury snack	265.1 (121.3)	9	Tea	425.3 (400.6)	14
Apple	360.0 (325.2)	12	Sausage curry	225 (−318.1)	8	Banana	248.1 (350.9)	9	Potato stew	231.1 (77.0)	8

3.3. Anthropometric Status

Figure 1 illustrates that the majority of the participants had a normal height for age in both groups. Stunting was noted in 7% of girls and 20% of boys between 48 and 60 months ($p = 0.012$), and 7% of girls were severely stunted, as per WHO standards (19). The percentage of girls with a normal weight for height was lower in the 48–60 months age group (32%) compared to girls between 24 and 47 months (60%). Among boys, 46% in the 24 to 47 months and 53% in the 48 to 60 months age group, a normal weight for height was recorded. Wasting was observed in 3% of boys between 48 and 60 months. The risk of being overweight was higher in girls between 48 and 60 months (46%) compared to 27% of boys in the same age group ($p = 0.026$). In contrast, more boys (29%) were at risk of being overweight compared to girls (20%) in the 24 to 47 months age group. Eighteen percent of boys between 24 and 47 months were overweight, closely followed by boys between 48 and 60 months at 17% and girls between 24 and 47 months at 13%. Results showed a statistically significant difference between overweight girls and boys between the ages of 48 to 60 months ($p = 0.041$). Seven percent of girls and 7% of boys between 24 to 47 months were obese. In the 48 to 60 months age group, 14% of girls between were obese, and none of boys were obese in that age group ($p = 0.004$).

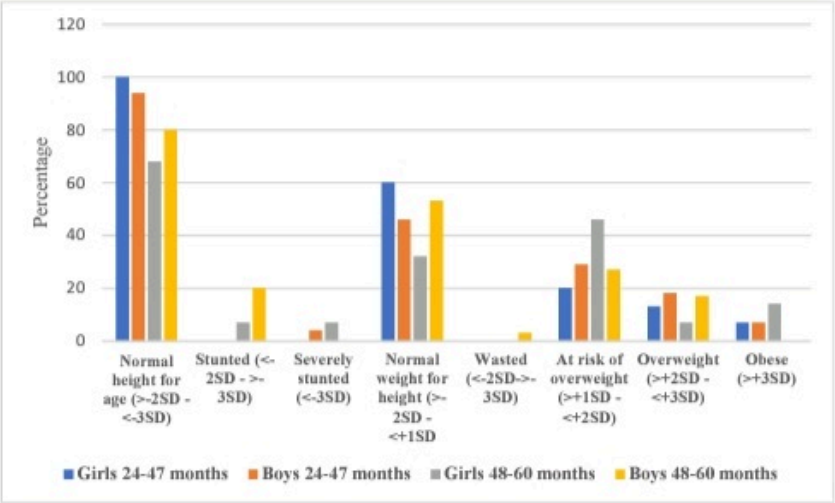

Figure 1. Girls' and boys' anthropometric results ($n = 116$).

3.4. Vitamin A and Iron Status

For the biochemical measurements, the sample size decreased to $n = 90$ due to 15 participants being absent on blood collection days and the inability to detect serum retinol in $n = 11$ of the samples (refer to Table 4). Low serum retinol levels (<0.070 µmol/L) were found in 9.1% of boys between 24 and 47 months, and none of the girls had low serum retinol levels in this age group. Eight-point three percent girls and 7.2% of boys between 48 to 60 months had low serum retinol levels. In the 24 to 47 months age group, 50.0% of girls and 30.4% of boys had low Hb levels (<11.0 g/dL) whereas in the 48 to 60 months age group, low Hb levels were found in 28.6% of girls and 39.3% of boys.

Table 4. Serum retinol (n = 90) and Hb (n = 101) levels.

		Girls 24–47 Months (n = 17) for Serum Retinol, (n = 22) for Hb (%)	Boys 24–47 Months (n = 22) for Serum Retinol, (n = 23) for Hb (%)	Girls 48–60 Months (n = 24) for Serum Retinol, (n = 28) for Hb (%)	Boys 48–60 Months (n = 27) for Serum Retinol, (n = 28) for Hb (%)
Serum retinol levels	>0.070 µmol/L	100	90.9	91.7	92.6
	<0.070 µmol/L	0	9.1	8.3	7.2
Hb levels	>11.0 g/dL	50.0	69.6	71.4	60.7
	<11.0 g/dL	50.0	30.4	28.6	39.3

4. Discussion

In general, the study findings showed that participants between 24 and 47 months had a higher mean energy intake whereas those in the 48 to 60 months age group had a low mean energy intake compared to EER for that age group. There was low fruit and vegetable consumption, high prevalence of stunting, overweight and iron deficiency. The importance of nutrition in early childhood development and the effects of inadequate nutrition beyond childhood has been well established [24]. Results in this study show that the fibre and calcium intake were lower than the recommended amount in all the age groups, similar to findings in a study conducted in Durban in South Africa [6]. The contribution of fat to total energy intake was less that the recommended 30–40% for children between 24 and 47 months. However, for children between 48 and 60 months, it was within the recommended Acceptable Macronutrient Distribution Range (AMDR) of 25–33%. Furthermore, even though the mean dietary intake was higher than the RDA for vitamin A in all groups, low serum retinol levels were found in some boys between 24 and 47 months and in both girls and boys between 48 and 60 months. Similarly, low Hb levels were found in all age groups, despite dietary intake indicating adequate iron intake. This highlights that dietary intake results from a 24 h dietary recall should be interpreted with caution as some participants may underreport or incorrectly estimate their food intake despite using food samples during data collection. Moreover, there was generally a high protein intake in all groups, and none of the participants consumed less than the recommended intake. Given that the food intake results are similar to findings reported in the National Food Consumption Survey conducted in 1999 and a more recent study at an ECD centre in a similar context [6,7], and despite national interventions, various reasons can be attributed to the current results. Nutritional status is influenced by several environmental factors and, as such, in countries like South Africa where the prevalence of HIV infection is high, HIV infection has both a direct impact on the nutritional status of women and children who are infected and an indirect effect through changes in household food security and inappropriate choices of infant-feeding practices to prevent mother-to-child transmission of HIV [25].

It has been well established that adequate fruit and vegetable consumption is crucial for child health. Globally and nationally, most children do not meet the guidelines for adequate fruit and vegetable intake. The results from this study are no different; the mean fruit and vegetable intake for all participants between 24 and 47 months and 48 to 60 months was less than the recommended 320 to 480 g per day and 400 to 480 g per day respectively. These findings of low fruit and vegetable intake compare with the SANHANES-1 study. Cost is the major constraint prohibiting daily consumption of fruits and vegetables [26]. Given that 65% of young children in South Africa live below the poverty line, affordability is related to the low fruit and vegetable intake [27]. Although initiatives such as food gardens have been amplified and promoted as a nutrition intervention strategy, its impact is seldom measured. Moreover, the dislike of fruit and vegetables among children and the habit of eating fruits and vegetables at an early age is another possible reason. According to Raggio and Gambaro, (2018) the sensory characteristics of vegetables and the habits of

consumption in the family environment play an important role in acceptance or rejection of vegetables by children [28].

Anthropometric results show that over and undernutrition coexists within the study population, which reflects similar trends in developing countries [29]. The incidence of stunting was noted in girls and boys between 48 and 60 months, with severe stunting being more pronounced among girls. The high prevalence of stunting in this study population is similar to other studies in South Africa [30,31]. While wasting was only observed in boys aged 48 to 60 months, the risk of overweight was high in all age groups, especially in girls between 48 and 60 months. The anthropometric results indicating the prevalence of overweight in this study link with the dietary intake results, as the group with higher mean energy intake (24–47 months) had a higher percentage of participants who were overweight. The more recent South African Demographic Health Survey in 2016 found a decline in wasting and underweight, yet stunting remained high, affecting 27% of children under five [32]. Stunting is an indicator of chronic malnutrition compromising children's cognitive development, education and employment prospects, and increases their risk of overweight and obesity [25]. While South Africa has experienced a rapid nutrition transition characterised by an increase in the prevalence of obesity and non-communicable diseases, the South African pattern of transition differs in that stunting persists [33]. To effectively direct public health initiatives, an understanding of the long-term dynamics of stunting in the South African context is required in conjunction with the interplay of the obesogenic food environment.

In children, vitamin A is essential to support rapid growth and helps to combat infections (WHO). The findings in this study show that some of participants had low serum retinol levels. When comparing vitamin A dietary intake and serum retinol concentration similar results were noted. For girls 24–47 months, both methods recorded the same results (100% of the DRI for vitamin A and 100% serum retinol level > 0.070 µmol/L). For all other age groups a close difference between dietary vitamin A and serum retinol level was reported; boys 24–47 (9.1% and 14% lower, girls 48–60 (8.3% and 11%), boys 48–60 (7.2% and 22%) were lower than the DRI for vitamin A and serum retinol level < 0.070 µmol/L. In the SAHANES study at the national level, the prevalence of vitamin A deficiency was 43.6%. South Africa introduced routine periodic high-dose vitamin A supplementation in 2002 to reduce childhood mortality, however, there is no evidence from the past two decades, with changing disease profiles, increased use of vaccines and reduced morbidity from diarrhoea and pneumonia, that a high-dose programme is nearly as effective today as it was in some countries 20 to 30 years ago [34]. Moreover, it has been found that there may also be pockets where, due to unique eating patterns, vitamin A deficiency may not be present at all [35].

Iron deficiency can have a serious impact on children's health and later development through alteration of the immune status, adverse effects on morbidity and delayed behavioural and mental development [36]. In this study, the prevalence of anaemia was high contrary to the findings of the SAHANES study where the overall prevalence of anaemia was 10.7%, mild anaemia 8.6% and moderate anaemia 2.1% [8]. It was also found that children in the 24–47 months age group had lower Hb levels. Likewise, the prevalence of anaemia was highest in children in the 24–35 months (15.2%) age group and decreased to 3.0% in the 48–59 months age group in the SAHANES study [8]. The mean iron intake of participants seemed adequate however, low Hb levels were noted in all groups. A possible reason for the low Hb levels in this study population could be alluded to inaccurate reporting of food intake or dietary bioavailability. Co-morbid anaemia and stunting among young children are highly prevalent in low- and middle-income countries [9]. Hence a syndemic framework approach is encouraged integrating the co-occurrence of health problems with social and environmental factors.

5. Limitations

This study is not without limitations. The results of this study represent a semi-rural geographical area which may not represent a typical rural setting. Using a finger prick to draw blood samples posed limitations as serum retinol could not be detected in some samples. Researchers could not draw blood intravenously as that would be invasive given the age of participants. Other limitations included a small sample size and potential recall bias.

6. Conclusions

Despite the numerous efforts to improve the nutritional status of children, a high prevalence of malnutrition still exists in South Africa. Malnutrition, presented through micronutrient deficiencies, stunting, overweight and obesity, co-exist in this study population. The nutritional status of children's diet, attending ECD centres, is sub-optimal and is characterised by inadequacies for optimum growth with a marked increase in the prevalence of stunting, overweight and low haemoglobin levels.

7. Recommendations

Early interventions to address both under and overnutrition are required. Menus should be reviewed to include more fruit and vegetables and unrefined carbohydrates. Sustainable food-based interventions should be explored with the intent to support good health, proper nutrition and early learning at ECD centres towards the optimum development of human capital. The co-morbidity of anaemia and stunting in early childhood resource-constrained settings should be managed using a syndemic approach. Sustainable interventions should be explored with the intent to support good health, proper nutrition and early learning at ECD centres, towards the optimum development of human capital.

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Institutional Review Board Statement: Ethical approval was granted by the Institutional Research Ethics Committee at Durban University of Technology (IREC no 019/13).

Informed Consent Statement: Gatekeeper permission to conduct the research was sought from relevant stakeholders. A letter of information in English and in isiZulu (local language) was shared and explained to all internal gatekeepers, parents and caregivers. Written consent was obtained from the principals of the ECD centres to conduct the study at their facilities and from parents or caregivers of the child. All biomedical waste was disposed of using biomedical waste management rules.

Data Availability Statement: Data available on request due to restrictions: ethical. The data presented in this study are available on request from the corresponding author. The data set are not publicly available due to ethical reasons and institutional data privacy rules.

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Conflicts of Interest: The authors declare no conflict of interest.

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