Nutritional status and development in 12-18 months old young children in a post-intervention study

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Mini-dissertation submitted in fulfilment of the requirements for the degree Master of Science in Nutrition at the North-West University

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Graduation: 2019

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PREFACE

“Make up your mind that no matter what comes your way, no matter how difficult, no matter how unfair, you will do more, than simply survive. You will thrive in spite of it.” —Joel Osteen

ACKNOWLEDGEMENTS

I would like to give thanks to the Lord Jesus Christ for blessing me with the abilities to have completed my studies and most importantly for His unfailing love. Thanks to the Centre of Excellence for Nutrition (CEN), most especially my supervisor, Professor C.M. Smuts and my assistant supervisor Dr Marinel Rothman. I really enjoyed working with you all and your inputs were most valuable. Special thanks to my supervisor Prof Marius Smuts, for your support; motivation and always having your door open to assist. To Prof Mieke Faber, my co-supervisor, you have taught me so much and I could not have done this without you. Thank you for making the load lighter, for guiding me academically and encouraging me in my wild pursuits. To Dr Carl Lombard our incredible statistician, thank you for your vital contribution to this study and for the many hours of hard work and collaboration. I also want to thank Global Alliance for Improved Nutrition (GAIN) and co-sponsorship from Unilever and DSM for the opportunity, financial assistance and support to complete this study.

To the CEN Tswaka team and Tswaka fieldworkers, thank you for all the hard work, fun times and tough times, we had during data collection. Thanks to Dr Linda Malan for guiding me during data entry and cleaning. To my mother Gladys, my sister Nsuku, my brother Hlayisani, and other family members, thank you for everything that you have done for me. Without you I would not have had the opportunity to complete my studies. Thanks to my daughter, Mixo, who understood when I needed time to work on my mini-dissertation. My baby daddy for looking after our daughter while I was busy working on my mini-dissertation.

I would also like to thank the reviewers of my mini-dissertation for their time and positive feedback and contributions. Lastly to all of the friends who supported me in this work.

ABSTRACT

Nutritional status and development in 12-18 months old young children in a post-intervention study.

Background: Infancy is a critical stage of life for rapid brain growth that requires adequate and proper nutrition. Without proper nutrition, infants may become micronutrient deficient leading to poor growth and cognitive development. Small-quantity lipid-based nutrient supplements (SQ-LNS) are one of the promising strategies to address poor nutrition and micronutrient deficiencies during infancy. The effect of providing daily SQ-LNS from age 6 to 12 months on early child growth and development was investigated in a randomized controlled trial (Tswaka) in the peri-urban Jouberton community in the Matlosana Municipality, Klerksdorp, in North West Province.

Objectives: To determine the nutritional status and psycho-motor development at the age of 18 months of children who received a delayed SQ-LNS intervention daily from the age of 12 to 18 months compared to those who received the same intervention daily from the age of 6 to 12 months but no intervention from 12 to 18 months

Design: At age 12 months, children (n=392) who completed the Tswaka randomised controlled trial and whose parents consented were enrolled into the post-intervention study. End results (at 12 months) of the Tswaka trial were used as baseline data for the post-intervention study, and end-line measurements were taken at age 18 months. Measurements taken at age 12 and 18 months were weight, length, haemoglobin (Hb) and psychomotor development outcomes. Weight-for-length (WLZ), length-for-age (LAZ) and weight-for-age z-scores (WAZ) were calculated based on the WHO growth reference standards. For Hb values, a finger prick was done. Children in group 1 and 2 received SQ-LNS products from age 6 to 12 months in the Tswaka trial, but no supplements from age 12 to 18 months in the post-intervention study; while children in group 3 received no supplements from age 6 to 12 months in the Tswaka trial, but SQ-LNS from age 12 to 18 months in the post-intervention study.

Results: At age 18 months, the mean Hb concentrations were significantly (p=0.003) higher in the children who received SQ-LNS from age 12 to 18 months (group 3) compared to the two previously exposed groups (groups 1 and 2); and 45.38% in group 3 were anaemic compared to 53.98% in group 1 and 58.67% in group 2. The anthropometric data showed that 53.57% of the children were stunted (LAZ< 2), 6.77% overweight (WLZ > 2), 12.30% underweight (<−2 WAZ) and 0.79% and wasted (<−2 WHZ) at 18 months. Compared to group 2 (previously intervention group at 6-12, now control group), children in group 3 (SQ-LNS group) had higher WAZ (P = 0.027) at 18 months. There was no statistically significant difference on intervention effects for loco-motor development and parental rating scores at 18 months when comparing group 3 with

group 1 and 2. However, there was a trend (p=0.086) for an intervention effect for eye-hand coordination in group 2 compared to group 3.

Conclusion: The provision of SQ-LNS product as point-of-use fortificant showed improvement in the haemoglobin status of children and may be an effective option for preventing anaemia. This study indicated the need for more trials to be done on this topic. It also demonstrated the need to strengthening optimal infant feeding practices and nutritional intervention in relation to growth and development as it remained a public health concern in our population group.

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LIST OF ABBREVIATIONS

ABR/ACR	Description
AE	Adverse Event
AI	Adequate Intake
ARA	Arachidonic Acid
CFR	Case Fatality Rate
DHA	Docosahexaenoic Acid
DOH	Department of Health
DRI	Dietary Reference Intakes
EAR	Estimated average requirement
EFA	Essential Fatty Acid
FAO	Food and Agricultural Organization
GAIN	Global Alliance for Improved Nutrition
HB	Haemoglobin
HAZ	Height-for-age z-score
ID	Iron Deficiency
IDA	Iron Deficiency Anaemia
IFPRI	International Food Policy Research Institute
LA	Linoleic acid
LAZ	Length-for-age z-score
LCPUFA	Long-Chain Polyunsaturated Fatty Acids
LNS	Lipid-based Nutrient Supplement
MMN	Multiple Micronutrient
MNP	Micronutrient Powder
MUAC	Mid-Upper Arm Circumference
NFCS	National Food Consumption Survey
NFCS-FB-1	National Food Consumption Survey Fortification Baseline
NWU	North-West University

PUFA	Polyunsaturated Fatty Acids
RBC	Red Blood Cells
RCTs	Randomised Clinical Trials
RUSF	Ready-to-Use Supplementary Food
SAE	Serious Adverse Event
SAMRC	South African Medical Research Council
SADHS	South African Demographic and Health Survey
SANHANES	South African Health and Nutrition Examination Survey
SQ-LNS	Small Quantity Lipid-based Nutrient Supplement
UNICEF	United Nations Children's Fund
WHO	World Health Organisation

CHAPTER 1 INTRODUCTION

1.1 Background

Worldwide appropriate feeding practices are poorly practised (WHO, 2018). Undernutrition is the underlying cause of death for 45% of all child deaths in children under the age of 5 years in the world (FAO, 2014). According to UNICEF, WHO, and World Bank (2015) out of 667 million children under the age of 5 years worldwide, 159 million are stunted, 50 million wasted, and 41 million are overweight (UNICEF, WHO, and World Bank 2015). Black *et al.* (2008) reported that over 40% of under 5-year-old children living in Africa were estimated to be stunted in 2008. In addition, Black *et al.* (2013) reported that stunting prevalence among children younger than 5 years was 2.47 times higher in the poorest quintile of households than in the richest households worldwide. Stunting has adverse long-term consequences on children's immune function and survival risk, cognitive and behavioural development, educational attainment and economic productivity (Black *et al.*, 2013). Furthermore, children are more prone to iron deficiency (ID) during their first two years of life, because of their increased requirements for growth (Burke *et al.*, 2014). Stunting and poor nutrition in the first two years of life are associated with increased morbidity and mortality (Black *et al.*, 2008).

In South Africa, undernutrition is of national concern with 27% of children under the age of 5 years being stunted (LAZ less than –2SD), with 10% being severely stunted (LAZ below –3 SD), as indicated by the 2016 South Africa Demographic and Health Survey (SADHS) (NDoH *et al.*, 2017). The prevalence of anaemia in children under 5 years has decreased from 28.9% in 2005 National Food Consumption Survey Fortification Baseline (NFCS-FB) to 10.7% in 2012 (Shisana *et al.*, 2014).

Growth faltering and undernutrition can be prevented during the first 1000 days of life. In most cases, stunting occurs in the first two years of life when children have a high demand for nutrients and there are limitations in the quality and quantity of their diets, especially after the period of exclusive breastfeeding (Shrimpton *et al.*, 2001). However, meeting the nutritional needs of children younger than two years remains a challenge worldwide (Dewey, 2013).

In vulnerable communities, local complementary foods are mostly cereal-based porridges with low nutrient density and poor mineral bioavailability (Dewey, 2013). Furthermore, Faber *et al.* (2016) in a study conducted in urban and rural KwaZulu-Natal, found that infants' complementary diets had poor nutrient density. Strategies to promote appropriate complementary feeding, which include education about complementary feeding, increasing

the nutrient quantity of complementary foods, and fortification of complementary foods (De Onis *et al.*, 2013), can be important to improve the nutrient quality of complementary foods. Complementary feeding interventions are regarded as effective strategies that have been proven to reduce stunting in children less than 5 years (Bhutta *et al.*, 2013).

Children, mostly those who are under the age of two years are easily affected by multiple micronutrient (MMN) deficiencies (Bhutta *et al.*, 2013). UNICEF (2014) reported that many children in South Africa are deficient in vitamins and minerals which are essential for good health and optimal development. However, consuming complementary foods with inadequate iron content may lead to less iron being stored in the body, causing ID to progress into iron deficiency anaemia (IDA) (WHO, 2001). Children under two years who are poorly nourished have more difficulty in fighting infections, and as a result they become sick more often and they also don't grow well compared to children of similar age (Burke *et al.*, 2014). Therefore, strategies to improve the nutrient content of the complementary diet of infants and young children are needed. Improving micronutrient intake of children during the first two years of life is important because this is the time where irreversible outcomes of malnutrition may be prevented (De Onis *et al.*, 2012a; De Onis *et al.*, 2012b; De Onis *et al.*, 2012c).

Deficiencies of micronutrients like vitamin A, iron, zinc, iodine and essential fatty acids (EFA) may affect neurodevelopmental processes (Prado & Dewey, 2014). The major domains of child neurodevelopment are sensori-motor, cognitive-linguistic, and social-emotional function (Grantham-McGregor *et al.*, 2007). Infants and young children who are micronutrient deficient often do not attain the required growth and development according to their age and they are susceptible to morbidity and mortality (Black *et al.*, 2013). Improving the micronutrient status may however not necessarily result in improved growth (Smuts *et al.*, 2005). Furthermore, children who are stunted are more likely to have irreversible long-term physical and mental damage (Piwoz *et al.*, 2012). Significant association between stunting and delayed cognitive development was also found by Fernald *et al.* (2009).

Nutrition intervention is essential for optimising child development throughout the first 1000 days of life and beyond (Dewey, 2013). This led to the development of point-of-use fortifications with fortified products including small quantity lipid-based nutrient supplements (SQ-LNS) and multiple micronutrient powders (MMP) (Dewey & Arimond, 2012; Arimond *et al.*, 2015). Ready-to-Use Supplementary Food (RUSF)/medium-quantity LNS were designed for treatment of moderate and acute malnutrition (Matilsky *et al.*, 2009; Lagrone *et al.*, 2010; LaGrone *et al.*, 2012), prevention of seasonal wasting (Isanaka *et al.*, 2010; Huybregts *et al.*, 2012) or prevention of stunting and/or underweight or promotion of growth (Isanaka *et al.*,

2010; Grellety *et al.*, 2012; Huybregts *et al.*, 2012). In contrast, SQ-LNS products were designed to prevent undernutrition and promote growth and development through home fortification of the daily diet (Adu-Afarwuah *et al.*, 2007; Phuka *et al.*, 2008).

In South Africa, the effects of two novel SQ-LNS products on linear growth and motor development in infants were investigated in a randomized controlled trial (RCT; referred to as the Tswaka study). Infants were enrolled at the age of 6 months, and randomly assigned to one of three groups, namely SQ-LNS (n=250), SQ-LNS-plus (n=250) and a no-supplement control group (n=250). SQ-LNS and SQ-LNS-plus both contained micronutrients and EFAs. SQ-LNS-plus, in addition, contained docosahexaenoic acid, arachidonic acid (important for brain and eye development), lysine (limiting amino acid in maize), phytase (enhances iron absorption), and other nutrients. The 6-month intervention study showed an early transient intervention effect on linear growth and improved locomotor development for SQ-LNS-plus, and both SQ-LNS products showed positive intervention effects for anaemia and iron status (Smuts *et al.*, 2019). An acceptability study that was done prior to the RCT showed that the use of both SQ-LNS products was acceptable and caregivers indicated that their children liked the taste when mixed into maize porridge and/or other complementary foods (Rothman *et al.*, 2015). After completion of the 6-month intervention (at age 12 months), children in the no-supplement control group received SQ-LNS for 6 months (delayed intervention). Supplementing children aged 12-18 months (delayed intervention group) still falls within the 1000 days' window of opportunity.

The current study (Tswaka post-intervention study) is a follow-up study of children who participated in the Tswaka-RCT. The hypothesis is that Tswaka children who received the SQ-LNS from 12-18 months of age will have the same benefit as those children who received the SQ-LNS from age 6-12 months. This study will also provide evidence on possible delayed intervention effects in the children exposed to SQ-LNS from age 6-12 months by determining differences between the groups that received early intervention (6-12 months) and the one that received the intervention later (12-18 months).

1.2 The study population and area

The study population consisted of 12-18 months-old children from the peri-urban Jouberton area of the greater Matlosana (Klerksdorp) municipality, Dr Kenneth Kaunda district, North West Province of South Africa, who participated in the Tswaka-RCT from age 6 to 12 months. The study site is 200 km from the nearest metropolitan area (Johannesburg). At age 12 and

18 months, all measurements were taken at the central site on the premises of the Baptist church in the Y-section of Jouberton. At the central study site, four mobile containers that were purchased for the Tswaka study served as temporary office, lab space, space for assessment of anthropometry and psycho-motor development.

1.3 Aim

The aim of this study was to determine the nutritional status and psycho-motor development at age 18 months of children who received a delayed SQ-LNS daily from age 12 to 18 months compared to those who received the same intervention daily only from age 6 to 12 months but no intervention from 12 to 18 months.

1.4 Objectives

In order to address the aim of the study, the following objectives were formulated:

- To determine the anthropometric status in children at age 12 and 18 months.
- To determine haemoglobin status in children at the age of 12 and 18 months.
- To determine psycho-motor development in children at age 12 and 18 months.
- To compare anthropometric status, haemoglobin status and psycho-motor development between children who received SQ-LNS from age 12 to 18 months to those who received SQ-LNS from age 6 to 12 months.

1.5 Ethical approval

The Tswaka RCT is registered at Clinicaltrials.gov registry (NCT01845610) and ethical approval was obtained from the Ethical Committees of the North-West University (NWU-00001-14-A1) and the South African Medical Research Council (SAMRC, EC011-03/2012). Ethical approval for the Tswaka post-intervention study was obtained from the Ethics Committee of the North-West University (NWU-00060-17-A1). After institutional ethical approval the project was reviewed by the provincial Department of Health and Social Development for registration with the Directorate for Policy, Planning and Research. The Kenneth Kaunda District Department of Health also granted permission for the study in the Matlosana area of Klerksdorp. The stakeholder engagement process for the Tswaka study started after all the relevant authorities had given permission. This process included informing and negotiating with a broad range of local government, civil and political structures to ensure a stable and collaborative environment in which to work.

1.6 Research team

Members of the research team and their main roles and contributions are listed in Table 1-1

Table 2-1: Research team and their responsibilities.

Name	Role/ Function	Signature
[1]Prof Marius Smuts	Supervisor of this study, Principal Investigator (PI) and responsible for the study design. Responsible for overall monitoring of data collection and quality control, guidance on analysis of biochemical data, academic input, guidance regarding study design, protocol development, review of dissertation components, interpretation and review of all results	
[1,2]Prof Mieke Faber	Co-Supervisor of this study, Co-Principal investigator (Co-PI) and overseeing all dietary data collection. Involved in training, guidance on data collection, quality control and analysis of feeding practices, academic input and guidance on interpretation of research results, interpretation and review of all results.	
[1]Dr Marinel Rothman	Project coordinator of the Tswaka trial, supervising field data collection and data quality control of Kilifi and parental rating evaluations. Provided training, guidance, and direction on protocol development.	
[1]Dr Tonderayi M Matsungo	Project coordinator of the Tswaka study, supervising field data collection and quality control of the anthropometric data. Responsible for the study product management.	
[1]Rikhotso Idah	M.Sc. student, study-coordinator of follow-up study (delayed-intervention), supervising field data collection on cognitive assessments and anthropometric data in terms of execution and monitoring. Full responsibility of writing mini-dissertation.	
[1,3]Prof Carl Lombard	Biostatistician; data analysis	

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1.7 Structure of this mini-dissertation

This thesis is divided into five chapters.

The five chapters for the thesis and the contents of each chapter are outlined as follows:

Chapter 1 Covers the introduction, aim and objectives as well as the research team and author's contribution to the research.

Chapter 2 Covers the literature on children's nutritional status and the strategies to improve child growth and development.

Chapter 3. Covers the methodology of the study and ethical considerations of both the Tswaka RCT and the post-intervention study.

Chapter 4. Research article entitled *Nutritional status and development in 12-18 months old young children in a post-intervention study.* The article has been prepared according to the guidelines to authors for publication in the South African Journal of Clinical Nutrition. The referencing style is not according to SAJCN guidelines and this will be revised before submitting the manuscript to the journal.

Chapter 5. Conclusions and recommendations.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Malnutrition still remains a public health concern in the developing regions, although there has been a decline in the number of deaths of children under five from 12.7 million in 1990 to around 6 million in 2015 globally (UN, 2015). Children most affected by under-nutrition are those younger than 2 years (Bhutta *et al.*, 2008). In 2016, stunting affected an estimated 154.8 million children under 5 globally, with 59 million children being stunted in Africa. In the same year, 14 million children under the age of 5 were wasted and 10 million were overweight (UNICEF / WHO / World Bank Group, 2017). The global nutrition targets for 2025 are to reduce the number of stunted children by 40%, reduce and maintain child wasting to less than 5%, no increase in childhood overweight, reduce low birth weight by 30% and increase exclusive breastfeeding to at least 50% (IFPRI, 2016)

Scaling up Nutrition (SUN) has committed itself and encourages all governments to focus on ending hunger and malnutrition in all its forms by 2030 (SUN, 2016). As growth faltering and micronutrient deficiencies start during pregnancy, addressing it should start by prioritising nutrition of all women of child bearing age; followed by prevention of micronutrient deficiencies, and prevention of stunting and wasting in young children (SUN, 2012). However, providing safe and adequate amounts of local foods to meet the nutritional requirements of infants is challenging. This is due to the fact that complementary foods that are locally available and affordable are often inadequate in micronutrients required for growth. Furthermore, inappropriate complementary foods given to young children may increase their risk of malnutrition, illness and mortality (WHO & UNICEF, 2003).

The focus of the SUN approach is the first 1000 days, from conception to age two years (SUN, 2012). Black *et al.* (2008) indicated that undernutrition mostly happens in the first 1000 days, when children's linear growth is most sensitive to nutrition deprivation and environmental stress. In addition, Dewey and Begum (2011) indicated that growth faltering occurs between 6 and 24 months of age, when children start consuming complementary foods and are more prone to diseases. This was supported by UNICEF (2015) that found that the high prevalence of stunting occurs during the complementary feeding period when children are 6–24 months. Growth faltering and poor nutrition in the first two years of life have critical consequences that may persist throughout the life-course (Black *et al.*, 2008). Therefore, since growth faltering typically occurs before the age of two years, children under the age of two years should be the main target groups for preventative interventions.

Early childhood undernutrition may lead to short- to long-term poor cognitive development (De Onis, 2008). Malnourished children are often sick, less often present in school and they perform less well in class when compared to well-nourished classmates (IFPRI, 2016). The nutritional status of a child is reflected by the ability of that child to achieve optimal growth and development and it can be used as an indicator of socio-economic development and improvement of the society that the child lives in (De Onis, 2008). Unfortunately, the food that is available and affordable to most families is often of poor nutritional value and it fails to meet nutrient needs, particularly when families cannot afford frequent consumption of animal-source foods, such as meat, fish, eggs and dairy products (Dewey & Vitta, 2013).

Good nutrition builds strong immune systems and helps in protecting children from infection, hence giving them higher chances of survival (IFPRI, 2016). However meeting nutritional needs of children who are 6 to 24 months of age remains a challenge (Dewey, 2013). This chapter will review the literature on the on effect of SQ-LNS on growth and development of children and delayed lipid-based nutrient supplementation on child nutritional status and development of children in South Africa and other countries.

2.2 Prevalence of malnutrition

The leading cause of death during childhood is malnutrition (WHO 2013). The immediate causes of undernutrition and malnutrition are illness, poor feeding and care (Bhutta *et al.*, 2008; Black *et al.*, 2008). In addition, malnutrition results from factors related to health-care access, education, sanitation and hygiene, access to food and resources, women's empowerment and more (IFPRI, 2016). Malnutrition is the cause of poor growth and development in young children, and it prevents children from attaining a bright future by hindering their growth and development (UNICEF / WHO / World Bank, 2017). Malnutrition, especially undernutrition, remains a major public health concern worldwide (FAO, 2014). It is the main course of more than 33% of child deaths worldwide (WHO, 2013).

Although the rate of undernutrition in developing regions has improved (The Sustainable Development Goals Report 2016), child malnutrition remains a public health concern. In 2015, 13% of children were classified to be overweight (weight-for-height greater than +2 SD from the reference median) (IFPRI, 2016). In 2016, wasting affected the lives of an estimated 7.7 per cent or nearly 52 million children under 5 globally (UNICEF / WHO / World Bank, 2017). Undernutrition was found to be the leading cause of stunting, wasting and intra-uterine growth retardation (IUGR) (FAO, 2014). In addition, undernutrition is associated with increased risk of mortality and decline in anthropometrical status (Olofin *et al.*, 2013).

2.3 Child mortality rate

It is estimated that around seven million children die annually from infectious diseases and undernutrition worldwide (Black 2013 *et al.*, UNICEF, 2014). According to the 2016 South Africa Demographic and Health Survey (SADHS, 2016), there was a drop in the infant mortality rate to 35 deaths per 1,000 live births, for the 5 years' prior the 2016 SADHS. The neonatal mortality rate in South Africa has dropped to 21 deaths per 1,000 live births, accounting for about half of under-5 deaths. The child mortality rate was 7 deaths per 1,000 children surviving to age 12 months. The neonatal mortality rate was 21 deaths per 1,000 live births (NDoH *et al.*, 2017).

In South Africa the number of children under the age of 5 years who died due to severe acute malnutrition decreased from 1 852 in 2014/15 to 1 380 in 2015/16 (Massyn *et al.*, 2016). The proportion of people who die from a specified disease among all individuals diagnosed with the disease over a certain period of time is called case fatality rate (CFR). The number of deaths due to severe acute malnutrition (SAM) and the CFRs decreased in all provinces, although CFRs remained high in a number of provinces, namely Mpumalanga (12.5%), North West (12.3%), Limpopo (11.6%) and the Eastern Cape (10.1%) (Massyn *et al.*, 2016).

2.4 Micronutrient deficiencies

Micronutrient deficiencies refer to deficiencies of essential vitamins and minerals (Black *et al.*, 2013b) and are also called hidden hunger (WHO & FAO 2014). Multi-micronutrient (MMN) deficiencies are recognized as the leading contributor to burden of disease in children under the age of 5 years, especially in the developing world. Deficiencies of vitamin A, zinc, iodine, and iron are the major contributors to high rates of morbidity and mortality among infants and children in developing countries (Khan *et al.*, 2016). This was supported by Black *et al.* (2013b) who indicated that MMN deficiencies cause an increase in infant and child morbidity and mortality. They further indicated that MMN deficient children can also be prevented from attaining the required growth and development according to their age. Children are prone to MMN deficiencies due to increased micronutrients requirements and increased susceptibility to infection (Bhutta *et al.*, 2013). In many low-income communities, caloric intake may be sufficient, yet the consumption of micronutrients and essential fatty acids tend to be lower than recommended (Dewey & Brown, 2003; Huffman *et al.*, 2011).

2.5 Measures of nutritional status

2.5.1 Anthropometric measurements

Growth assessment is done through the measurement of certain physical parameters (such as weight and height) and interpreting these parameters according to age. Anthropometric measurements that are used for the assessment of nutritional status of young children include weight, standing height (used in children aged 24 months and older), recumbent length (used in children from birth to 24 months) (WHO, 2006).

Three most commonly used anthropometric assessments in children to assess growth status are weight-for-age (WA; underweight), length/height-for-age (stunting) and weight-for-length/height (WL/H; wasting and overweight) (De Onis, 2008). These indices are expressed either as z-scores, percentiles, or percentage of median, which enables comparison of a child or a group of children with a reference population (De Onis *et al.,* 2003).

2.5.2 Stunting

Stunting is a chronic form of malnutrition (UNICEF, 2016). Stunting is a height-for-age Z-score (HAZ) below minus two standard deviations (-2 SD) from the median of the reference population. Children who are stunted are considered short for their age (NDoH *et al.*, 2017). Stunting can be identified by assessing a child's length or height (recumbent length for children less than two years old and standing height for children age two years or older). It is interpreted by comparing them with an acceptable set of standard values of the international agreement from the WHO Child Growth Standards median for the same age and sex (WHO 2008; De Onis *et al.* 2013).

2.5.3 Wasting (weight-for height)

A child is classified as wasted when their Z-score is below minus two standard deviations (-2 SD) from the median of the reference population and they are classified severely wasted when their weight-for-height Z-score is below minus three standard deviations (-3 SD) from the median of the reference population (NDoH *et al.*, 2017). Wasting /low weight for height (either moderate or severe) is used as a predictor of mortality among children and can be caused by a combination of infection and poor nutrient diets amongst under five children

(WHO/UNICEF/WFP, 2014). Children who rapidly lose weight become wasted (NDoH *et al.*, 2017).

2.5.4 Underweight (weight-for age)

A child is classified as underweight when the weight-for-age Z-score (WAZ) is below minus two standard deviations (-2 SD) from the median of the reference population and as severely underweight when WAZ is below minus three standard deviations (-3SD) from the median of the reference population (NDoH *et al.,* 2017).

2.5.5 Overweight and obesity

In young children, overweight is when a child's weight-for-height/length is above +2 SD of the median weight-for length z-scores (WLZ) and obese is when a child's WLZ is above +3 SD of the median of the reference population (FAO, 2014).

2.6 Child Growth

Stunting is a global problem (Black *et al.*, 2013b) which is the most prevalent form of child malnutrition that affects millions of children globally (De Onis & Branca, 2016). In 2016, stunting affected an estimated 154.8 million children under 5 globally (UNICEF / WHO / World Bank, 2017). The 2013 Maternal and Child Nutrition series reported that stunting prevalence for children under the age of 5 years was 2.47 times higher in the poorest households than in the richest households throughout the world (Black *et al.*, 2013b). The World Health Organisation has called for the implementation of global actions to reduce child stunting by 40% by 2025 (De Onis *et al.*, 2013). If stunting is not rectified by the age of 2 years, it usually persists into adulthood (Victora *et al.*, 2008). Poor nutrition is the main cause of stunting in early childhood (UNICEF / WHO / World Bank, 2017).

In South Africa, stunting remains a national concern with around 27% of children being stunted; and stunting was found to be higher among male children (30%) than among female children (25%) (NDoH *et al.*, 2017). A systematic review by Said-Mohamed *et al.* (2015) on the prevalence of stunting in South African children showed that the majority of the more rural

provinces, Eastern Cape, North West province and Mpumalanga, have a high but consistent level of stunting in comparison to Gauteng and the Western Cape.

In 2016, nearly 52 million children under 5 were wasted and 17 million were severely wasted globally. In Africa, there are 14.0 million children under 5 who are wasted, of which 4.1 million are severely wasted (UNICEF / WHO / World Bank, 2017). In addition, wasting accounts for around 3% of child deaths in children under the age of 5 years in South Africa (NDoH *et al.*, 2017). Wasting in children under the age of 5 years is a life-threatening condition that may be caused as a result of hunger and/or diseases. Children who suffer from wasting have a weak immune system, they are at risk of long term developmental delays, and have an increased risk of death. Therefore, they require urgent treatment and care for them to recover and survive from wasting (UNICEF / WHO / World Bank, 2017).

In sub-Saharan Africa, more than one-fifth of all children are underweight (UNICEF 2015). An estimated 6% or 40.6 million children under the age 5 around the world were overweight in 2016. Furthermore, 10 million children under the age of 5 years were overweight in Africa (UNICEF / WHO / World Bank, 2017). The results from the DHS (2016), show that 6% of all children were underweight, and 1% were severely underweight in South Africa. The proportion of children who are underweight ranges by province, from a low of 3% in Eastern Cape to a high of 13% in North West *(*NDoH *et al.*, 2017).

2.7 The association between malnutrition and child development.

Most of the linear growth faltering in children under the age of 5 years occurs between 6 and 24 months (Dewey & Huffman, 2009, Victora *et al.,* 2010). In addition, growth faltering often begins in utero and continues for at least the first 2 years of post-natal life (De Onis & Branca, 2016) and it can also still continue up until the child is around 4 years old before growth faltering actually stops or stabilises (Shrimpton *et al.*, 2001; Victora *et al.*, 2008). Prado *et al.* (2016a) investigated linear growth and child development in Burkina Faso, Ghana, and Malawi; they found that growth faltering during any period from conception to 18 months is associated with language, motor, and personal-social development but not socio-emotional development or executive function.

Nutrition is the key to children's survival, growth and development. Well-nourished children are healthier and have better cognitive development than their undernourished peers. They also grow and develop better to their full potential and perform better in school and as adults (Aguayo & Menon, 2016). Although, children who receive good nutrition are able to grow and

develop well in life, there are some children who are affected by more than one form of malnutrition, such as stunting and overweight or stunting and wasting (UNICEF / WHO / World Bank, 2017). According to De Onis (2008), the major outcomes of poor growth in children can be classified based on mortality, morbidity (incidence and severity), and psychological and intellectual development.

Malnutrition is closely linked or associated with poor cognitive and education performance in children (Grantham-McGregor *et al.,* 2007). In addition, poor growth in the first two years of life is associated with shorter adult height, lower levels of attained schooling, reduced adult income and low birth weight infants (Victora *et al.* 2008). Hoddinott *et al.* (2013b), indicated that being malnourished before the age of two years is associated with less schooling (due to sickness), a lower test performance, a lower household per capita expenditure, and an increased probability of living in poverty later in life (Hoddinott *et al.*, 2013b). Furthermore, in the first 1,000 days of life malnutrition has a high impact on children's developmental potential and it restricts their cognitive development. Children who are malnourished are more likely to be sick and miss out on school. This reduces their ability to learn (Prado & Dewey, 2014). Therefore nutrition interventions in early childhood are necessary to enhance cognitive function, improve schooling outcomes and improve the economic productivity later in adulthood (Hoddinott *et al.*, 2008).

Malnutrition was found to be associated with life-time consequences which includes impaired intellectual development (Victora *et al.*, 2008). Furthermore, ID with and without anaemia in younger children has been shown to have long-term consequences for cognitive, motor, and behavioural development (Georgieff, 2011). In addition, children who are malnourished begin their lives at a marked disadvantage as they mostly encounter learning difficulties in school and earning less when they become adults (UNICEF / WHO / World Bank, 2017).

2.8 Cognitive development

The first 1000 days' period (from conception to the age of two years) represents the optimal "window of opportunity" where the young child benefits from growth promoting interventions. During this time, the child's brain and body rapidly develop and young children are also at their greatest vulnerability to infection and at risk of malnutrition (Piwoz *et al.*, 2012). In addition, the process of human growth and development also includes the domains of sensory-motor, cognitive language and socio-emotional abilities (Grantham-McGregor *et al.*, 2007). Child development is often assessed by an inventory of milestones through testing and evaluating the ability of a child in performing a series of tasks. There are a number of standardised

assessment tools that are available to measure achievement of psychometric such as psychological characteristics or domains such as language, cognitive, etc. and also motor developmental skills (Fernald *et al.*, 2009).

Information on developmental status of a child can be obtained either through direct testing of the child, reports of the child's behaviours or skills by key informants, e.g., parents, and observation of the child in daily or structured activities (Fernald *et al.*, 2009). Direct tests assess infants either by presenting stimuli, e.g., an object, and note responses, or by asking children to complete tasks or activities e.g., stacking blocks. Key informants' reports contain responses on specific questions about the child's abilities and behaviour based on what parents or guardians know of the child, with no direct assessment of the child by an independent observer. Lastly, observational measures rely upon a trained observer to document the behaviour of a child. Most standardised tests combine two or more modes of assessment (Fernald *et al.*, 2009).

2.9 Consequences of stunted growth and impaired development

Most of the children who live in developing countries are exposed to multiple risks for poor development such as poverty and poor health and poor nutrition (Grantham-McGregor *et al.*, 2007). Early childhood growth faltering is often associated with structural and functional damage to the brain that can result in developmental delays and deficits in cognitive functions (Grantham-McGregor *et al.,* 2007). Being stunted in early childhood can affect the child's progression in life, as indicated in Figure 2-1 (below).

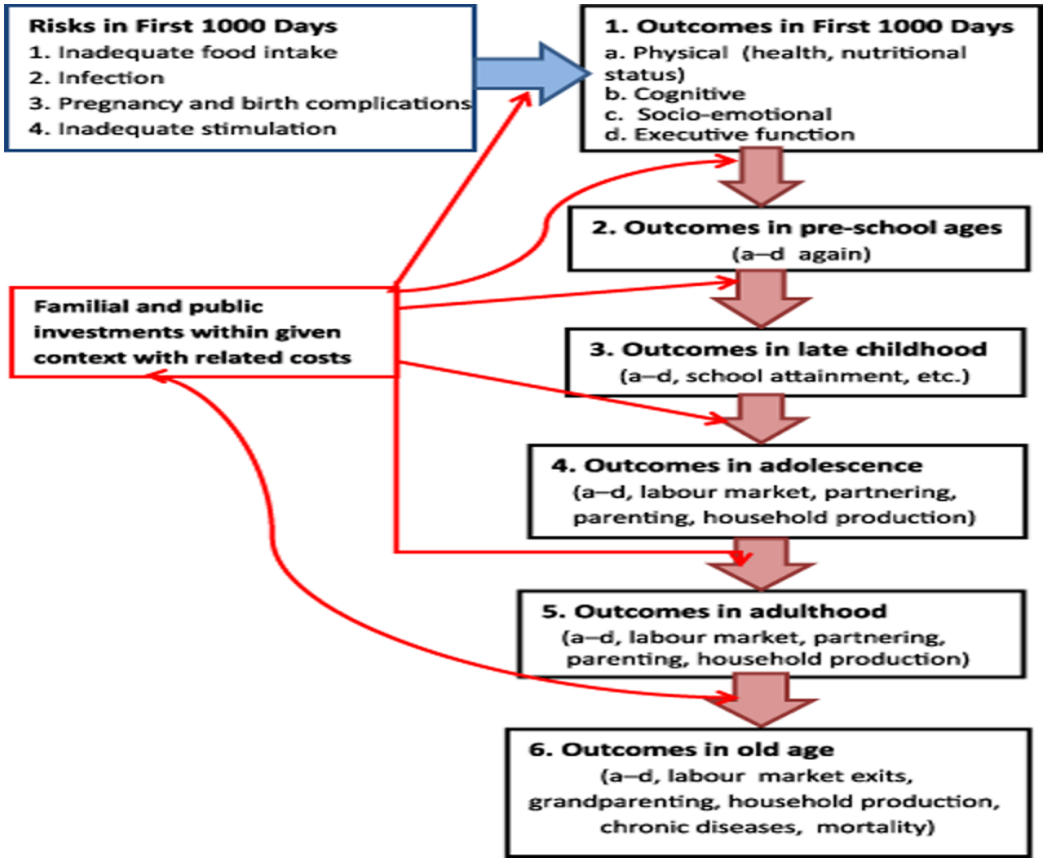

Figure 2-1: A life-cycle approach to investments in the First 1000 Days. Source: Hoddinott *et al.* (2013a)

Being stunted in the first 1000 days of life can effect school attainment in late childhood and can have important economic consequences for both sexes at the individual, household and community levels in adulthood and old age (Hoddinott *et al.*, 2013a). Stunted children may enrol in school late and are more likely to achieve lower grades due to the fact that they have poorer cognitive ability and impaired behavioural development than non-stunted children (Hoddinott *et al.*, 2013b; Prendergast & Humphrey, 2014). Furthermore, stunting is linked with impaired cognitive development, poor school outcomes, lesser income payment later in adulthood and poor maternal reproductive health outcomes (Dewey & Begum, 2011; Victora *et al.*, 2008). Stunted growth has also been associated with later mental health problems (Cheung, 2013). In addition, in a total of 204 children (105 girls) from two resource-limited communities in the Coast Province in Kenya, significant associations were found between anthropometric status (as measured by weight-for-age, height-for-age, mid-upper arm circumference, and head circumference) and psychomotor functioning (Abubakar *et al.*, 2008). In addition, it was shown that children with higher length-for-age Z-scores and that were non-

anaemic started walking at an earlier age than children with lower Z-scores and having anaemia (Siegel *et al.*, 2005).

Childhood stunting is also associated with increased risk of death from infectious diseases (Olofin *et al.*, 2013) and shorter adult stature which is associated with low skilled employment, lower wage earnings and poorer productivity (Hoddinott *et al.*, 2013b). In addition, other consequences of stunting include decreased language and motor development, as well as increased health care expenditure and opportunity cost for caring for the child, decreased reproductive health as well as increased chance of being obese and associated co-morbidities (Stewart *et al.*, 2013).

Growth faltering before the age of 18 months is associated with poor language and motor skills development (Prado *et al.*, 2016a). Although children may recover from early stunting, it was shown that they performed worse on cognitive assessments compared to those who were never stunted (Casale & Desmond, 2016; Mendez & Adair, 1999). On the contrary, a study conducted by Crookston *et al.* (2011) found that children from a Peruvian cohort who experienced catch-up growth had cognitive scores similar to children who were never stunted. They further indicated that children who had catch-up growth between 6–18 months and latter followed again at the age of 4.5–6 years, scored the same in cognitive tests as children who were never stunted; in addition they were also found to have performed better than children who remain stunted from age 6-18 months. However, findings by Crookston *et al.* (2013) indicated that catch-up growth between 1 and 8 years does not eliminate the cognitive deficit associated with early stunting, although it appeared to reduce the deficits associated with early stunting. Furthermore, although children may recover from stunting by the age of 5 years, they still perform significantly worse on cognitive tests than children who do not experience early malnutrition, and almost as poorly as children who remain stunted (Casale & Desmond, 2016).

There is a lack of attention to nurturing care especially during the stage of children's rapid brain development and learning (Black *et al.*, 2017). However, young children who suffer from stunting might not grow to their full height and their brains may also not be able to develop to their full cognitive potential (UNICEF / WHO / World Bank, 2017). Therefore, timing of nutritional intervention in early childhood is a key strategy in enhancing the child's cognitive development and to minimise implications for school readiness and achievement (Casale & Desmond, 2016). Evidence indicates that early interventions can help prevent stunting and improvements can happen rapidly (Grantham-McGregor *et al.,* 2007). In addition, preventing stunting is likely to be of benefit to young children for multiple outcomes, including cognitive development, school achievement and improving wages earned during adulthood period (Dewey & Begum, 2011).

Stunting has the potential to cause a ripple effect, which can be observed well into adulthood and is especially true for height (Black *et al.*, 2013b). Despite its high prevalence and consensus regarding how to define and measure it, stunting often goes unrecognized in communities where short stature is the norm (De Onis & Branca, 2016). This is supported by De Onis *et al.* (2012) who maintains that stunting is often considered as normal in children who live in communities where short stature is common.

Several approaches have been put in place to enhance growth and development as indicated in figure 2-2 below. These include nutrition specific interventions and programmes, building an enabling environment, and nutrition sensitive programmes and approaches (Black *et al.*, 2013b). Nutrition-specific interventions also include several interventions like support for exclusive breastfeeding up to 6 months of age, continued breastfeeding while giving the child appropriate and nutritious complementary foods from 6 months to two years of age; fortification of foods; micronutrient supplementation and treatment of severe malnutrition (Bhutta *et al.*, 2013). The irreversible physical and neurocognitive damage that accompanies stunted growth is a major barrier to child development.

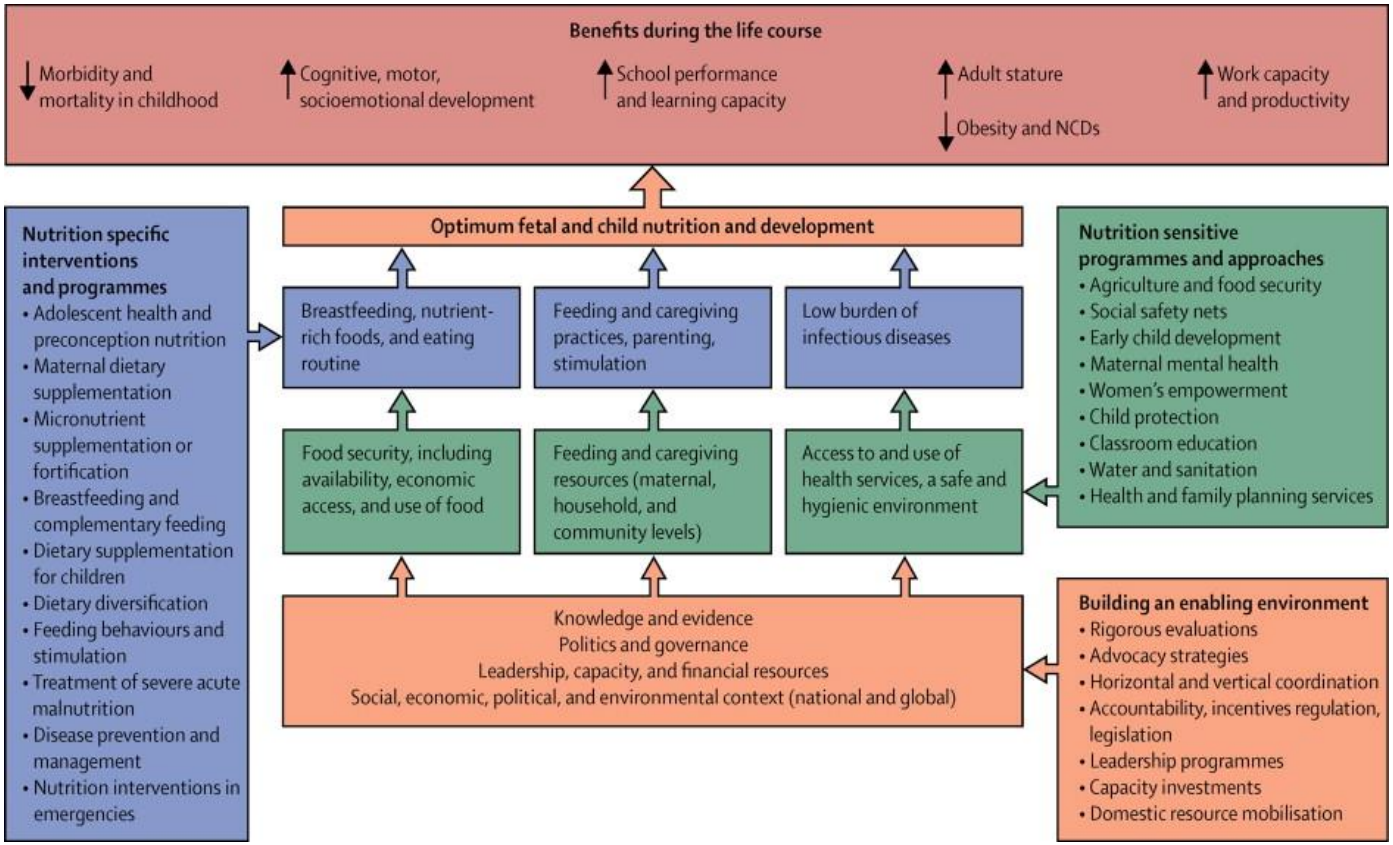

Figure 2-2: Framework for actions to achieve optimum fetal and child nutrition and development (Source: Black *et al.* 2013a).

The National department of Health indicated that the health departments should put more focus on nutrition promotion, exclusive breastfeeding, complementary feeding, dietary diversity, hygiene and food security by implementing food gardens (DOH, 2013b).

2.10 Infant feeding and dietary intake

Infant feeding recommendations include early initiation and exclusive breastfeeding to 6 months, continued breastfeeding to two years or beyond, and timely introduction of nutritionally adequate and safe complementary food after 6 months of age (WHO/ UNICEF, 2003).

2.10.1 Breastfeeding

South Africa has lower rates of exclusive breastfeeding (EBF) compared to other developing countries (NDoH *et al,* 2017). Exclusively breastfeeding can be defined as a practice wherein mothers feed their infants only breast milk without adding any food additives, complementary foods or fluids, including water (Black *et al.*, 2008; WHO, 2011). Continued breastfeeding from age 6-23 months is most frequent in Africa (mean 77%) as compared to other world regions (Black *et al.*, 2013).

Breastfeeding children for a longer period is beneficial, as breastfed children tend to have lower infectious morbidity and mortality, and higher intelligence than do those who are breastfed for shorter periods, or not breastfed (Victora *et al.*, 2016). Growing evidence also suggests that breastfeeding might protect against overweight and diabetes later in life (Victora *et al.*, 2016). Breastfeeding, especially EBF for the first 6 months of life has been shown to have many benefits for both the mother and infant by preventing diseases and promoting health in both short and long term situations (Inoue *et al.*, 2012).

Increasing the number of mothers who breastfeed could potentially prevent an estimated 823 000 annual deaths in children younger than two years worldwide (Victora *et al.*, 2016). There are several advantages associated with breastfeeding, which include: ideal nutritional composition, it provides enzymatic and immunologic properties, it is economic and convenient, there is a decreased risk for respiratory and gastrointestinal infections, and there is improved cognitive development (Mahan & Escott-Stump, 2012; Samour & King, 2012).

In South Africa, the SANHANES-1 survey reported that the average age for the introduction of solid food was 4.5 months and 67% of children were given solid or semi-solid food before

the age of 6 months (Shisana *et al.*, 2014). Results from the South Africa Demographic Health Survey (SADHS) 2016 showed that 25% of infants under age 6 months were not breastfed at all (NDoH *et al.*, 2017). In addition, in a low socio-economic urban area and a rural area in KwaZulu-Natal Province, at the time of the survey, children who were never breastfed in both the urban and the rural area was over 20%; while only 14.4% of 18–24-month-old children were still breastfeeding (Faber *et al.*, 2016). Kruger and Gericke (2003) reported that, even though mothers decide to formula feed their infants, due to high cost of formula milk, mothers prepared formula by adding more water so it could last longer. In addition in the study conducted in KwaZulu-Natal Province, of mothers who formula fed their infants, only 25.2% mixed the formula with the correct amount of water, while 8.8% used less water per scoop formula (which means the formula milk will be too concentrated) and 66% used more than the required amount which makes the formula milk to be too diluted (Faber *et al.*, 2016).

According to Siziba *et al.* (2015) more than a third (41%) of the mothers from Gauteng Province knew about the importance of breastfeeding, although they (41%) knew, they still stopped breastfeeding before the age of 6 months. Of the mothers who stopped breastfeeding, 40% did so within one month of the birth of their infant (Siziba *et al.*, 2015). In the study conducted in Dzimauli community in Limpopo, South Africa, most mothers believed that breast milk alone could not satisfy the baby's hunger, and as a result, they introduced water or soft porridge before the recommended age of 6 months. When the infant was crying more often, other mothers interpreted it as a sign of hunger and introduced complementary food earlier than recommended. Going back to school or work was the main reason why mothers stopped breastfeeding. EBF for the first 6 months was rarely practised, as most infants were introduced to complementary foods or liquids before the age of 3 months (Mushaphi *et al.*, 2017).

2.10.2 Complementary feeding

The introduction of complementary feeding should start at the age of 6 months as recommended by WHO (WHO & UNICEF, 2003; WHO, 2013). However, in the study conducted in KwaZulu-Natal Province, the mean age for introducing solid foods was found to be 3.5 months in the rural area while in urban area it was 4.2 months (Faber *et al.*, 2016). Complementary feeding is giving infants foods or fluids in addition to breast milk or breast milk substitutes from the age of 6 to 24 months. Globally, when young children start consuming complementary foods, they are usually exposed to poor complementary feeding practices and increased exposure to infections (Caulfield *et al.*, 2006). During the transition from exclusive breastfeeding to consumption of complementary foods that may be of poor nutritional quality;

stunting may result (WHO, 2013). In addition, if complementary feeding is introduced at the age of 6 months and not earlier than that, it helps reduces the incidence of diseases and undernutrition (Dewey, 2001; Child Health Research, 2002).

Complementary feeding procedures generally require cautious introduction to new foods in small quantities (Mahan & Escott-Stump, 2012). UNICEF (2003) recommended that health professionals should ensure that infant's nutritional needs are met by educating the mothers about the importance of timely introduction of complementary food, complementary foods must be adequate and provide sufficient energy and nutrients and complementary foods should be safe (hygienically stored and prepared, should be fed from clean hands or by using clean utensils and not bottles and teats). Feeding should be consistent with the child's appetite and satiety, and young children should be encouraged to eat sufficient food using fingers, spoon or self-feeding even during illness. The South African Department of Health (2013) recommends that young children must be given small, frequent, nutrient dense meals due to their limited gastric capacity and high nutrient needs. However, quantity and frequency should be gradually increased from pureed food to solid food by 12 months (NDOH, 2013a).

Complementary foods should be high in nutrient density, including iron and zinc, as they are generally problematic nutrients. This is important as infants consume relatively small amounts of foods in addition to breast milk (Dewey, 2013). In most low-income communities, the first semi-solid foods given to infants are cereal-based gruels with low energy and nutrient density and low bioavailable iron (Dewey, 2013). In a study conducted in KwaZulu-Natal Province, South Africa, the first solid foods given were maize meal porridge (55%), infant cereals (32%), and ready-to-eat bottled baby foods (9%) (Faber & Benadé, 2007). Faber *et al.* (2016) also reported that maize meal porridge was the most popular first food given to 69.6% and 59.5% of infants in both rural and urban areas, respectively, in KwaZulu-Natal; followed by infant cereals. According to national data collected in 2012 the most common complementary food to be introduced first was commercial infant cereal or porridge (51.2%) and homemade cereal/porridge (29%) (HSRC, 2013).

The 2016 SADHS found that only 23% of infants aged 6-23 months were fed a diet that is considered to be adequate for infants and young children (NDoH *et al.*, 2017). Feeding complementary foods of adequate nutritional value during the period of complementary feeding can help by making children healthy and less prone to infections (Dewey & Brown, 2003). However, meeting nutritional needs of younger children, mostly those that are still learning to eat is not simple as it seems because children tend to dislike certain foods and parents might stop feeding that kind of food, instead of helping the child learn new tastes and eating a variety of foods (Dewey & Begum, 2011). These challenges may be critical because

children between 6 and 24 months of age require nutrient-dense food for them to grow healthy (Dewey & Brown, 2003). However, complementary foods need to be nutrient-rich, adequate and safe to support optimal physical growth and brain development in children and prevent stunting (UNICEF, 2015).

Complementary foods have to be rich in energy and nutrients, contamination free, easy to chew and digest and easily accepted by the infant, as well as served in an appropriate amount and easily prepared from family foods (WHO, 2000). Micronutrient fortification of complementary foods and increasing energy density of complementary foods has generally failed to improve linear growth or prevent stunting (Dewey & Adu-Afarwuah, 2008). However, complementary staple foods, fed to children aged 6–12 months are not sufficient to contribute to a significant increase in micronutrient intake (Dewey *et al.*, 2009). Therefore, this calls for an improvement in infant and young child feeding practices for young children from the age of 6 to 24 months old and infants and young child feeding practices should be a very high global priority (Arabi *et al.*, 2012; Daelmans *et al.*, 2013).

Inadequate complementary feeding occurs as a result of poor quality of foods; inadequate feeding practices and food and water safety (see Figure 2.3). Adequate complementary feeding is the central pillar in supporting healthy growth and development of young children, yet much work is needed to build evidence documenting what works and why some programmes succeed while some struggle (Stewart *et al.*, 2013). Several intervention strategies to promote appropriate complementary feeding has been put in place (Dewey & Adu-Afarwuah, 2008). Complementary feeding promotion to parents and guardians of children aged 6–24 months, leads to an increase in height gain and significant reduction of stunting in a food insecure population (Lassi *et al.*, 2013).

2.10.3 Dietary diversity

Dietary diversity is a strategy that aims to alleviate micronutrient deficiencies by promoting the consumption of a variety of foods (Swart *et al.*, 2008). However, the foods that are available and affordable often fail to meet nutrient needs of growing children, particularly when families cannot afford frequent consumption of animal-source foods, such as meat, fish, eggs and dairy products (Dewey & Brown, 2003; Vitta & Dewey, 2012). Furthermore, dietary diversity strategies appear to be failing due to the fact that poor communities have limited access to a diversified diet (Swart *et al.*, 2008). Furthermore, in rural areas in developing countries, most people consume diets that have very limited variety with people also consuming inadequate fruits and vegetables (Black *et al.*, 2008).

In addition, more than 70% of the children in a rural area in KwaZulu-Natal Province of South Africa were fed a complementary diet of inadequate variety, where cereals and starchy foods, especially maize-based foods were found to be the most consumed foods (Faber *et al.*, 2016). In a study conducted by Siziba *et al.* (2015) the standard for minimum daily dietary diversity was achieved by one infant while most infants were consuming foods from one food group only. Dietary diversity in children 6–23 months old was found to be associated with lower odds of stunting in India while it had a positive association with HAZ in Bangladesh and India (Zongrone *et al.,* 2012; Menon *et al.,* 2015). Energy-dense starchy staple foods, such as cereals, roots, and tubers, have only small amounts of bioavailable micronutrients. Hence those who consume large amounts of them tend to be vulnerable to nutrient deficiencies (Ruel, 2003).

In countries where nutrition programmes have been successful, there have been reductions in the rates of stunting through positive benefits on household food consumption and dietary diversity (Casanovas *et al.*, 2013; Hoddinott *et al.*, 2008; Ruel *et al.*, 2013). Interventions targeting child feeding practices were found to be positively associated with child growth in settings where food security is sufficient. Attained linear growth (height-for-age z-score) was significantly lower in children from households without access to improved sanitation and children 6–23 months old who were not fed dairy products, fruits and vegetables (Aguayo *et al.*, 2016).

2.11 Strategies to improve child nutrition

Nutrition specific interventions directly affect nutrient intake. This include among others prenatal nutrition, promotion and support for optimal breastfeeding, promotion of appropriate complementary feeding practices, provision of complementary foods, micronutrient supplementation or fortification of local diets and treatment of severe acute malnutrition (Bhutta *et al.*, 2013; Black *et al.*, 2013a; Piwoz *et al.*, 2012). The prevalence of micronutrient deficiencies is high among infants and young children aged 6-24 months in most developing countries (Bhutta *et al.*, 2013; Prentice *et al.*, 2013). Complementary feeding interventions were designed to ensure that infant diets fulfil their micronutrient needs (Dewey and Brown, 2003).

2.11.1 Dietary modification

Dietary modification covers a variety of approaches aimed at increasing the production, availability and access to, and ultimately intake of micronutrient-rich foods. It also refers to strategies aimed at increasing the bioavailability of micronutrients such as vitamin A and iron in the diet (Ruel, 2001). Through nutrition education and communication, individuals and households can be encouraged to improve the quality of their diet by growing their own nutrient-rich foods in their home gardens and making healthy food choices (Ruel, 2001).

2.11.2 Supplementation

Vitamin A deficiency is a public health concern in more than half of all countries, and most of the countries affected are in Africa (WHO, 2008). It is a DOH regulation, that all infants and children aged 6-59 months should be supplemented with vitamin A. A therapeutic dosage of vitamin A is given to infants during clinic visits who present with clinical signs of vitamin A deficiency, diarrhea, measles and those who are severely malnourished (NDOH, 2012). Many people from poor rural communities may be unable to take their children to clinics and hospitals for them to receive their routine doses of vitamin A supplementation due to the distance it takes to go to the local clinics and lack of knowledge on the importance of vitamin A (NDOH, 2013b*).*

2.11.3 Food fortification and Point-of-use fortification.

Food fortification is the addition of vitamins and minerals to food. The national mandatory food fortification of staple foods, namely maize meal and wheat flour (used for making bread) with vitamins and minerals such as vitamin A, iron, zinc, folic acid, thiamine, niacin, vitamin B6 and riboflavin was implemented in South Africa in October 2003 (NDOH, 2003; Labadarios *et al.*, 2005). The fortification of staple foods with vitamins and minerals, as well as the mandatory salt iodisation programme contributed towards the reduction in the prevalence of folate and iodine deficiencies among children in South Africa (NDOH, 2010). Fortified maize-meal porridge was shown to reduce anaemia and improve iron status in infants and young children in a randomised controlled trial in South Africa (Faber *et al.*, 2005). A systematic review conducted on all age groups reported that iron-fortified foods may increase haemoglobin and serum ferritin (Gera *et al.*, 2012).

Fortified blended foods are products that are used as a replacement for the traditional porridge. They are usually made from cereals, legumes, and sugar or oil and are fortified with certain micronutrients (Dewey & Vitta, 2013). Ready-to-use foods (RUFs) or ready-to-use therapeutic foods (RUTF) can be stored at room temperature and is designed in a way that it can be consumed without cooking (WHO/WFP/UNICEF, 2007). RUTF is provided in amounts ranging from 200-300g/day and temporarily replace other foods apart from breast milk (Dewey & Arimond, 2012). Ready-to-use supplementary foods has proven beneficial in the management of moderate acute malnutrition (Dewey & Vitta (2013).

Point-of-use fortification was developed to fill nutrient gaps, without replacing or reducing breastfeeding or diversification of infant diets with local foods (Arimond *et al.*, 2017). SQ-LNSs as one of the methods of point-of-use fortification are used to add energy, protein and EFAs needed for healthy growth and development in children (Arimond *et al.*, 2015). Furthermore, a systematic review on point-of-use fortification conducted by De-Regil *et al.* (2013) reported that MNP for health and nutrition in children under two years of age can be used to reduce anaemia and iron deficiency.

2.8 Lipid-based nutrient supplements (LNS)

Lipid-based nutrient supplements (LNS) are a family of products designed to deliver nutrients to vulnerable people. They are considered “lipid-based” because the majority of the energy provided by these products is from lipids (fats). All LNS provide a range of vitamins and minerals, but unlike most other multiple micronutrient supplements, LNS also provide energy, protein, and EFA (iLiNS, https://ilins.ucdavis.edu).

Previous studies that were conducted in Ghana (Adu-Afarwuah *et al.*, 2007) and Malawi (Phuka, 2009; Phuka *et al.*, 2008) showed that LNS had positive effects on infant growth, development and also on micronutrient status. LNS in the form of RUSF are high in micronutrients, cost less and may range from 20 to 50g/day. They are used in prevention of wasting and stunting (Dewey & Arimond, 2012). LNS products with a lower energy dose of less than 110 kcal a day and with a full complement of micronutrients have been shown to prevent growth faltering of infants 6 to 11 months and to support normal motor development in Ghana (Adu-Afarwuah *et al.*, 2007).

A study conducted in Malawi to assess the effect of supplementation with corn–soy blend (CSB) or LNS on energy and nutrient intake among moderately underweight (8–18-month-old) children showed an increased weight gain among children supplemented with LNS, but not those supplemented with CSB compared with a control group receiving no supplement

(Thakwalakwa *et al.*, 2010). Furthermore, a study in Burkina Faso, indicated that nutritional supplements given from age 9–18 months, together with maternal supplementation are more likely to protect children from growth faltering, and poor language and motor development skills (Prado *et al.*, 2016a).

A study conducted in Ghana showed that a higher percentage of children who received 20 g LNS/day from age 6 to 12 months walked independently at age 12 months, compared to a non-supplemented group (Adu-Afarwuah *et al.*, 2007). Some intervention studies from sub-Saharan Africa found that provision of small daily doses of LNS from 6–18 months old infants and young children can promote their linear growth and yield other health benefits (Adu-Afarwuah *et al.*, 2007; Phuka *et al.*, 2008). In addition, a study in Malawi showed a reduction in the odds of stunting with LNS supplementation compared to corn-soy blend with effects sustained even after a two-year non-intervention period (Phuka *et al.*, 2009; Phuka *et al.*, 2008).

In Malawi, LNS showed no positive benefit on developmental outcomes measured on the Griffiths scale at 18 months of age (Phuka *et al.*, 2012). Although a positive effect of LNS on motor development was found at age 12 months, there were no significant effects on motor, cognitive, or socio-emotional development at age 18 months in these trials (Prado *et al.*, 2016c; Prado *et al.*, 2016d). In addition, LNS supplementation was shown to decrease mortality (Isanaka *et al.*, 2009). Furthermore, two studies did not find any effect of doses ranging from 20 to 54 g on the age of attainment of developmental milestones (Iannotti *et al.*, 2014; Mangani *et al.*, 2014).

2.12 Small quantity LNS

SQ-LNS are given at a lower daily ration, but they contain higher concentration of micronutrients (Arimond *et al.*, 2015; Dewey & Arimond, 2012). SQ-LNS provide less than 110 calories per serving (Hess *et al.*, 2015), are rich in micronutrients and are mixed into the infant's complementary foods (Dewey & Arimond, 2012). Micronutrients that are added in SQ-LNS products help to prevent undernutrition and promote health and development (Arimond *et al.*, 2015) through point-of-use fortification of the local diet (Adu-Afarwuah *et al.* 2007, Phuka *et al.* 2008). SQ-LNSs were initially developed to address undernutrition for young children during the first 1000 days and now extended to pregnant and lactating women (Arimond *et al.*, 2015)

SQ-LNS contain a vitamin-mineral mix, and because the micronutrients in SQ-LNS are embedded in a lipid-rich base, the supplements also provide some macronutrients (fats, protein, and carbohydrates) (UNICEF 2015). Most SQ-LNS are made from vegetable oil,

peanut paste, milk powder, and sugar, with added vitamins and minerals. This means SQ-LNS is made to provide fatty acids and micronutrients that are essential for brain development (Arimond *et al.*, 2015). Many nutrients, which are mostly added in SQ-LNS, including essential fatty acids (EFA), B-vitamins, iron, iodine, and zinc, are necessary for development of the brain during early life. This includes the development of motor, cognitive, and socio-emotional skills (Prado & Dewey, 2014).

Studies conducted in Bangladesh, Malawi, Ghana and Burkina Faso suggest that the use of SQ-LNS to enrich home-prepared foods, is a promising new approach that can be used to enrich the diets of young children (Adu-Afarwuah *et al.*, 2007; Adu-Afarwuah *et al.*, 2016; Ashorn *et al.*, 2015; Hess *et al.*, 2015; Mridha *et al.*, 2016).

Low-cost solutions for preventing growth-faltering in young children in the form of SQ-LNS were tested in studies conducted in Malawi. Studies have tested the growth-promoting efficacy and found no effects of SQ-LNS supplementation on child growth (Iannotti *et al.*, 2014; Mangani *et al.*, 2015). SQ-LNS supplementation given to infants from 6 to 12 months of age showed no effects when the infants were 12 months old in a study conducted in Haiti (Iannotti *et al.*, 2014).

Supplementing women with SQ-LNS during pregnancy and the first 6 months of lactation and their children between 6 and 18 months of age had a positive effect on child length at 18 months in Ghana (Adu-Afarwuah *et al.*, 2016). In contrast, there was no growth-promoting effect in a large study conducted in Malawi of a 12 months LNS supplementation (Mangani *et al.*, 2015). In addition, the study conducted in Malawi showed no impact in child length at 18 months (Ashorn *et al.*, 2015). Dietary supplementation with SQ-LNSs or medium quantity Lipid-based nutrient supplements (MQ-LNS)(20–50 g/d) reduced the incidence of stunting on young children aged 6 to 18 months –old in sub-Saharan Africa (Adu-Afarwuah *et al.*, 2007; Phuka *et al.*, 2008). Furthermore, one-year-long (from 6-18 months) complementary feeding with ready-to-use fortified spread did not have a significantly larger effect than micronutrient-fortified maize–soy flour on mean weight gain in all infants, but it is likely to boost linear growth in the most disadvantaged individuals and could potentially prevent severe stunting (Phuka *et al.*, 2008). In addition, LNS given to children from the age of 6 months, using varying quantities of LNS (20–50 g) and duration of supplementation (3–12 months), severe stunting was prevented as children showed weight gain and linear growth (Adu-Afarwuah *et al.*, 2007; Phuka *et al.*, 2008; Thakwalakwa *et al.*, 2012)

In a study to investigate linear growth and child development in three countries (Burkina Faso, Ghana, and Malawi), linear growth was significantly associated with language, motor, and personal-social development (Prado *et al.*, 2016a). Although the SQ-LNS was given along

with malaria and diarrhoea treatment SQ-LNSs given for a period of 9 months in Burkina Faso showed a positive effects on language, motor, and personal-social development at the age of 18 months (Prado *et al.*, 2016b). Furthermore, the findings of the study by Hoddinott *et al.* (2008) indicate that nutritional supplementation to the mother when their infant is 0-6 months and infant from 6–36 months of age and follow-up from 36–72 months of age, later resulted in higher average wages among adult men. In contrast, a study conducted in Haiti, when comparing LNS and non-supplemented controls there were no differences in proportion of children achieving a number of motor milestones at about 12-18 months of age (Iannotti *et al.*, 2014).

A study conducted in Burkina Faso indicated that SQ-LNS given to young children from 9–18 months of age, resulted in improved growth and reduced stunting, wasting and anaemia (Hess *et al.*, 2015). In contrast, a study conducted in Malawi by Maleta *et al.* (2015) indicated that LNS supplementation of young children from 6 and 18 months old of age did not improve linear growth or prevented growth faltering/stunting. Although cognitive gains are uncertain, there is a possibility of some catch-up in height-for-age after 24 months (Casale & Desmond, 2016; Crookston *et al.*, 2013).

Stunting in children under the age of 5 years is caused by several factors that include food insecurity, poverty, poor access to health care, lack of safe drinking water and poor sanitation (Stewart *et al.*, 2013).

2.13 Summary of literature review

In South Africa, more work still needs to be done in order to improve EBF and continued breastfeeding rates (Du Plessis *et al.*, 2016). Appropriate interventions include early nutrition interventions which include micronutrient supplementation which can be supported with nutrition education and counselling. However, the post-natal 'window of opportunity' can be divided into two major periods that is 0 – 5.9 months when exclusive breastfeeding is recommended, and from 6 to 23.9 months when complementary feeding is implemented while breastfeeding is continued (Black *et al.*, 2013b).

There is need to focus strongly on the nutritional quality of the complementary diet (Faber *et al.*, 2016). More awareness is required as an average South African diet is said to be less diverse and poor in micronutrient content (Faber *et al.*, 2016; Faber & Wenhold, 2007). SQ-LNSs were developed as a point-of-use fortificant to prevent undernutrition and also to

improve growth and development (Arimond *et al.*, 2015). SQ-LNSs can be used to supplement the food that infants consume (Iannotti *et al.*, 2014).

Since women are the primary caregivers, female empowerment is an important factor that underlies child growth and development as well as involvement of the mother's social support network in complementary feeding programmes need to be considered (Stewart *et al.*, 2013). Improving knowledge and skill building is necessary to improve complementary feeding practices. Timely introduction of solid food is important for dietary diversity and is associated with reduced probability of underweight and stunting.

In conclusion, based on the literature review it is evident that there remain inconsistances regarding the use of SQ-LNS to affect growth and development. To our knowledge, the is no previous study that has investigated the effect of a delayed intervention on a control group using the approach that was used in our sudy.

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CHAPTER 3 METHODOLOGY FOR THE TSWAKA RANDOMISED CONTROLLED TRIAL AND THE TSWAKA POST-INTERVENTION STUDY

3.1 Methodology of Tswaka study

The Tswaka post-intervention study is a follow-up study of Tswaka Randomised Controlled Trial (RCT). Therefore, this chapter will describe the methodology of firstly the Tswaka-RCT and then the Tswaka post-intervention study.

3.1.1 Study population

This randomized controlled trial consisted of 750 infants, where infants were enrolled when they were approximately 6 months old and the study was carried out from September 2013 to July 2015.The trial was done in the peri-urban Jouberton area in the greater Matlosana Municipality in Klerksdorp in the North West Province of South Africa. Jouberton is a low socio-economic community and is 200 km from the nearest metropolitan area (Johannesburg). The mother-infant pairs were recruited through five primary health care clinics in the community and house-to-house visits. Trained fieldworkers who were fluent in the local language explained the study to the mothers. If the mother expressed willingness to participate, an eligibility questionnaire was administered to determine whether the infant could be included in the study.

3.1.2 Study design

The Tswaka-RCT investigated the effects of two different SQ-LNS formulations on the growth and development of 6-month-old infants (Smuts et al., 2019). The study used a randomised controlled design. Block randomisation of sizes 3, 6 and 9 was used to randomly allocate the infants to one of three groups: SQ-LNS A (n=250); SQ-LNS plus (n=250), and the control group (n=250). The two SQ-LNS groups received supplements for 6 months during the intervention period, and the control group received no supplement, yet they were informed that they would receive SQ-LNS upon completion of the intervention period. All questionnaires used for data collection were completed at a central study site where the mothers were interviewed in their preferred language by trained field workers. Anthropometric measurements were taken when infants were 6 months, 8 months, 10 months and 12 months

old, whereas blood samples, parental ranting and Kilifi were taken only at 6 months and 12 months of age.

Table 3-1: The nutrient content of the two intervention products

	SQ-LNS-plus	SQ-LNS
Amount (g) (1 portion), (g)	20	20
Energy (kcal)	113	114
Energy density (kcal/g)	5.7	5.7
Protein (g)	3.7	3.0
Percentage of calories from protein	13	10
Fat (g)	8.8	8.0
Percentage of calories from fat	70	63
Essential fatty acids		
Linoleic acid (LA) g	1.8	1.5
α-linolenic acid (ALA) mg	348	265
Linoleic acid:α-linolenic acid	5.0	5.7
Long-chain polyunsaturated fatty acids		
Docosahexaenoic acid (DHA) mg	75	-
Arachidonic acid (ARA) mg	75	-
Micronutrients		
Vitamin A µg	200	200
Vitamin D µg	2.5	2.5
Vitamin E mg	2.5	2.5
Vitamin K µg	7.5	7.5
Thiamin mg	0.25	0.25
Riboflavin mg	0.25	0.25
Niacin mg	3	3
Pantothenate mg	1.0	1.0
Vitamin B6 mg	0.25	0.25
Biotin µg	4.0	4.0
Folate (B9) µg	80	80
Vitamin B12 µg	0.45	0.45
Vitamin C mg	23.3	23.3
Calcium mg	396	250
Iodine µg	45	45
Iron mg	5.8	5.8
Zinc mg	6.2	6.2
Copper mg	0.28	0.28
Selenium µg	8.5	8.5
Magnesium mg	30	-
Manganese mg	0.6	-
Phosphorus mg	230	-
Potassium mg	257	-
Choline (from lecithin), mg	7.8	2.0
L-Lysine, mg	160	-
Phytase, FTUs	200	-

3.1.3 Recruitment and selection of infants

Infants who had the potential to be enrolled into the study were recruited through five clinics as well as door-to-door visits. Mothers were recruited through churches and at the community centre on days when grants were given. Posters were put up in supermarkets, primary schools, crèches, and all the clinics in the Jouberton area. During recruitment fieldworkers were stationed at each clinic where the nursing staff screened all the infants at their 14-week vaccinations. The designated fieldworker informed mothers/ primary caregivers (hereafter collectively will be referred to as caregiver) about the purpose and nature of the study along with an information sheet, thereby giving them the option to be recruited and allowing their babies to participate in the study. The information sheet (translated into Tswana and English) assisted the fieldworker in explaining the study, and it was read out loud for illiterate caregivers. Hereafter, the caregiver was given the opportunity to ask questions.

Selection criteria for infants to participate in the study were:

1. Mothers or caregivers and their young children had to be residing in the study area and not having a plan to move out of the area 6 months after enrolment.
2. All infants enrolled in the study had to be at least 6 months old (<7 months).
3. All infants enrolled in the study had to be from the Jouberton area in Klerksdorp.

Infants were excluded from participating in the Tswaka-RCT if they had:

1) Not received any breast milk
2) Severe obvious congenital abnormalities
3) Severe anaemia (haemoglobin < 70 g/L)
4) Severe malnutrition (weight-for-length Z-score <-3.00)
5) Chronic diseases
6) Plans to move out of the study area in the next 7 months
7) Known food allergies/intolerances i.e. to peanuts, soy, milk and/or lactose, fish
8) Infants given special nutritional supplements
9) Not been born as a singleton

3.1.4 Data collection procedure

3.1.4.1 Anthropometric measurements

Anthropometric measurements were measured by two extensively trained fieldworkers who were trained according to International Society for Advancement of Kinanthropometry (ISAK) procedures. Anthropometric measurements were taken in the recumbent position at age 6 and 12 months. Weight was measured using a mechanical infantometer (Seca 416, Germany). Children were weighed naked using a calibrated digital scale (Seca 354, Germany). All measurements were done in duplicate. If duplicate weights differed by >0.05 kg a third measurement of a child was done to verify correctness. If two length measurements of a child differed by > 0.3 cm or circumference measurements differ by > 0.2 cm a third measurement was done and the two closest values were recorded.

3.1.4.2 Psycho-motor milestones assessment

Two extensively trained fieldworkers who had also received several refresher trainings administered the psychomotor milestone and parental rating questionnaires. One of the former PhD students of NWU, Dr Rothman provided training and refresher training to the fieldworkers. Psychomotor milestones were assessed using the parent rating of motor development questionnaire (Appendix D) which has been validated and involves the mother/principal caregiver providing a rating of the child on gross motor developmental milestones. In addition, the Kilifi Developmental Inventory (KDI) (Appendix C), which was developed and evaluated in Africa using materials and activities that both parents and infants can relate to was used (Abubakar *et al.*, 2008). Psychomotor development was assessed using Kilifi Developmental Inventory and the South African parent rating scale at 6-month and 12 months visits.

The Kilifi Developmental Inventory (KDI) was developed in Africa by adapting a range of early childhood development (ECD) instruments and is a continuous measure used for the assessment of psychomotor development in a resource-poor setting (Fernald *et al.*, 2009; Sabanathan *et al.*, 2015). This inventory was designed to be used by assessors with little experience in child development and is an affordable tool for use in field studies. The child's performance is assessed in two main domains, namely locomotor development and fine motor skills by a parental report and direct observation. Early executive function and emotional control are also measured. Items used for assessment are based on Griffiths Mental Development Scale, the Kenyan Screening Test for Children aged 6 months to 6 years, The Portage Early Education Programme and the Movement Assessment Battery for Children

(Fernald *et al.*, 2009). The KDI has been evaluated for reliability and validity in normal and disease exposed populations in coastal Kenya (Abubakar *et al.*, 2008).

The South African Parent Rating Scale was developed by Dr Jane Kalsvig with financial and technical support from UNICEF and the Department of Basic Education and was validated in a study that included children 6-36 months from rural and urban settings in the South Africa context in a joint project of UNICEF and The Early Childhood Development Centre (Kvalsvig *et al.*, 2009). Samples have been drawn from both rural and urban resource poor environments and the validation process has included the development of age appropriate cut offs, and normal age ranges (Kitsao-Wekulo *et al.*, 2016).

3.1.4.3 Blood samples

Blood samples (4 ml) were sample was taken using into EDTA-coated trace-element free evacuated tubes by a qualified study nurse. Finger prick blood sample was taken only if blood could not be obtained successfully via antecubital venipuncture of the arm area or dorsal area. Haemoglobin concentrations were analysed immediately after finger-prink. All blood sample was that was obtained from 485 infants was stored at –80°C in monitored freezers at North-West University. All samples were shipped to Vitmin Lab Willstaett in Germany for analysis.

3.1.5 Data collection, analysis, capturing and storage

Protocols were put into place for each operating procedure. Every mother was routinely supplied with two weeks' worth of supplements at a time, in the event that a fieldworker fell ill or did not visit the mother within seven days after the previous visit. Caregivers were required to return all empty packaging. This eliminated the risk of participants not having enough sachets until the next supply arrived. Every week data was collected from the fieldworkers and these source data were given a date, participant number and data collector code. Source data were stored in individual coded folders. These source data were identified by date, participant number and signature of the data collector and then stored in individual participant folders.

All documentation regarding the participants, including the laboratory samples and source data was identified with appropriate participant codes, both on paper and in computer files. The name only appears on informed consent forms and a separate coding list. All documentation specific to the participants, including laboratory samples, source data and Case Report Forms (CRF), were given codes for identification purposes and these were used

on hardcopies as well as in the database. Data were only shared among the researchers, students and funders of the study by means of password locked data sets and with the permission of the principal investigator.

3.1.6 Ethical aspects and approval

The Tswaka-RCT is registered at Clinicaltrials.gov registry (NCT01845610). Ethical approval for conducting Tswaka-RCT was obtained from the Ethics Committee of North-West University (NWU-00011-11-A1) and the South African Medical Research Council (SAMRC) (EC011-03/2012). After institutional ethical approval the project had been reviewed by a provincial Department of Health and Social Development for registration with the Directorate for Policy, Planning and Research. The Kenneth Kaunda District Department of Health also granted permission for the study in the Matlosana area of Klerksdorp. The stakeholder engagement process for the Umbrella study started after all the relevant authorities had given permission. This process included informing and negotiating with a broad range of local government, civil and political structures to ensure a stable environment in which to work.

3.1.7 Signing of consent forms

Mothers were recruited to enrol their infants if they had a plan to reside in the study area on the area for the next 6 months after enrolment into Tswaka RCT. An “Information sheet” was prepared (Appendix A) and translated into the local language (Tswana) to assist the fieldworker to explain the study to the mother and for the mother to be able to read and understand. The mother was given the opportunity to ask questions.

After the mother had agreed to participate, she was asked to read the information sheet and sign the consent form (Appendix A). For illiterate mothers the fieldworker read aloud the information to the mother, and the mother’s thumbprint was used as “signature” on the consent form. Recruited participants who agreed to participate in the study were asked to sign consent forms. An information sheet was provided to participants who still needed consent from their partners or other family members and also those who needed time to decide. Consent forms were signed during enrolment into the study when the child was 6 months old and children were followed-up until they reached the age of 12 months. The control group participants were informed during enrolment into the Tswaka-RCT that they would get SQ-LNS, after completion of the 6 months’ trial (12 month exits).

3.1.8 Mothers who are illiterate and those that are younger than 18-year-old.

Minors were classified as when the primary caretaker of the baby was younger than 18 years. A parent of a minor or family member who was older than 18 years was then asked to sign on behalf of the minor, only after understanding the purpose and nature of the study. The minors also signed next to the older member on the consent form as an indication of ascent. For illiterate subjects, a thumb print was taken to represent the signature. This was only done after a trained field worker had explained the purpose and nature of the study and ensured sure that the parent or family member knew what was expected from her and her child as participants in the study. Time for questions was also allowed.

3.1.9 Data handling in case of withdrawal from the study.

The Tswaka-RCT analysed the data based on intention to treat principle. For this reason, once enrolled in the study the data of the infant (from inclusion until time of withdrawal) was kept in the analysis even if withdrawn. However, the participants were informed that they could ask for their data not to be used and if the participants asked for their data not to be used, participant's wishes were respected.

3.1.10 Adverse events and serious adverse events.

Adverse Events (AEs) (any unfavourable and unintended sign subjective and objective symptom or disease temporarily associated with the use of a product, accidents, whether or not considered related to the product) reported by the subject were recorded to their files and the participant was followed up until the incident was resolved. SAEs (death and hospitalisation) were recorded on a SAE report form. The investigator(s) completed it and reported it within 24 hours after becoming aware of an SAE to the sponsor, HREC and the Data Safety Monitoring Board (DSMB). The original forms were retained with the other participant specific study documentation at the site. Where appropriate, suspected and unexpected serious adverse reactions were reported and processed according to the applicable laws and regulatory requirements governing the conduct of biomedical research projects involving human subjects.

3.1.11 Post-study SAE

The principle investigator reported any SAE that occurred from enrolment in the study to 28

days following the last dose of investigational product. If a participant was withdrawn from the study due to the occurrence of a SAE the participant was followed until the SAE outcome had been established or the condition was stabilised. SAE occurring more than 28 days after the last dose of investigational product need only be reported if a relationship to the investigational product is suspected.

3.2 Tswaka post-intervention study

After completion of the 6-month intervention (at age 12 months), children whose mothers consented were enrolled in the Tswaka post-intervention study. Children who were in the no-supplement control group in the Tswaka-RCT received SQ-LNS from 12-18 months (group 3), while children who were in the two SQ-LNS groups in the Tswaka-RCT received no supplement from 12-18 months (group 1 and group 2).

The Tswaka post-intervention study is a follow-up study of participants who participated in the Tswaka-RCT study. The Tswaka post-intervention study had no true control group; that is children that had never received SQ-LNS before. The intervention group in the current study received SQ-LNS. While following up participants from Tswaka RCT, we realized that there was a high number of lost-to-follow-up which made it difficult to compare the two studies.

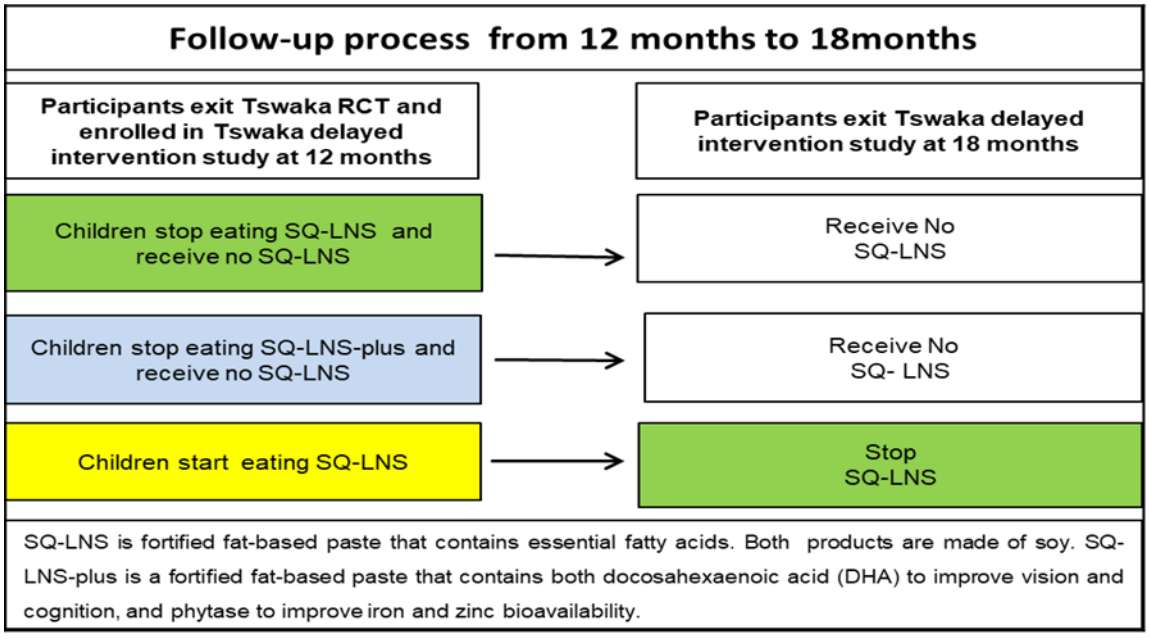

Figure 3-1: Summary of enrolment of children in to the Tswaka post-intervention study.

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CHAPTER 4: RESEARCH ARTICLE

Nutritional status and psychomotor development in 12-18 months old young children in a post-intervention study.

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Abstract

Objectives: To determine the nutritional status and psycho-motor development at age 18 months of children who received a delayed small-quantity lipid-based nutrient supplement (SQ-LNS) daily from age 12-18 months compared to those who received the same intervention daily only from age 6-12 months but no intervention from 12 to 18 months.

Design: From age 12-18 months, children in groups 1 and 2 received no supplement (group 1 and 2; received an SQ-LNS from 6 to 12 months of age), while children in group 3, the delayed intervention group, received SQ-LNS.

Methods: This study used the end-results of a randomised controlled trial as baseline values, to determine the nutritional status and psychomotor development in children from age 12 to 18 months. Mothers brought their children to the field station at 12 and 18 months respectively. Both at 12 and at 18 months' weight, length, haemoglobin (Hb) and psychomotor developmental outcomes were measured. The weight-for-length (WLZ), length-for-age (LAZ) and weight-for-age z-scores (WAZ) were based on the WHO classification. For Hb values, a finger prick was done.

Setting: Peri-urban Jouberton area in the Matlosana Municipality, Klerksdorp, South Africa.

Subjects: 12-18 months old children.

Outcome measures: Parental rating, loco-motor and eye-hand coordination, weight, height and haemoglobin measurements were collected.

Results: At age 18 months, mean Hb concentrations were significantly higher in children receiving SQ-LNS from 12-18 months (group 3) compared to children who received no supplement during this period (groups 1 and 2) (p=0.003); and 45.38% in group 3 were anaemic compared to 53.98% in group 1 and 58.67% in group 2. Compared to group 2, children in group 3 had higher WAZ (p=0.027). Although not significant, there was a trend for LAZ to be lower for both group 1 (p=0.091) and group 2 (p=0.075) when compared to group 3. There was no statistically significant effect for the locomotor development score; there was a trend (p=0.086) for an intervention effect for eye-hand coordination in group 2 compared to group 3.

Conclusion: The provision of SQ-LNS as point-of-use fortificant showed improvement in the haemoglobin status of children, but SQ-LNS alone may not be effective in preventing anaemia at this age. Incorporating other interventions may be necessary.

Keywords: Stunting, cognitive development, haemoglobin, complementary feeding, iron deficiency anaemia, South Africa

4.1 Introduction

Improving the survival and well-being of children is an important health and development goal throughout the world (Massyn *et al.*, 2015). Globally, in 2016, an estimated 22.9% or 154.8 million children under the age of 5 years were stunted, 6.0% or 40.6 million were overweight, while 7.7% or nearly 52 million were wasted. Globally, the proportion of children younger than 5 years in low-income and middle-income countries at risk of not attaining their developmental potential because of extreme poverty and stunting remains high (43%) (Black *et al.*, 2017). The South African National Health Nutrition survey (SANHANES) indicated that the prevalence of stunting, wasting and underweight for children under the age of 5 years was 21.6%, 2.5%, 5.5% respectively (Shisana *et al.*, 2013). The 2016 South African Demographic and Health Survey indicated that stunting remains a national concern as it has increased, with an estimated 27% of children less than 5 years being stunted (NDoH *et al*, 2017).

In most developing countries there is a high prevalence of micronutrient deficiency in children from the age of 6 to 24 months (Bhutta *et al.*, 2013; Prentice *et al.*, 2013), as they are fed nutritionally inadequate cereal-based diets, which are deficient in energy and micronutrients (particularly iron and zinc) and have poor mineral bioavailability (Dewey, 2013). Children under the age of 5 years are at risk of developing IDA because they grow rapidly and their diets are often lacking in sufficient absorbable iron (Dewey & Brown, 2003). Iron deficiency can also affect children's cognitive development (Dewey, 2013).

Poor nutrition leads to growth retardation, which both lead to serious public health implications and contribute to early age morbidity and mortality (Bentley *et al.*, 2014). Furthermore, other studies indicated cognitive gains are uncertain at a later age, however there is a possibility for a child to catch-up in height-for-age after 24 months. (Casale & Desmond, 2016; Crookston *et al.*, 2013).In addition, Casale & Desmond indicated that early intervention (before 2 years of age) is the best way to improve child's cognitive development (Casale & Desmond, 2016; Crookston *et al.*, 2013).

Prevention of stunting can bring about multiple benefits that include cognitive development, school achievement and better wages earned in adulthood (Dewey & Begum, 2011). However, intervention strategies should target the first 1000 days of life (Dewey & Begum, 2011), during which a child has an increased metabolic demand, increased nutrient needs, major tissue deposition, and rapid growth and development. If nutrition intervention is not done in the first 1000 days, a child can be at risk to impaired development and increased risk of mortality (Adu-Afarwuah *et al.*, 2017). At present the focus is on the first 1000 days (from conception to age 2 years), which is the crucial period for childhood development (Piwoz *et al.*, 2012) and

therefore the appropriate window of opportunity for nutritional interventions for improved growth and development of children.

The need for stronger focus on the nutritional quality of the complementary diet was emphasized by Faber *et al.* (2016). There are several strategies to improve the nutritional status of younger children during the period of complementary feeding, which include dietary diversification, the use of locally available micronutrient-rich foods, and the encouragement of the production of low-cost, nutrient rich complementary foods (Dewey, 2013; Dewey & Vitta, 2013). However the foods that are available and affordable often fail to meet nutrient needs of growing infants, particularly in families that cannot afford frequent consumption of animal-source foods (Dewey & Brown, 2003; Vitta & Dewey, 2012).

The development of point-of-use fortifications like small quantity lipid-based nutrient supplements (SQ-LNS) was implemented as a way of preventing childhood stunting (Arimond *et al.*, 2015; Dewey & Arimond, 2012). SQ-LNS contain over 20 micronutrients including zinc, iron and vitamin A, essential fatty acids and a small amount of protein (Hess *et al.*, 2015). SQ-LNS are used to improve the nutrient content of local complementary foods (Dewey & Arimond, 2012). A study conducted in Burkina Faso indicated that SQ-LNS given to young children from 9–18 months of age, resulted in improved growth and reduced stunting, wasting and anaemia (Hess *et al.*, 2015). In contrast, a study conducted in Malawi by Maleta *et al.* (2015) showed that LNS supplementation in young children from 6 and 18 months old did not improve linear growth or prevented growth faltering/stunting. In addition, the findings from previous studies conducted on children 6-18 months are inconsistent (Adu-Afarwuah *et al.*, 2007; Hess *et al.*, 2015; Maleta *et al.*, 2015; Mangani *et al.*, 2015; Phuka *et al.*, 2008). There is less information available on post-intervention studies that provided SQ-LNS to children.

In South Africa, the effect of two novel SQ-LNS products on linear growth and motor development in children was investigated in a randomized controlled trial (RCT; referred to as the Tswaka-RCT). Children were enrolled at the age of 6 months, and randomly assigned to one of three groups, namely SQ-LNS (n = 250), SQ-LNS-plus (n = 250) and a no-supplement control group (n = 250). The 6-month intervention study showed an early transient intervention effect on linear growth and improved locomotor development for SQ-LNS-plus, and both SQ-LNS products showed positive intervention effects for anaemia and iron status (Smuts *et al.*, 2019). An acceptability study that was done prior to the Tswaka-RCT showed that the use of both SQ-LNS products was acceptable and caregivers indicated that their children liked the taste when mixed into maize porridge and/or other complementary foods (Rothman *et al.*, 2015). After completion of the 6-month intervention (at age 12 months), children in the no-

supplement control group received SQ-LNS for 6 months (delayed intervention group – group 3).

The current study (Tswaka post-intervention study) is a follow-up study including children who completed the Tswaka-RCT. The aim of this study was to determine the nutritional status and psycho-motor development at age 18 months of children who received SQ-LNS daily from the age of 12 to 18 months compared to two previously exposed groups who received the same intervention daily from age 6 to 12 months but no intervention from 12 to 18 months.

4.2 Methods

4.2.1 Study population

The Tswaka post-intervention study is a follow-up study which followed children that were enrolled in the Tswaka-RCT. For the Tswaka-RCT, children were randomly allocated to one of the three groups (SQ-LNS, SQ-LNS-plus and control). The trial duration was 6 months with enrolment at age 6 months and exit at age 12 months. Children who were in the control group in the Tswaka-RCT received no supplement during the Tswaka-RCT, and those who completed the 6-month Tswaka-RCT were provided with a 6-month supply of SQ-LNS thereafter, from age 12 to 18 months (delayed intervention group – group 3). Children who were in the two SQ-LNS groups in the Tswaka-RCT received no supplements from age 12 to 18 months (groups 1 and 2).

The study population consisted of 12-18 month-old young children from peri-urban Jouberton and Alabama areas of the greater Matlosana (Klerksdorp) municipality, Dr Kenneth Kaunda District, North West Province of South Africa. The study site is 200 km from the nearest metropolitan area (Johannesburg). Recruitment for Tswaka post-intervention study was done by a trained fieldworker, who recruited mothers to enrol their children.

4.2.2 Recruitment

Recruitment for the Tswaka post-intervention study was done when the mother/caregiver came for the 10-months visit at the Tswaka field station during the Tswaka-RCT. After detailed explanation about the Tswaka post-intervention study to the mother or caregiver, she was given an information sheet to take home to read and to inform family members where

necessary. The mothers or caregivers of the 514 children that completed the Tswaka-RCT were then recruited again during the 12-month exit visits of the Tswaka-RCT by a trained fieldworker who explained the nature and purpose of the study to them (see Fig 4.1).

Children who were in the control group during the Tswaka-RCT (group 3) received SQ-LNS from 12 to 18 months of age during the Tswaka post-intervention study. The two groups that received SQ-LNS and SQ-LNS-plus, respectively during the Tswaka-RCT (groups 1 and 2) did not receive any supplement but they were monitored closely during the first month, and they visited the study site at age18 months. Mothers/caregivers brought their children to the study site at age 18 months for weight and length measurements, psychomotor milestones assessment and for measuring haemoglobin.

Compliance was calculated based on the formula: Total intake at the end of study = (sum of child's weekly intake [g])/ (days of the child in study * 20).

4.2.3 Inclusion criteria

Children who completed the Tswaka-RCT were enrolled in the study if the mother or caregiver planned to reside in the study area for the next 6 months, the mother had to be willing to bring her child to the field station when the child was 15 months and also 18 months old, and only children whose mothers re-consented to participate in the Tswaka post-intervention study were included.

4.3 Data collection

4.3.1 Measurements

All team members were trained to conduct the study according to good clinical practice (GCP). The source data were identified by date, participant number and signature of the data collector and then stored in individual participant folders as per GCP requirements. All data were entered into an EpiInfo database and were captured by one trained research assistant. Quality control was conducted to correct obvious errors in the data set.

Two trained fieldworkers administered the Kilifi Developmental Inventory (KDI) and South African Parental Rating Score. Psychomotor development as a secondary outcome was assessed by observation of child's activities. KDI scores and parent rating scores were calculated by adding up the scores recorded by the fieldworkers.

Finger pricks were done by a qualified nurse. Haemoglobin was assessed using the Hemocue method (Ames Mini-Pak haemoglobin test pack and Ames Minilab, Bio Rad Laboratories (Pty) Ltd). Anaemia was defined as haemoglobin (Hb < 11.0 g/dl) (Thurnham *et al.*, 2015).

Anthropometric measurements were measured by trained fieldworkers who were trained on the WHO Training Course on Child Growth Assessment for the children. Anthropometric status was assessed using the WHO Child Growth Standards. Weight and recumbent length were taken according to WHO standardized techniques. Children were undressed and weighed to the nearest 0.01 kg using a digital baby scale (Seca model 354, GmbH & Co. KG., Hamburg, Germany, maximum weight 20 kg). Recumbent length was measured to the nearest 0.1 cm using infantometer (Seca model 416, GmbH & Co. KG., Hamburg, Germany. All measurements were done in duplicate and if the first two measurements differed by >0.05 kg for weight or by >0.3 cm for length a third measurement was done and the two closest values were recorded. Anthropometric indices were generated using WHO Anthro 2005 software. Length-for-age Z-scores (LAZ) and weight-for-height Z-scores were calculated using World Health Organization growth curves (De Onis *et al.*, 2012). Stunting was classified as LAZ <−2SD, wasting as WLZ < −2SD, and underweight as WAZ <−2SD. (De Onis *et al.*, 2012).

4.3.2 Statistical analysis

Data were analysed using IBM SPSS for Windows, version 23 (SPSS Inc., Chicago, Illinois, USA) and STATA V14 (StataCorp Ltd). Characteristics of the children at 12 and 18 months are presented as frequencies (categorical data) and means and standard deviations (continuous data). To test whether the three groups differed at age 12 months (baseline), categorical data were analysed using the Chi-square test and continuous data using ANOVA. To test for intervention effects at 18 months, group 1 and group 2 respectively were compared to group 3 as was done in the Tswaka-RCT, except that group 3 was now the active intervention group. For LAZ, WAZ, parent rating, locomotor scores and eye-hand coordination scores median regression analysis was used. For haemoglobin concentration, median regression analysis adjusted for baseline (12 months) was used. The intervention effect for anaemia was assessed using logistic regression analysis, and the Odds Ratio (OR) and 95% CI were calculated.

4.3.3 Ethical considerations

The study was approved by the ethics Committee of the North-West University (NWU-00060-17-A1). The provincial, district and community's approval to conduct the study was obtained through an engagement with relevant stakeholders. Written informed consent was obtained from the mothers before all interviews and measurements were conducted and all interviews and measurements were conducted in a specified separate room to maintain confidentiality. Names of the children we're not recorded on the questionnaires, only the study identity number. All questionnaires were kept in a locked cupboard and the electronic database was secured, and only the principal investigator had access to the database.

4.4 Results

A total of 514 children completed the Tswaka-RCT and were recruited, of whom 122 mothers declined to participate, while 392 consented and were enrolled into the current study (Figure 4.1). Of these 392 children, 252 children completed the post-intervention study. The reasons for withdrawal included: loss of follow-up, mothers relocating out of the study area or changing address without notifying study staff, children refusing the SQ-LNS, AE related concerns and personal reasons. In total, 1 SAE and 27 AEs were reported for the duration of the study. The child who was hospitalized due to SAE did not drop out of the study and amongst those who had AE, only 4 withdrew from the study. The used sachets were collected during the bi-weekly visit for compliance monitoring and the mean compliance to the intervention was 92%.

Table 4-2 summarizes the main characteristics of the children, as well as the findings on anthropometric indices, psychomotor development, parent rating scores and anaemia at age 12 months. Of the 392 study children who enrolled into the current study, 51.92% were males and 48.08% were females; the sex distribution across the three study groups differed statistically significant (p=0.012). At baseline (12 months), 39.90% of the children were stunted, 13.55% were underweight, 2.05% were wasted, 5.12% were overweight and 27.62% were anaemic. There was no statistically significant difference between the groups for any of the anthropometric measurements. There were also no significant differences across the groups for the eye-hand coordination score, loco-motor development score or parental rating. The haemoglobin concentration differed significantly across the three groups (p=0.003). The percentage of children with anaemia did not differ statistically significantly across the groups, although there was a trend towards significance (p=0.051). Group 3 had a higher percentage of children (33.94%) who were anaemic compared to group 1 (24.37%) and group 2 (21.50%).

Table 4-3 summaries the outcome of the study at 18 months. It shows the outcomes at follow-up and estimated intervention effects for growth, psychomotor development scores, and Hb concentrations and prevalence of anaemia for group 1 and 2 versus group 3. It further shows the mean anthropometric indices and comparison according to groups.

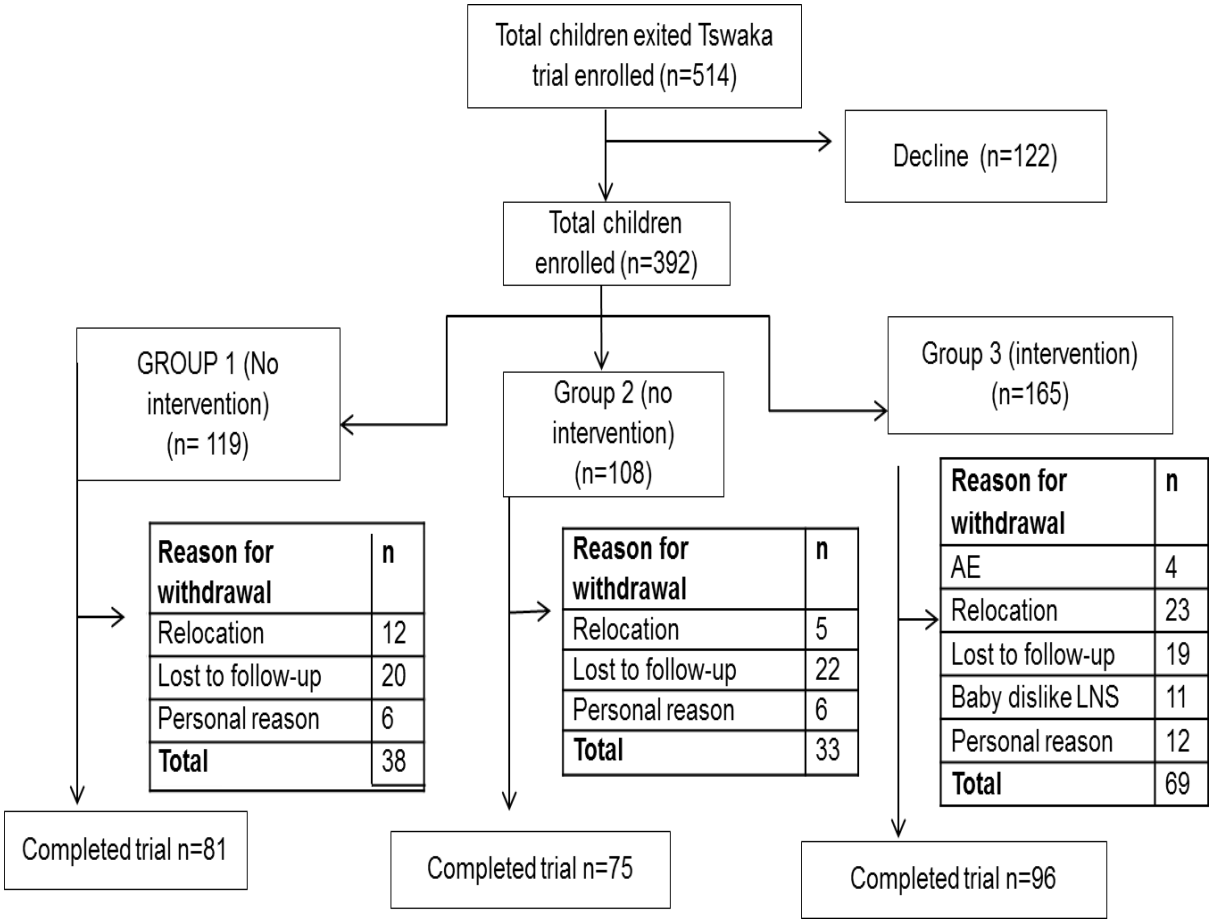

Figure 4-1: Flow diagram of children in Tswaka post-intervention study from enrolment to end of study

Table 4-1: Composition of SQ-LNS

	SQ-LNS
Amount (g) (1 portion), (g)	20
Energy (kcal)	114
Energy density (kcal/g)	5.7
Protein (g)	3.0
Percentage of calories from protein	10
Fat (g)	8.0
Percentage of calories from fat	63
Essential fatty acids	
Linoleic acid (LA) g	1.5
α-linolenic acid (ALA) mg	265
Linoleic acid:α-linolenic acid	5.7
Long-chain polyunsaturated fatty acids	
Docosahexaenoic acid (DHA) mg	-
Arachidonic acid (ARA) mg	-
Micronutrients	
Vitamin A µg	200
Vitamin D µg	2.5
Vitamin E mg	2.5
Vitamin K µg	7.5
Thiamin mg	0.25
Riboflavin mg	0.25
Niacin mg	3
Pantothenate mg	1.0
Vitamin B6 mg	0.25
Biotin µg	4.0
Folate (B9) µg	80
Vitamin B12 µg	0.45
Vitamin C mg	23.3
Calcium mg	250
Iodine µg	45
Iron mg	5.8
Zinc mg	6.2
Copper mg	0.28
Selenium µg	8.5
Magnesium mg	-
Manganese mg	-
Phosphorus mg	-
Potassium mg	-
Choline (from lecithin), mg	2.0
L-Lysine, mg	-
Phytase, FTUs	-

The SQ-LNS was manufactured by Unilever R&D Vlaardingen BV and packed by Budel pack BV. Table was adapted from Smuts et al. (2019).

Table 4-2: Characteristics of children at age 12 months; baseline for post-intervention study (*n*=392)[1]

Characteristics	Total (*n* = 392)	Group 1 (*n* = 119)	Group 2 (*n* = 108)	Group 3 (*n* = 165)	*P*[2]
Infant characteristics					
Sex: Male, *n* (%)	204 (51.92)	50 (42.02)	67 (61.68)	87 (52.73)	0.012*
Female, *n* (%)	188 (48.08)	69 (57.98)	41 (38.32)	78 (47.27)	
Age, months	12.65 ± 0.52[3]	12.70 ± 0.58	12.70 ± 0.55	12.60 ± 0.46	0.180
Anthropometric status					
Length, cm	71.29 ± 3.02	71.01 ± 3.07	71.32 ± 3.9	71.47 ± 3.22	0.460
Weight, kg	8.82 ± 1.29	8.68 ± 1.30	8.94 ± 1.17	8.83 ± 1.29	0.302
LAZ	−1.68 ± 1.17	−1.73 ± 1.23	−1.76 ± 0.98	−1.60 ± 1.24	0.433
Stunted (<−2 LAZ), *n* (%)	156 (39.90)	53 (44.54)	40 (37.38)	63 (38.18)	0.460
WAZ	−0.66 ± 1.21	−0.74 ± 1.26	−0.60 ± 1.11	−0.64 ± 1.23	0.634
Underweight (<−2 WAZ), *n* (%)	53 (13.55)	20 (16.81)	13 (12.15)	20 (12.12)	0.464
WLZ	0.24 ± 1.08	0.17 ± 1.14	0.35 ± 1.06	0.21 ± 1.55	0.383
Wasted (<−2 WLZ), *n* (%)	8 (2.05)	3 (2.52)	3 (2.80)	2 (2.05)	0.603
Overweight (>+2 WLZ), *n* (%)	20 (5.12)	8 (6.72)	5 (4.67)	7 (4.24)	0.626
Kilifi Developmental Inventory					

Characteristics	Total (n = 392)	Group 1 (n = 119)	Group 2 (n = 108)	Group 3 (n = 165)	P^2
Loco-motor development score	25.24 ± 5.70	24.73 ± 5.67	25.77 ± 5.21	25.28 ± 6.02	0.394
Eye-hand coordination score	22.85 ± 3.82	22.73 ± 6.03	23.03 ± 5.74	22.82 ± 6.40	0.932
Parent rating	32.43 ± 4.08	33.07 ± 3.82	31.97 ± 4.58	32.27 ± 3.89	0.106
Iron Status					
Haemoglobin (Hb), g/L	118.61 ± 15.78	119.39 ± 14.56	122.27 ± 15.30	115.69 ± 16.51	0.003*
Anaemic (Hb <110g/L), *n* (%)	108 (27.62)	29 (24.37)	23 (21.50)	56 (33.94)	0.051

[1]LAZ, Length-for-age z-score; WAZ, weight-for-age z-score; WLZ, weight-for-length z-score. Group 1 = Received no supplement at 12-18 months, but received SQ-LNS at 6-12 months, Group 2 =Received no supplement at 12-18 months, but received SQ-LNS plus at 6-12 months, Group 3 =Received SQ-LNS at 12-18 months, but received no supplement at 6-12 months

[2]Categorical data were analysed using Chi-square test and continuous data using ANOVA.

[3] Values are Means ± SD.

*Significant at $P < 0.05$

Table 4-3: Outcomes at follow-up at age 18 months and estimated intervention effects for growth, psychomotor development scores, and anaemia and iron status indicator.

	Group 1	Group 2	Group 3	Group 1 vs. Group 3 Effect (95% CI)	P^2	Group 2 vs. Group 3 Effect (95% CI)	P^2
Anthropometry							
Height, cm	76.23 ± 3.39[1]	76.48 ± 3.48	76.87 ± 3.71				
LAZ	-2.16 ± 1.15	-2.18 ± 1.12	-1.85 ± 1.29	-0.32 (-0.68, 0.05)	0.091	-0.34 (-0.71, 0.034)	0.075
Weight, kg	9.90 ± 1.3	10.10 ± 1.41	10.19 ± 1.40				
WAZ	-0.79 ± 1.15	-0.72 ± 1.15	-0.53 ± 1.14	-0.04 (-0.10, 0.021)	0.201	-0.07 (-0.13, - 0.01)	0.027*
Kilifi Developmental Inventory							
Locomotor development score	39.15 ± 18.78	39.87 ± 18.45	41.58 ± 20.34	-2.44 (-8.28, 3.41)	0.412	-1.72 (-7.66, 4.22)	0.569
Eye hand coordination score	33.31 ± 10.20	34.0 ± 7.54	31.50 ± 10.61	1.81 (-1.30, 4.91)	0.252	2.50 (-0.36, 5.36)	0.086
Parent rating							
Adjusted	43.64 ± 2.34	43.64 ± 2.68	4.28 43.64 ± 4.28	0.56 (-0.48, 1.61)	0.286	0.26 (-0.85, 1.37)	0.645
Haemoglobin and iron status							
Haemoglobin g/L	107.96 ± 14.07	106.97 ± 14.69	111.60 ± 13.40	-3.64 (-7.72, 0.44)	0.080	-4.63 (-8.88, -0.38)	0.033*
Anaemia, *n (%)*	43 (53.98)	44 (58.67)	44 (45.38)	1.34 (0.74, 2.41)[4]	0.337	1.68 (0.91, 3.09)	0.097

[1] Values are means ± standard deviations (SD) unless otherwise indicated.

Infant anthropometric measures of length and weight were taken at 12 and 18 months visits to the study site during the intervention period (12-18 mo old); number of children seen at specific visits: age 18 mo (n = 252). LAZ, length-for-age z score; WAZ, weight-for-age z score.

[2]Obtained by using regression models. For LAZ, WAZ, parent rating, locomotor scores and eye-hand coordination scores, median regression analysis was used; for haemoglobin concentration, median regression analysis adjusted for baseline Hb was used; and for anaemia, logistic regression analysis was used.

[3]Hemoglobin <110g/L; Values are means (standard deviations); intervention effects and 95% CI

[4]Odds Ratio (OR) intervention and 95% CI

*Significant at $P < 0.05$

Table 4-4: Characteristics of the children at 18 months (*n*=252)[1]

Characteristics	Total (*n* = 252)	Group 1 (*n* = 81)	Group 2 (*n* = 75)	Group 3 (*n* = 96)
Anthropometric status				
Stunted (<−2 HAZ), *n* (%)	135 (53.57)	49 (60.49)	42 (56.00)	44 (45.83)
Underweight (<−2 WAZ), *n* (%)	31 (12.30)	10 (12.35)	12 (15.00)	9 (9.38)
Wasted (<−2 WHZ), *n* (%)	2 (0.79)	2 (2.47)	0 (0.00)	0 (0.00)
Overweight (>+2 WLZ), *n* (%)	17 (6.77)	6 (7.50)	5 (6.67)	6 (6.25)

[1] Group 1 = Received no supplement at 12-18 months, but received SQ-LNS at 6-12 months, Group 2 =Received no supplement at 12-18 months, but received SQ-LNS plus at 6-12 months, Group 3 =Received SQ-LNS at 12-18 months, but received no supplement at 6-12 months; WAZ, weight-for-age z score
WLZ, weight-for-Length z score; WLZ, weight-for-length z score.

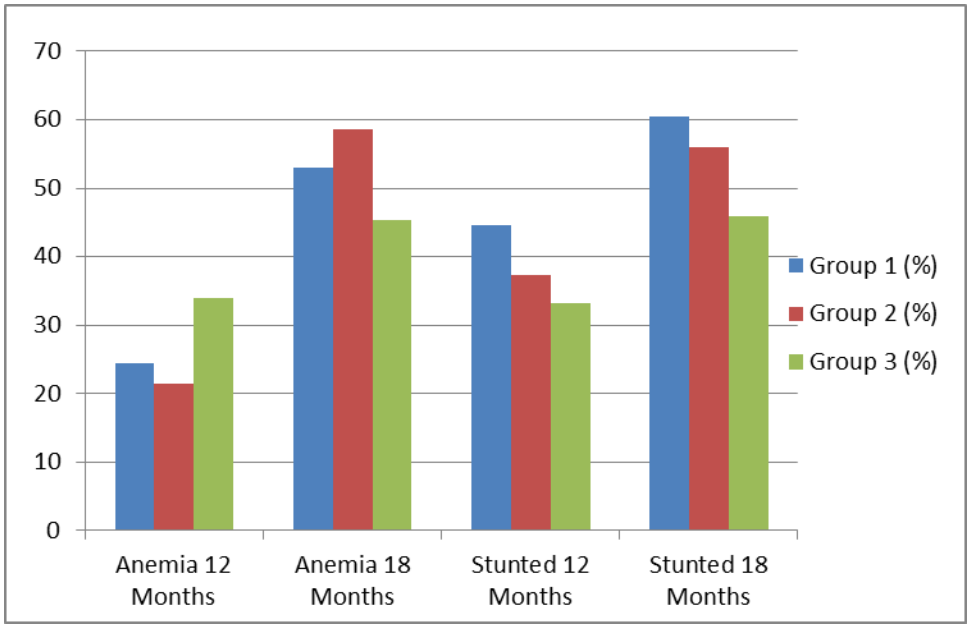

Figure 4-2: Anaemia and stunting prevalence

As shown in Table 4-3, at age 18 months there were no statistically signifcant differences in intervention effects for LAZ when comparing children in group 1 and 3, and group 2 and 3, yet there was a trend towards a significant intervention effect for children in group 1 versus group 3 (p=0.091) and group 2 versus group 3 (p=0.075). There was a significant intervention effect for WAZ when comparing children in group 2 and 3, (p=0.027), but no statistically significant effect for WAZ when comparing children in group 1 and 3.

Intervention effects on haemoglobin concentration at 18 months showed a trend for children in group 1 versus group 3 (p=0.080), while the intervention effect for children in group 2 versus group 3 was statistically significant (p=0.033). There was no statistically significant intervention effect on anaemia for children in group 1 versus group 3, while children in group 2 versus group 3 showed a trend towards significance (p=0.097). Children in group 2 had a 68% higher chance of being anaemic compared to group 3 (OR = 1.68 (0.91, 3.09)). The percentage of children with anaemia ranged from 45.38% (group 3) to 58.67% (group 2). As shown in figure 4.2, the percentage of children with anaemia at age 12 was highest for children in group 3. Although the percentage of children with anaemia increased in all three groups, at age 18 months, group 3 had the lowest percentage of children with anaemia. This shows that the likelihood of anaemia decreased in children in group 3 compared to 1 and 2, and also indicates that children in group 3 benefited the most during the period from 12-18 months.

There was no statistically significant difference on intervention effects for loco-motor development and parental rating scores at 18 months (Table 4-3). Although there was no

significant difference for eye-hand coordination scores at 18 months when comparing group 1 to group 3, there was a trend towards significance when comparing children in group 2 to group 3 (p= 0.086).

4.5 Discussion

The Tswaka-RCT in South Africa investigated the effect of two novel SQ-LNS products (SQ-LNS and SQ-LNS-plus) on linear growth and motor development, compared to a non-supplemented control group. Our study was a continuation of the Tswaka-RCT, and followed the children from age 12 to 18 months, with the no-supplement control group of the Tswaka-RCT receiving SQ-LNS. Those who received SQ-LNS in the Tswaka-RCT, received no supplement from age 12 to 18 months. The Tswaka-RCT study showed a positive intervention effect for SQ-LNS-plus on linear growth at 8 and 10 months of age but not at 12 months, as well as improved locomotor development score and parental rating scores at 12 months. Both SQ-LNS products showed positive intervention effects for anaemia and iron status at 12 months (Smuts *et al.*, 2019).

Because of the small sample size at 18 months, we also highlight the trend towards statistically significant effects. At 18 months, the effect for LAZ showed a trend towards significance for the two previously exposed groups (p=0.091 and p=0.075, respectively) when compared to children who received SQ-LNS from age 12 to 18 months. Both effects were negative, meaning that children who received SQ-LNS from age 12-18 months showed better linear growth compared to previously exposed children. These slight changes in anthropometric measurements are not a surprise, as a meta-analysis by Ramakrishnan *et al.* (2009), on the effects of micronutrients on growth of children under 5 years of age, showed that multiple micronutrient interventions improved linear growth, yet the benefits were small (Ramakrishnan *et al.*, 2009). In our study we gave only SQ-LNS, meaning that the outcome may have been smaller due to the amount in grams (20g) of micronutrient supplement giving to children in our study, compared to other studies that administered more than 20g per day of micronutrient supplement. Although children who received SQ-LNS from age 12 to 18 months (group 3) showed a trend towards better linear growth compared to the other two groups, linear growth from age 12 to 18 months deteriorated in all three groups, but less so in group 3. The deterioration in linear growth during the post-intervention study is reflected by the overall more negative mean LAZ and higher percentage of stunting at 18 months, compared to 12 months.

A study in Malawi, showed no impact of SQ-LNS supplementation on child growth (Ashorn *et al.,* 2015). However, another study in Malawi showed that provision of milk-SQ-LNS, but not soya-SQ-LNS promotes linear growth in the at-risk children aged between 9 and 12 months, yet the growth effect disappeared from 12 to 18 months (Mangani *et al.*, 2015). In Malawi, again there was no effect seen on linear growth in children from 6 to 18 months after the provision of SQ-LNS regardless of the fact that SQ-LNS contained milk (Maleta *et al.*, 2015). In Burkina Faso, provision with SQ-LNS showed positive effects on linear growth in children from 9 to 18 months (Hess *et al.*, 2015). Provision of SQ-LNS to children who already showed growth faltering at baseline has been shown to reduce the incidence of severe stunting (Phuka *et al.*, 2008).

When comparing group 2 with group 3, our result showed a WAZ intervention effect and a trend towards significant effect in LAZ (p=0.075). A study conducted in Ghana, showed that SQ-LNS provided to mothers during pregnancy until 6 months postpartum and then to their children from 6 to 18 months, had a positive impact on children's weight and length by 18 months of age compared to children in the two control groups (Adu-Afarwuah *et al.*, 2016). The iLiNS-ZINC trial that was conducted in Burkina Faso found that children who received SQ-LNS supplementation had greater weight and height, and showed a reduction in the prevalence of stunting and wasting when compared to those who received no intervention (Hess *et al.,* 2015). In addition, at 24 months of age, children in Bangladesh who received SQ-LNS and whose mothers also received SQ-LNS had significantly higher length-for-age Z-scores when compared to children whose mothers received iron plus folic acid, and the children received MNP and those children who received no supplementation (Dewey *et al.,* 2017)

Our study results showed no statistically significant effects for developmental outcomes at 18 months. Our study results are consistent with a previous study done in Malawi, where LNS had no positive benefit on developmental outcomes at 18 months of age (Phuka *et al.*, 2012) and also in Haiti, where no positive benefit on developmental outcomes was seen between 12-18 months of age when comparing LNS and non-supplemented controls (Iannotti *et al.*, 2014).

A cluster-randomised trial conducted in Bangladesh, provided children between 7 and 12 months of age with MNP, then followed them from 16–22 months of age and they found improvements in expressive, but not receptive, language development (Singla *et al.*, 2014). An effect of supplementing mothers plus their children after 6 months of age with SQ-LNS supplementation or child-only SQ-LNS supplementation on motor development at 18 months

of age was seen in Bangladesh (Matias *et al.*, 2017). In addition, the iLiNSZINC trial that was conducted in Burkina Faso, showed higher mean scores for language development in children who received SQ-LNS supplementation compared to those who received no intervention (Prado *et al.,* 2016a). On the contrary, provision of SQ-LNSs to pregnant women and children in Malawi showed no effect on motor, language, socio-emotional, or executive function skills at 18 months of age (Prado *et al.*, 2016c). In addition, the results from Malawi showed that SQ-LNS did not improve child developmental outcomes at 18 months and no difference was observed between intervention groups (Prado *et al.*, 2016b). Therefore the lack of effects on developmental outcomes at age 18 months observed in our study and in other studies suggests that this early intervention effect might not be sustained (Larson *et al.*, 2018; Phuka *et al.*, 2012; Prado *et al.*, 2016c).

The Tswaka-RCT showed that the provision of SQ-LNS-plus from 6-12 months had a positive effect on locomotor development and parental rating scores, but no effect on eye-hand coordination (Smuts *et al.*, 2019). At age 12 months, the mean eye-hand coordination scores did not differ between the three groups. However, there was a trend (p=0.086; group 2 versus group 3) towards an intervention effect for eye-hand coordination, with group 2 doing better than group 3. This may indicate a delayed intervention effect for group 2.

A significant increase in Hb was observed in children who received SQ-LNS from age 12 to 18 months, compared to the two previously exposed groups. These findings are supported by a study conducted by Mangani *et al.* (2014), who found that children in the intervention group had a greater increase in Hb from 9 to 18 months for control, milk–LNS, soy–LNS and CSB groups, respectively. In addition, the provision of a fat-based spread to undernourished children 6 to 17 months old in Malawi, also showed a positive effect on haemoglobin concentration (Kuusipalo *et al.*, 2006). In our study, we compared group 1 and 2 respectively to group 3, which is similar to the approach used in the Tswaka-RCT (Smuts *et al.*, 2019), the intervention effect for Hb when comparing group 1 and 3 was 3.94 and in the current study it was -3.64. Furthermore, in the Tswaka-RCT the intervention effect for Hb when comparing group 2 (Innervation group that received SQ-LNS B, from 6-12 months) with group 3 (Control group, received no supplement, from 6-12 months) it was 4.81 and in the current study it was -4.63. These results indicate improvement in Hb status in group 3 (who received SQ-LNS from 12-18 month), similar to what was found in the Tswaka-RCT when groups 1 and 2 received SQ-LNS from age 6-12 months (Smuts *et al.* 2019). Therefore, provision of SQ-LNS improved Hb concentration, regardless of age when the SQ-LNS was provided.

Although the two previously exposed groups had benefited from provision of SQ-LNS from age 6-12 months (Smuts *et al.*, 2019), Hb concentration deteriorated from age 12-18 months, compared to group 3. Our results for Hb at 12 months and Hb at 18 months indicate that children who had received SQ-LNS during the preceding 6 months (whether at 6-12 months or 12-18 months) were less likely to be anaemic, which indicates that that SQ-LNS supplements may have protective effects on anaemia. Osei *et al.* (2015) showed that supplementation may be able to reduce anaemia and iron deficiency in children. In Democratic Republic of Congo the provision of caterpillar cereal resulted in reduction of the risk of anaemia and also improved Hb levels in 6 month old children followed to 18 months old when compared to the control group (Bauserman *et al.*, 2015).

Both markers of nutritional status (anaemia and stunting) deteriorated from age 12-18 months, but the group that received SQ-LNS (group 3) from 12-18 months, deteriorated less than the two previously exposed groups (see figure 4.2). At age 18 months, the two previously exposed groups presented with higher percentages of stunting (56% and 60.44%, respectively) compared to 45.83% of children who received SQ-LNS from age 12 to 18 months. Although the study sample was not representative of the study population, the high overall percentage of stunted children at age 18 months (53.57%) indicates a public health concern. The 53.57% stunting that was observed in our study is greater than the findings from the 2012 SANHANES-1 survey, which found that for children 0-3 years old, 26.9% of boys and 25.9% of girls were stunted (Shisana *et al.* 2014). Available evidence shows that stunting may result in poor cognitive and physical development, reduced productivity and may cause an increased risk of chronic diseases in adulthood (Black *et al.*, 2013), which further indicates the need for preventing stunting.

4.6 Limitations of the current research

The main limitation of our study was the lack of a true reference control group (a group of children that have never been exposed to SQ-LNS before). The absence of a true reference control group made the assessment of the actual impact of the SQ-LNS intervention difficult. A large number of children who completed the Tswaka-RCT did not consent to the post-intervention study, and in addition, we encountered a high number of dropouts between 12 and 18 months. As a result, the final sample size was smaller than anticipated, so we couldn't make a firm conclusion from our results. Also, the study sample was not representative of the study population and the actual percentages for stunting and anaemia should be interpreted with caution.

4.7 Conclusion and recommendations

The Tswaka-RCT showed that provision of two SQ-LNS products from age 6-12 months had a positive impact on anaemia and iron status, while SQ-LNS-plus showed an early transient effect on linear growth and improved locomotor development, compared to a no-supplement control group (Smuts *et al.*, 2019). However, when they no longer received SQ-LNS from age 12 to 18 months, and compared to the delayed intervention group, the intervention effects were reversed. The delayed intervention group showed improvements in anthropometric status and anaemia compared to the two other groups, although for several of these results only a trend towards significance was observed. The two previously exposed groups deteriorated at 18 months, suggesting that provision of SQ-LNS should have to be continued after age 12 months. This study shows the need for more trials to be done on this topic, and with the possibility of using a non-previously supplemented control group as we do not know what happened to children who have never received SQ-LNS in the same study population.

Intervening with SQ-LNS alone may not have been sufficient for children in our study. We could have combined point-of-use fortification with SQ-LNS, with other strategies that concern the health of the family and many other factors that may reduce the risk of stunting (De Onis *et al.*, 2013). In future we should make sure we ensure early childhood development, by making an intervention that encourages caregiver activities with children, and educate them about diverse diet. Therefore, it is possible that SQ-LNS alone are not sufficient; incorporating other interventions that aim to improve children's well-being and existing stunting reduction interventions may have helped in improving the outcome of our study. We could have possibly increased the dosage of SQ-LNS as children grow older. However, we can't rule out the possibility of starting to give intervention from pregnancy and continue to 2 years of life in future studies, to help prevent growth faltering.

4.8 Acknowledgements

Thank you to all the members of the Tswaka team, parents/guardians of the young children who participated in the study and the fieldworkers who helped with data collection. To the administrative units of Matlosana Municipality, as well as Department of Health and local clinics we appreciate your understanding and support.

4.9 Source of funding

The study was funded by Global Alliance for Improved Nutrition (GAIN) and co-funded by Unilever R&D and DSM. The funding bodies had no influence on the study design, data collection, analysis or interpretation of data, writing of the manuscript or the decision to submit the manuscript for publication.

4.10 Conflicts of interest

This manuscript is original work, and has not been published elsewhere. The author(s) reported no potential conflicts of interest with respect to the research, authorship, and publication of this article. The authors declare no conflict of interest except C.M. Smuts who received traveling support from Unilever, DSM and Sight & Life. None of the study funders had any involvement in the study design, analysis, or interpretation of data; the writing of the report; or the decision to submit the article for publication.

4.11 Author contributions

IP was involved in supervising field data collection and data quality control, data analysis and interpretation of results, and drafted the paper. CL analysed the data, provided guidance on statistical analysis and interpretation. TMM and MR were study coordinators and they contributed by supervising field data collection and quality control of the data. CMS and MF were the principal investigators, initiated the study and provided training, gave guidance on data collection, quality control and analysis, academic input and review of the paper. All authors read and approved the final manuscript.

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CHAPTER 5 CONCLUSION

5.1 Summary of literature review

The first 1000 days are said to be a period in which there is great demand for nutrients as the child is rapidly growing (Black *et al.*, 2008) and the child is vulnerable to infections and disease (Dewey & Begum., 2011). Meeting the nutritional needs during this time can be a challenge (Black *et al.*, 2008). Not meeting the nutritional needs can lead to impaired growth and development (Hoddinott *et al.*, 2013a). As we live in times where poor habitual diet is practised, there is a need for nutritional intervention (Dewey & Vitta, 2013). Nutrition intervention is required during the first 1000 days to optimise a child's development (Dewey, 2013), as being stunted in the first 1000 days of life can have a negative impact on school achievement in late childhood, which leads to economic consequences (Hoddinott *et al.*, 2013a). In this study, the delayed intervention group received SQ-LNS from 12-18 months which still falls within the 1000 days' window of opportunity.

5.2 Conclusion

The Tswaka-RCT showed that provision of two SQ-LNS products from age 6-12 months had a positive impact on anaemia and iron status, while SQ-LNS-plus showed an early transient effect on linear growth and improved locomotor development, compared to a no-supplement control group (Smuts *et al.*, 2019). However, when they no longer received SQ-LNS from age 12-18 months, and compared to the delayed intervention group, the intervention effects were reversed. The delayed intervention group showed less deterioration in anthropometric status and anaemia compared to the two other groups, although for several of these results only a trend towards significance was observed. The two groups who received no supplements from age 12-18 months deteriorated at 18 months, suggesting that provision of SQ-LNS should have continued after age 12 months.

Intervening with SQ-LNS alone may not have been sufficient for children in our study. We could have combined point-of-use fortification with SQ-LNS with other strategies that concern the health of the family, like water and sanitation, and many other factors that may reduce the risk of stunting (De Onis *et al.*, 2013).

5.3 Recommendations for future research

For future studies, we recommend the use of no previously supplemented control group (a group of children that have never been exposed to SQ-LNS before). There might have been a potential for respondent bias when it comes to adherence to intervention due to the fact that it was self-reported and we didn't observe the child actually eating nutrient supplement. Future studies may try to address this and also consider to try and increase the dosage of SQ-LNS as children grow older. In future we should make sure that we integrate other factors that influence child growth and development with SQ-LNS. We suggest giving nutrition education about diverse diet, optimal and adequate complementary foods and giving nutrient supplementation from 6 months, to help improve children's nutritional status. At national level, we encourage the strengthening of nutrition programmes and improving food security. The high prevalence of stunting seen in our study further, encourages for more in-depth research, to investigate the efficacy and effectiveness of SQ-LNS in preventing stunting and micronutrient deficiencies in different settings. Tswaka RCT gave intervention from 6-12 months, while Tswaka post-intervention gave intervention from12-18 months. However, the first 1000 days is an important stage of nutritional intervention, so we suggest that future studies should start giving intervention pre-pregnancy through pregnancy possibly, to two years of life to prevent growth faltering.

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APPENDIX

Appendix A

INFORMATION SHEET (Post Intervention)

STUDY: Randomized controlled trial in South Africa comparing the impact of complementary food products on child growth - follow-up study

Principal investigator: Prof Marius Smuts
Co-principal investigator: Prof Mieke Faber

Dear Parent / Legal Guardian

Who are we?

We are from the North-West University (PUKKE), Potchefstroom. For the past 6 months, you and your baby participated in a study that looked at the effect of newly-developed nutritional supplements, i.e. a paste that can be mixed with the baby's food, on the growth and development of babies. In the study that you have just completed, babies where given the paste when the baby was 6 months old, until the baby was 12 months old. Babies in the control group did not receive any supplement, but will be given the supplement when the baby is 12 months old. In the extension of this study we are monitoring the effect of the paste on growth and development of babies when given at 12 months of age. We invite you and your baby to participate in this follow-up study.

Why are we doing this?

Iron and fatty acids in foods are important for the growth and development of babies. For optimal growth and development of babies, the different types of fatty acids in food need to be present in the right amounts. The aim of this follow-up study is to test if the supplement has a similar effect on the growth and development of babies when given at age 12 - 18 months, compared to babies who were given the supplement at age 6 months. This will be done by measuring nutritional status, growth and development of babies after they have eaten the supplement mixed with their usual food every day for six months. The study will also test whether babies who were given the supplement at age 6 – 12 months, show improved growth and development after completion of the 6-month supplementation period.

What do we expect from participants during the study?

All babies and their mothers (or primary caregiver) who completed the first 6 months of the Tswaka study will be asked to participate in this follow-up study. All babies will be 12 months old at the start of this study and will be followed up until they are 18 months old. Only mothers who plan to stay in the Jouberton area for at least the next 7 months can take part in the study.

Babies who were in the control group (orange group) of the original Tswaka study will receive a fortified fat-based paste that contains essential fatty acids. The product contains allergens from soy, milk, and fish, and may also contain traces of peanuts. Babies with known allergy to soy, peanut, milk/lactose and fish can therefore not participate in the study. The amount of nutrients (e.g. iron and fatty acids) used in the two supplements is safe and no side effects such as nausea or diarrhoea is expected. The supplement will be provided free of charge to all babies who previously were in the control group. Mothers will be asked to mix a certain amount of the supplement with the child's usual food daily for 6 months. Babies who received supplement during the first 6 months of the Tswaka study (blue and green groups) will not receive any supplement from age 12 – 18 months.

If you agree to participate in the study, we will ask the following from you:

You will also be asked to record daily how much product your baby consumed (for those receiving the supplement) and to report illness.

If you are in the orange group a field worker will visit you at home every second week. During these visits the fieldworker will ask you questions on the usage of the supplement (for those receiving the supplement), illnesses that your baby may experience and developmental milestones that your baby has achieved.

You and your baby will be asked to visit the research site at the Baptist Church when the baby is 15 months old (all groups). During this visit you will be asked questions about the foods that your baby eats and drinks, and your baby's weight and length will be measured.

When your baby is 18 months old, you will be asked to go with your baby to the research site (all groups). During this visit, we will ask the following from you:

- You will be asked questions about the foods that your baby eats and drinks, any illnesses that your baby had during the previous two weeks, and development that your baby has achieved.
- You will be asked to recall the foods and drinks that your baby consumed the day before.
- Your baby's weight and length will be measured.
- A nursing sister will collect a drop of blood from your baby by a finger prick. This blood will be used to measure the baby's hemoglobin levels in the blood (which is an indicator of the amount of iron on the blood). If your baby is showing too much resistance during this process, blood will not be taken from him/her. The procedure is completely safe.
- We will collect a small amount of urine from your baby using a special nappy. We will measure the iodine in the urine.

Payment, Expenses and Costs

You will not have to pay for any costs that are directly related to the research study, for example blood and urine tests. Your taxi-fare from your home in Jouberton to the research site at the Baptist Church will be refunded on the day that you visit the research site.

Who will have access to my child's information?

All information collected about your baby will be treated as confidential (will not be given to or discussed with anybody) and only the researchers and the ethics committee of the North-West University will have access to it. No abnormal finding is expected, but should anything abnormal be found we will refer the baby to the local clinic or a medical doctor for the necessary treatment. You will be kept informed in this regard and are welcome to discuss any concerns that you may have with us.

What will the benefit be for my child who participates?

Your child may not benefit from the study, but children may in future benefit from the results. Your child will be monitored for the 6-month period and, should anything abnormal be found, be referred to the local clinic or a medical doctor for the necessary treatment. You will also gain information on your child's nutritional status and development.

What will the risks be for my child who participates?

The nutritional supplement is safe and should not harm your child or make your child sick.

Your child may experience some discomfort when the finger prick is done or when the weight and length are taken. This discomfort will be minimized as the staff taking these measurements will be experienced. If your child does not want to cooperate, the procedures will be stopped.

Must I participate?

Participation in this study is completely voluntary (your own choice). Whether you do, or do not, give your permission will not influence your baby's access to health care in any way.

May I change my mind?

Certainly, you may do this at any time without having to give a reason. The study is completely voluntary and it will not be kept against you in any way should you decide to withdraw from the study.

Who can you contact if there are any queries?

For more information on the study you may contact Prof Marius Smuts at 018-299 4670 or 082 451 0486 **OR** Prof Mieke Faber at 021-938 0404 or 0824602946.

The study has been approved by the Ethics Committee of North-West University (NWU), as well as the Department of Health. If you have any queries or problems regarding the study, you can contact Prof Minrie Greeff the chairperson of the Faculty of Health Sciences Ethics Committee at (018) 2992094.

If you are happy for you and your child to take part in the study, please read and sign the consent form.

Thank you!

STUDY: Randomized controlled trial in South Africa comparing the impact of complementary food products on child growth – follow-up study

I voluntary agree to take part in the study.
I have been informed about and understand the purpose of the study.
I have been informed about and understand the advantages and possible side-effects that may result from procedures.
I understand that I can withdraw my consent at any time without being penalised as far as my routine health care is concerned.
I have been informed that all information will be treated as confidential.
I understand that if my baby was in the control (orange) group in the Tswaka RCT, my baby will receive the nutritional supplement free of charge for six months (starting when my baby is 12 months old) and must mix one portion of the supplement with my baby's normal food every day. If my baby was in any of the two groups (blue and green) that received supplement when they were 6 – 12 months old, they will not receive any supplement for the duration of this follow-up study.

I understand that, regardless of which group my baby is in, my baby and I need to go to the research site when my baby is 18 months old.

At 18 months visit to the field station, the following will be done:

- I will be asked questions about the foods that my baby eats and drinks, any illnesses that my baby had during the previous 2 weeks, and development milestones that my baby has achieved.
- I will be asked to recall the foods and drinks that my baby consumed the day before.
- My baby's weight and length will be measured.
- A nursing sister will do a finger prick to collect a drop of blood from my baby; the blood will be used to measure the amount of nutrients in my baby's blood.
- A small amount of urine will be collected from my baby by using a special nappy.

My taxi fare to travel from my home in Jouberton to the research site at the Baptists church will be refunded.
I understand that if my child is in the orange group a field worker will visit me at home every second week. During these visits the fieldworker will ask me questions on the usage of the supplement, illnesses that my baby had and developmental milestones that my baby has achieved.

Any abnormal findings will be attended to and referred, where necessary.

If I have any queries or problems regarding the study, I can contact either Prof Minrie Greeff the chairperson of the NWU Ethics Committee at (018) 2992094.

Baby's code: | | | | |

Mother/guardian's name & surname: .....

Baby's name & surname: .....

Address: .....

.....

.....

I hereby give consent that my baby may participate in the study.

Signature: ..... Date: .....

Signed at: .....

Witness: .....

Fieldworker who informed the mother / guardian: ……

Researcher's signature: .....

Appendix B: ANTHROPOMETRY

Tswaka

Baby's Sex	1=Boy	2=Girl		**Baby's Code:**				

DATE	**Month 15**					**Month 18**				
Year	**2**	**0**	**1**			**2**	**0**	**1**		
Day / month			**/**					**/**		
	d	*d*		*m*	*m*	*d*	*d*		*m*	*m*
Fieldworker code										

Child has oedema (*If yes record as AE)	Yes*	1		Yes*	1	
	No	2		No	2	

WEIGHT (kg)	**Month 15**					**Month 18**				
1st Measurement			.					.		
2nd Measurement			.					.		
3rd (if needed)			.					.		

LENGTH (cm)	**Month 15**					**Month 18**				
1st Measurement				.					.	
2nd Measurement				.					.	
3rd (if needed)				.					.	

Tswaka

Appendix C: KILIFI – MONTH 18

Baby's code: | | | | |

What does the mother usually call her baby? **..**.....

Date of the interview (dd/mm/yyyy): | | | / | | | / | 2 | 0 | 1 | |

Date of birth (dd/mm/yyyy): | | | / | | | / | 2 | 0 | 1 | |

Fieldworker's code: | | |

TEST SESSION OBSERVATIONS

1. Health during test session:
   - Good health = 1
   - Medium health = 2
   - Poor health = 3

2. Any unusual events during testing
   - Yes = 1
   - No = 2

   If yes, what exactly happened: .....

3. Observations of the child:

.....

.....

<u>Instruction:</u> Brief the person accompanying the child on the tasks and the role they are expected to play during the assessment.

Page numbers refer to KDI manual instructions

Scoring:

2 = able to carry out this action / activity as described with little effort or force

1 = beginning to carry out this action / activity, with limitations to control or strength or regularity

0 = unable to carry out action/activity NOT SEEN IN THE ASSESSMENT

97 = no score as item designated as inappropriate (too difficult) by assessor

99 = missing (failure to administer or refusal by child)

START TIME: [____:____]

MOVING (page 16)		**Unable**	**Once**	**More regular**	**Missing**	**Too young**	
LM01	**Stands with support**	**0**	**1**	**2**	**99**	**97**	
LM 02	**Stands without support**	**0**	**1**	**2**	**99**	**97**	

MOVING (page 16)		**Unable**	**Less than length of mat**	**Length of mat**	**Missing**	**Too young**	
LM 05	**Walks** when held with one hand	**0**	**1**	**2**	**99**	**97**	
LM 06	Walks without help	**0**	**1**	**2**	**99**	**97**	

PLAYING WITH THE BALL (page 17)		**Unable, ball just drops**	**1 or 2 times**	**3 or more times**	**Missing**	**Too young**	
EH 02	**Releases a ball** purposefully	**0**	**1**	**2**	**99**	**97**	
EH 03	Throws a ball that reaches or nearly reaches	**0**	**1**	**2**	**99**	**97**	
EH 04	**Catches** a ball using arms and hands	**0**	**1**	**2**	**99**	**97**	
EH 05	Catches a ball using hands only	**0**	**1**	**2**	**99**	**97**	

		Unable	**1 or 2 times**	**3+ times**	**Missing**	**Too young**	
EH 01	**THROWS** and **CATCHES** ball in sequence	**0**	**1**	**2**	**99**	**97**	
LM 03	**Can kick** a ball from stationary position	**0**	**1**	**2**	**99**	**97**	
LM 04	Can kick a moving ball	**0**	**1**	**2**	**99**	**97**	

STANDING ON ONE LEG (page 19)		**Unable**	**5-19 seconds**	**20+ seconds**	**Missing**	**Too young**	
LM 09	**Stands on one leg**, with support	**0**	**1**	**2**	**99**	**97**	
LM 10	Stands on one leg, without support	**0**	**1**	**2**	**99**	**97**	

WALKING		Unable	Less than length of mat	Length of mat	Missing	Too young	
LM 11	**Walk on tip toes,** with support (p.20)	**0**	**1**	**2**	**99**	**97**	
LM 12	Walk on tip toes, without support	**0**	**1**	**2**	**99**	**97**	
LM 13	**Walks backwards,** with support (p.21)	**0**	**1**	**2**	**99**	**97**	
LM 14	Walks backwards, without support	**0**	**1**	**2**	**99**	**97**	

CLIMBING AND JUMPING OFF A PLATFORM		Unable	Tries, partial success	Full success	Missing	Too young	
LM 18	Can **pull/climb** self onto platform (p.24)	**0**	**1**	**2**	**99**	**97**	
LM 19	Can **step up** onto platform	**0**	**1**	**2**	**99**	**97**	

		Unable	Steps down carefully	Jumps down, lands on both feet	Missing	Too young	
LM 20	**Jumps off** platform, with support	**0**	**1**	**2**	**99**	**97**	
LM 21	Jumps off platform, without support	**0**	**1**	**2**	**99**	**97**	

LIFTING UPPER BODY WHEN LYING ON THE STOMACH		Unable	Not stable, arms not strong	Stable arms strong and straight	Missing	Too young	
LM 24	Lifts upper body while lying on stomach (p.24)	**0**	**1**	**2**	**99**	**97**	

SITTING		Unable	Not stable	Stable	Missing	Too young	
LM 25	Sits with support (p.28)	**0**	**1**	**2**	**99**	**97**	
LM 26	Can sit steadily/ without support	**0**	**1**	**2**	**99**	**97**	
LM 27	No head lag in sitting position	**0**	**1**	**2**	**99**	**97**	
LM 28	Can reach out and return to sitting position	**0**	**1**	**2**	**99**	**97**	

ROLLING FROM SIDE TO SIDE		Unable	Able with effort	Easily	Missing	Too young	
LM 29	**Rolls** from side to back (p.27)	**0**	**1**	**2**	**99**	**97**	
LM 30	Rolls from side to side	**0**	**1**	**2**	**99**	**97**	

LYING TO STANDING (page 29)		Unable	Much effort	Hands for balance	Missing	Too young	
LM 31	**Moves from lying** to sitting pushing up with hands (p.29)	**0**	**1**	**2**	**99**	**97**	

		Unable	Not steadily, with effort or extra support	Steadily / smoothly	Missing	Too young	
LM 32	Moves from lying to sitting not using hands	**0**	**1**	**2**	**99**	**97**	
LM 33	Moves from sitting to standing rolling over and up	**0**	**1**	**2**	**99**	**97**	
LM 34	Moves from sitting to standing not using hands	**0**	**1**	**2**	**99**	**97**	
LM 35	Can sit down steadily (from a standing position- without hands) (p.28)	**0**	**1**	**2**	**99**	**97**	

VISION: RING AND RED TASSEL (page 31)		Unable	Once, but not reliably	Steadily / smoothly	Missing	Too young	
EH 06	Reaches for dangling ring	**0**	**1**	**2**	**99**	**97**	
EH 07	Takes dangling ring	**0**	**1**	**2**	**99**	**97**	
EH 08	Follows red tassel with eyes/attempts to grasp	**0**	**1**	**2**	**99**	**97**	
EH 09	Grasps red tassel successfully	**0**	**1**	**2**	**99**	**97**	
EH 10	Can hold and examine object (ring, bear etc.)	**0**	**1**	**2**	**99**	**97**	
EH 11	Passes object from hand to hand	**0**	**1**	**2**	**99**	**97**	

BLOCK TOWER (page 33) Tick the ones that the child does	**Tick**	Tick the ones that the child does	**Tick**
A. Can retain cube in either hand when given		**B**. Retains one cube when second offered	
C. Picks cube up from mat		**D**. Mature (radial) grasp	
E. Can hold 2 cubes in one hand		**F**. Retains 2 cubes when third offered	
G. Releases one cube on top of another		**H**. Builds tower 3-4 cubes	
I. Builds tower 5-6 cubes		**J**. Builds tower 7-8 cubes	
K. Builds tower 9-10 cubes		**L**. Builds tower 11-12 cubes	
EH 14		**Number of boxes ticked**	

missing = 99

no score as item designated as inappropriate (too difficult) by assessor = 97

CONTAINERS AND CUBES (pages 34 –35) Tick the ones that the child does	**Tick**	Tick the ones that the child does	**Tick**
A. Rattles box		**B**. Lifts lid of box (not knocking off/over)	
C. Tries to take cube out of box		**D**. Manages to take 1 cube out of box	
E. Removes both cubes from box		**F**. Opens 2 boxes	
G. Puts 1 cube in box (encourage)		**H**. Puts 2 cubes in box (encourage)	
I. Puts cubes in and out of box		**J**. Puts lids back, trial and error	
K. Puts 2 cubes and lid back		**L**. Puts lid back, adjusts lid to box	
M. Puts 3 boxes together		**N**. Assembles boxes by colour	
EH 15		**Number of boxes ticked**	

missing = 99

no score as item designated as inappropriate (too difficult) by assessor = 97

COIN BOX (pages 36-37) Tick the ones that the child does		**Tick**		**Tick**
A. Picks up coin any method	Right		Left	
B. Picks up coin between thumb and finger	Right		Left	
C. Can put coin in the box (slot horizontal)	Right		Left	
D. Can put coin in rotated box (slot vertical) shakily	Right		Left	
E. Can put coin in rotated box: easily	Right		Left	
F. Puts in 6 coins in rotated box	Right		Left	
EH 16			**Number of boxes ticked**	

missing = 99

no score as item designated as inappropriate (too difficult) by assessor = 97

EH 17 R 6 Rotated box	
a). Trial 1 (seconds)	
b). Trial 2 (seconds)	
c). Trial 3 (seconds)	
EH 18 L 6 Rotated box	
a). Trial 1 (seconds)	
b). Trial 2 (seconds)	
c). Trial 3 (seconds)	

BEAD THREADING (page 38)		**Unable**	**Trial and error**	**Fluid movement, several**	**Missing**	**Too young**	
EH 19	Picks up beads with pincer grasp	**0**	**1**	**2**	**99**	**97**	
EH 20	Drops beads into container	**0**	**1**	**2**	**99**	**97**	
EH 21	Threads 2 beads onto shoe lace	0	**1**	**2**	**99**	**97**	
EH 22 How many in 30 secs.	a) **Trial 1**				**record number**		
	b) **Trial 2**				**record number**		
	c) **Trial 3**				**record number**		

missing = 99

no score as item designated as inappropriate (too difficult) by assessor = 97

PAPER AND PEN (page 39)		**Unable**	**Hesitant**	**Fluid movement to paper**	**Missing**	**Too young**	
EH 23	Holds a pen in any way	**0**	**1**	**2**	**99**	**97**	
EH 24	Holds a pen between finger and thumb	**0**	**1**	**2**	**99**	**97**	
EH 25	Can scribble using a pen	**0**	**1**	**2**	**99**	**97**	
EH 26	Can imitate a straight line	**0**	**1**	**2**	**99**	**97**	
EH 27	Can imitate a circle	**0**	**1**	**2**	**99**	**97**	

TIME: [____:____] A-Not-B and Self Control Scoring Sheet

START TIME: [____:____]

Self Control:

SC1	Time in secs.	

A not B:

1. Delay time to be observed -*Tick delay time you will be using during this session.*
   3 secs **less than 12 months**
   5 secs **12 to 24 months**
   10 secs **25 to 36 months**
2. Left and right refer to the assessor's right or left.
3. Alternate the side you start with i.e. if the first child you started assessing from left, then second child starts from right.
4. Always place the mark where the child searched ✓ for getting the treat and **×** for missing the treat.

Child seating

TRIAL	**Left Cup**	**Right Cup**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Assessor seating

SCORING:		
Total number of valid trials		
Total number of trials correct		
Total number errors		
Total number on which the first set was achieved		
Total number errors (after first set)		
Total number of trials on where no response (a refusal) was registered)		

Self-control 2:

SC2	Time in secs.	

Test behavior:

Comment on child's behaviour and any unusual events during this task.

TIME [____:____]

APPENDIX D: PARENTAL RATING Month 18

Baby's code:				

Date of the interview (dd/mm/yyyy):										
		/			**/**	**2**	**0**	**1**	

Fieldworker code:	

Codes for questions to Mother/Caregiver:

1: Yes, the child has been able to do this for more than a month

2: The child is learning to do this or has only been able to do it for less than a month

3: Child not yet able to do it

4: Mother/caregiver not sure / has not seen the child do it/the child has not had the opportunity to do it

5: Mother/caregiver has not understood the question or finds it difficult to answer

Codes for observation items and instruction directly to the child (written in bold):

1: Yes, the child could do it

3: No, the child is not able to do it

4: Not sure if the child can do it (child shy or un-cooperative or tired etc.)

Special instructions which apply only to that question are written in italics.
Equipment needed, 2 Blocks; mirror, pictures (chair and window).

Introductory remarks for the parent/caregiver prior to questioning: "We would like to know what your child is able to do. In some cases we will ask the child to show us what s/he can do, but in most cases we will ask you what your child can do. Some of the statements apply to things that your child has been able to do for a long time, some of them apply to things your child has started to do only in the last month, and some apply to things that your child has not yet started to do. I will read out each statement and I would like you to say whether your child has been able to do it for over a month, is just learning to do it, or is not yet able to do it".

BY OBSERVATION		Yes	No	Don't know	
P1.1.1	The child can drop an object and watch it fall. **Give child a block**	1	2	4	
P1.1.2	The child is able to copy if you hold two blocks and bringing them together to make a sound	1	2	4	

ASK THE MOTHER		Yes	Yes, but mother not able to tell when started	Learning	No	Don't know	No reply	
P1.2.1	The child can recognize familiar people (e.g. parent / caregiver / siblings)	1	2	3	4	5	6	
P1.2.2	The child can recognize familiar objects. (e.g. a feeding bottle)	1	2	3	4	5	6	
P1.2.3	If you pick up a bowl, does the child expect food?	1	2	3	4	5	6	
P1.3.1	The child reaches for breast or bottle when hungry.	1	2	3	4	5	6	
P1.3.2	The child points when she/he wants something.	1	2	3	4	5	6	
P2.1.1	The child touches different parts of his/her own body	1	2	3	4	5	6	

BY OBSERVATION		Yes	No	Don't know	
P2.1.2	**Call the baby's name** Code 1 if the child smiles or looks at you, otherwise 3 or 4	1	3	4	
P2.1.3	**Ask the child to look at him/herself in a mirror. Say "Who is that?"** Code 1 if the child indicates by word or gesture that it is him/herself, otherwise 3 or 4	1	3	4	

ASK THE MOTHER		Yes	Yes, but mother not able to tell when started	Learning	No	Don't know	No reply	
P2.1.4	The child tries to do things for him/herself (e.g. dress or feed him/herself)	1	2	3	4	5	6	
P2.1.5	The child points to things she/he wants but are out of reach	1	2	3	4	5	6	
P2.2.1	The child responds to family members who live at home (but not necessarily people who come into the house from time to time) (e.g. smiling, making a sound or making a gesture)	1	2	3	4	5	6	
P2.2.2	The child makes sounds to get attention	1	2	3	4	5	6	

BY OBSERVATION		Yes	No	Don't know	
P2.2.3	**The child claps hands if shown and encouraged**	1	3	4	
P2.2.4	**Smile at the child and see if she/he smiles back**	1	3	4	

ASK THE MOTHER		Yes	Yes, but mother not able to tell when started	Learning	No	Don't know	No reply	
P2.3.1	Does the child follow a routine for eating, sleeping etc.?	1	2	3	4	5	6	
P2.3.2	Is the child aware of daily routines? (e.g. family members going to school or work)	1	2	3	4	5	6	
P2.3.3	Is the child able to follow simple instructions? (e.g. Give me that)	1	2	3	4	5	6	
P3.1.1.	The child often plays contentedly alone if s/he is near an adult	1	2	3	4	5	6	
P3.1.3	The child responds differently to children and adults	1	2	3	4	5	6	
P3.2.1	The child watches other children for long periods and smiles or stares	1	2	3	4	5	6	
P3.2.2	He usually plays next to other children although he does not yet often play with them	1	2	3	4	5	6	
P3.3.1	The child is curious about people around her/him	1	2	3	4	5	6	
P3.3.2	The child responds to people who visit often or who live close by (e.g. smiles or waves)	1	2	3	4	5	6	
P4.1.1	The child can say 1 word	1	2	3	4	5	6	
P4.1.2	The child can say 2 words	1	2	3	4	5	6	
P4.1.3	The child can say 6 words	1	2	3	4	5	6	
P4.1.4	The child copies adult conversation by babbling	1	2	3	4	5	6	

BY OBSERVATION		Yes	No	Don't know	
P4.1.5	**The child copies sounds (e.g. Say "Mama")**	1	3	4	
P4.1.6	**The child copies movements (e.g. clap hands)**	1	3	4	

ASK THE MOTHER		Yes	Yes, but mother not able to tell when started	Learning	No	Don't know	No reply	
P4.1.7	The child makes sounds to her/himself with changes in tone and loudness	1	2	3	4	5	6	
P4.1.8	Please speak to him/her. Does the child listen? *Only code 1 if the child smiles or gestures or responds with a sound or word*	1	2	3	4	5	6	
P4.1.9	Please say "Mother", "Father", "Grandmother". *Only code 1 if h/she copies at least one of the words?*	1	2	3	4	5	6	

BY OBSERVATION		Yes	No	Don't know	
P4.2.1	**Say the rhyme "Head and shoulders, knees and toes"** *Code 1 if The child responds. A simple stare is not enough*	1	3	4	

BY OBSERVATION		Yes	No	Don't know	
P4.2.4	**Show me the [say the name of an object nearby e.g. a table]**	1	3	4	
P4.2.5	**Show me the chair (give the child two pictures, one of which is a chair)**	1	3	4	
P5.1.2	**Say the rhyme with actions and note if the child responds:** **One, two, three, mother caught a flea,** **flea died mother cried, one, two, three OR** **One two, buckles my shoe . . .**	1	3	4	

ASK THE MOTHER		Yes	Yes, but mother not able to tell when started	Learning	No	Don't know	No reply	
P6.1.1	The child can feed him/herself with some help.	1	2	3	4	5	6	
P6.1.2	The child pushes and pulls large toys, boxes and light objects around the floor	1	2	3	4	5	6	
P6.1.4	The child eats with a spoon	1	2	3	4	5	6	
P6.1.5	The child holds a cup in both hands	1	2	3	4	5	6	
P6.2.1	The child prefers some foods over others	1	2	3	4	5	6	
P6.2.2	The child explores and plays with food	1	2	3	4	5	6	
P6.2.4	The child asks for some foods	1	2	3	4	5	6	
P6.2.5	The child is often willing to try new foods	1	2	3	4	5	6	
P6.2.6	The child chews food well	1	2	3	4	5	6	

<u>Appendix E:</u> DAILY FORM to be completed by the MOTHER/CAREGIVER

Baby's code: | | | | |

Week number: | |

Date (dd/mm/yyyy) **from** | | / | | | / | 2 | 0 | 1 | | **to** | | / | | | / | 2 | 0 | 1 | |

Fieldworker's code: | |

1. How much of the mixture was left in the baby's feeding bowl?

Day	a. Monday		b. Tuesday		c. Wednesday		d. Thursday		e. Friday		f. Saturday		g. Sunday	
 No left		1		1		1		1		1		1		1
 ¼		2		2		2		2		2		2		2
 ½		3		3		3		3		3		3		3
 ¾		4		4		4		4		4		4		4
 All left		5		5		5		5		5		5		5
Food used	.....		.....		.....		.....		.....		.....		.....	
NOT GIVEN		5		5		5		5		5		5		5
Reason why not given	.....		.....		.....		.....		.....		.....		.....	

2. How is your baby's health?

 **Healthy**		1		1		1		1		1		1		1
 **Gastro**		2		2		2		2		2		2		2
 **Cold/Flu**		3		3		3		3		3		3		3
 **Hot Body**		4		4		4		4		4		4		4

Appendix F

WEEKLY ADHERENCE for the FIELDWORKER

Baby's code: | | | | |

Week	**Field worker code**	**Date of delivery and visit** (dd/mm/yyyy)	**No. of empty sachets collected** (Do counting)	**No. of sachets used** (Ask caregiver)	**No. of full sachets** (Do counting)	**No. of sachets issued** (By fieldworker)	**Fieldworker SIGNATURE**	**Mother SIGNATURE**
		/ /201						
		Comment						
		/ /201						
		Comment						
		/ /201						
		Comment						
		/ /201						
		Comment						

Declaration

This is to declare that I, Annette L Combrink, accredited language editor and translator of the South African Translators' Institute, have language-edited the mini-dissertation by

TP Rikhotso

with the title

Nutritional status and development in 12-18 months old young children in a post-intervention study

Prof Annette L Combrink

Accredited translator and language editor

South African Translators' Institute

Membership No. 1000356

Date: 29 September 2018