Cost of diet in relation to nutrient intake of infants residing in an HIV-exposed environment

By

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DECLARATION

I declare that the dissertation herewith submitted for the degree of MSc Nutrition, at the University of Pretoria, is the presentation of my original research work and has not previously been submitted by me for a degree at any other university or institutions of higher education.

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September 2020

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DEDICATION

I dedicate this work to God, my creator and my late mother, Makhethang Ellen, who painstakingly laid the foundation for my education, giving it all it takes. Through her, I learnt to be persistence and to face challenges with humility and faith. She was my source of inspiration. You are missed terribly, and I will never forget you. To my father and my siblings, who continuously have confidence in me and heartens me in all my endeavours. My love for you can never be quantified.

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ABSTRACT

Cost of diet in relation to nutrient intake of infants residing in an HIV-exposed environment

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Background

About 1.4 million women living with HIV infection become pregnant every year in Africa. South Africa is not an exception with the HIV prevalence of 26.3% among women of reproductive age. The number of HIV-exposed-uninfected (HEU) infants is expanding due to the success of the prevention of mother to child transmission (PMTCT) of HIV programmes. HEU infants are at risk of low nutritional status. The cost of diet in terms of complementary foods may be high; such as fortified commercial foods, and low for staple foods with poor nutrient density. There is little known or documented about the cost of a diet of six-months infants. The present study investigated and compared the cost of diet in relation to nutrient intake and feeding practices of HEU versus HIV-unexposed-uninfected (HUU) infants aged six-months.

Methods

This cross-sectional descriptive study was a sub-study of the Siyakhula study, which recruits low-risk pregnant HIV-infected and HIV-uninfected women in the South-West Tshwane, Gauteng Province. The study longitudinally follows up their HEU and HUU children for two years. For this study, a self-designed cost of food questionnaire with a single 24-hour recall questionnaire was used. The SAMRC FoodFinder™ program was used for meal analysis to quantify nutrient intake. The estimation of diet cost utilised supermarket food prices and diet diaries method. The prices of

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food items were collected from three local supermarkets. The cost of diet and nutrient intake were derived by relating the food items and nutrients to food prices per 100g of raw food. At the time of data collection, 236 of recruited participants had six-months-old infants. Mother-infant-pairs (n=101) with complete feeding practices and infant dietary data were investigated (HEU (n=46); HUU (n=55)). A sub-study for the cost of diet was conducted on infants who had consumed complementary foods and breast milk substitutes (HEU (n=39); HUU (n=51)).

Results

Maternal HIV infection was associated with lower household income ($p<0.01$) and educational attainment ($p=0.04$). The median age of infants was 6m.3d (6.1;6.6) for HEU and 6m.4d (6.1;6.9) for HUU infants; $p=0.53$. Most feeding practices did not differ between HEU and HUU infants: early initiation of breastfeeding (75% vs 76%; $p=0.96$); any current breastfeeding (62% vs 71%; $p=0.37$); exclusive breastfeeding (46% vs 33%; $p=0.15$) and mixed feeding: 7% (HEU) vs 31% (HUU); $p=0.01$). Common complementary foods consumed by HEU and HUU infants included commercial infant cereals (49% vs 71%; $p=0.035$); fruits and vegetables (33% vs 16%; $p=0.05$) and maize meal porridge (26% vs 16%; $p=0.24$). The mean daily cost of diet among HEU vs HUU infants was ZAR40.60±41.70 vs ZAR29.50±31.10 ($p=0.43$). Only cost and intakes of iron and vitamin C differed between HEU and HUU infants: iron cost ZAR 0.00 (0.00;0.00) per group; $p=0.02$, and intakes were 5.00mg (2.10;10.30) vs 7.10mg (4.95;13.70); $p=0.03$. Vitamin C cost ZAR 0.01 (0.00;0.01) per group; $p=0.02$, and intakes were 43.00mg (14.00;98.50) vs 70.00mg (35.00; 124.50); $p=0.01$, for HEU and HUU, respectively. The percentages of nutrient intake adequacy for HEU and HUU infants were high for iron, zinc and calcium, while vitamin B12 was high in HUU group (86% vs 64%; $p=0.03$).

Conclusion

Suboptimal breastfeeding practices show that more effort is required to strengthen support and promote breastfeeding. There is inequality in the cost of diet between HEU and HUU infants. Caregivers of HEU infants spend more on less iron and vitamin C intakes. It is more cost-effective to buy commercial infant cereals with a higher nutrient density to ensure optimal infant nutrition.

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ACRONYMS

AI	: Adequate Intake
ART	: Antiretroviral Therapy
BFHI	: Baby-friendly Hospital Initiative
B-lymphocytes	: Bursa of Fabricius-lymphocytes
CD4+	: Cluster of Differentiation 4+
CD4+ T cells	: Cluster of Differentiation 4+ Thymus cell
CD8+ T cells	: Cluster of Differentiation 8+ Thymus cell
CFI	: Child Feeding Index
CFIAS	: Children Food Insecurity Access Scale
CHO	: Carbohydrate (Carbon, Hydrogen and Oxygen)
CotD	: Cost of the Diet
DRI	: Dietary Reference Intakes
EBF	: Exclusive Breastfeeding
EAR	: Estimated Average Requirement
EER	: Estimated Energy Requirements
EIBF	: Early Initiation of Breastfeeding
GHESKIO	: Groupe Haitien d'Etude du Sarcome de Kaposi et des Infections Opportunistes
HEU	: HIV Exposed Uninfected
HFIAS	: Household Food Insecurity Access Scale
HIV	: Human Immunodeficiency Virus
HUU	: HIV Unexposed Uninfected
ICFI	: Infant and Child Feeding Index
IgA	: Immunoglobulin A
IgD	: Immunoglobulin D
IgE	: Immunoglobulin E
IgG	: Immunoglobulin G
IgM	: Immunoglobulin M
IU	: International Unit
IYCF	: Infant and Young Child Feeding
Kcal	: kilocalorie

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KJ	: kilojoule
MTCT	: Mother to Child Transmission
NSC	: National Senior Certificate
PMTCT	: Prevention of mother-to-child transmission
RNI	: Reference Nutrient Intake
SAFOODS	: South African Food Data System
SAMRC	: South African Medical Research Council
SD	: Standard Deviation
SHINE	: Sanitation Hygiene Infant Nutrition Efficacy
SPSS	: Statistical Package for the Social Sciences
UNAIDS	: Joint United Nations Programme on HIV/AIDS
UNFPA	: United Nations Population Fund
UNICEF	: United Nations International Children's Emergency Fund
USD	: United States Dollar
WHO	: World Health Organization
ZAR	: South African Rand

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CHAPTER 1: INTRODUCTION AND PROBLEM STATEMENT

1.1 BACKGROUND

Globally, about 37.9 million people are living with Human Immunodeficiency Virus (HIV) with above 50% residing in Eastern and Southern Africa (UNAIDS, 2019). About 1.4 million women living with HIV become pregnant every year, with the majority from the African continent (Chandna *et al.*, 2020). South Africa has a high percentage of women (33.3%) living with HIV, with a prevalence of 26.3% among women of childbearing age (Simbayi *et al.*, 2019). The success and improved coverage of the prevention of mother to child transmission of HIV (PMTCT) programmes have presented a tremendous decline in new infection of HIV amongst infants born to HIV-infected mothers (Chandna *et al.*, 2020; Rossouw *et al.*, 2016; Sint *et al.*, 2013). As a result, the number of HIV-exposed-uninfected (HEU) infants is escalating, and it was reported to be around 15 million in 2017 (Chandna *et al.*, 2020). The social conditions and lack of maternal well-being make HEU infants susceptible to severe infections, which may be disadvantageous to their development and advancement during their first 1000 days of life (Rossouw *et al.*, 2016; Slogrove *et al.*, 2009). Morbidity and mortality rates and risks are high in HEU compared to HIV-unexposed-uninfected (HUU) infants (Sint *et al.*, 2013). Among many factors, early cessation of breastfeeding and low birth weight are the possible cause (Ajibola *et al.*, 2018; Sint *et al.*, 2013). Furthermore, it was found that the HIV status of the mother influences breastfeeding practices such as terminating breastfeeding in fear of HIV transmission (Nieuwoudt *et al.*, 2018).

The 2016 World Health Organization (WHO) guideline updates on HIV and infant feeding advise alignment of infant feeding guidelines for HIV-positive and HIV-negative mothers, within the context of antiretroviral therapy (ART) provision for HIV-positive women (WHO and UNICEF, 2016). These involve early initiation of breastfeeding (EIBF) within an hour after birth, exclusive breastfeeding (EBF) for the first six months, timely introduction of proper complementary feeds, and supplementary breastfeeding for a minimum of 12 months and may continue till 24 months and beyond (WHO and UNICEF, 2016). Breastfeeding provides nourishment to infants and consists of complete nutrients to meet the infant's nutrition requirements for proper development and advancement; it also stimulates the immune system and cognitive development of infants (WHO and UNICEF, 2014). Moreover, EBF for the first six months protects infants against diseases such as pneumonia and diarrhoea (Cai *et al.*, 2012; Chaponda *et al.*, 2017). Nevertheless,

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UNICEF and WHO indicated that the recommendations for breastfeeding are not being met globally (UNICEF and WHO, 2017) and this finding may also lead to the burden of malnutrition, infectious and diarrheal diseases in infants (Bernardo *et al.*, 2013; WHO and UNICEF, 2014). The suboptimal breastfeeding practices coupled with inadequate and early introduction of complementary foods is incorporated with a high risk of infections and malnutrition, and consequently retarded growth (Cai *et al.*, 2012; Patel *et al.*, 2015).

Despite the high HIV prevalence in women of childbearing age, the South African Demographic and Health Survey of 2016 reported that only 32% of children are EBF, and that is for an average period of 3 months, while 25% are not breastfeeding at all (National Department of Health (NDoH) *et al.*, 2018). HIV-infected mothers may choose not to breastfeed because of their poor health and HIV status. The untimely discontinuation of breastfeeding in favour of mixed and complementary feeding is also a prevalent infant feeding practice (Cai *et al.*, 2012), even in South Africa despite high rates of HIV infection.

During infancy, the diet of the six-month age group is crucial; hence WHO recommends the introduction of age-appropriate and reactive complementary feeding of nutritionally adequate diet at this age (WHO *et al.*, 2010). However, global data reported that the EBF rate is meagre, and mothers started to introduce complementary feeds already before the period of 6 months (UNICEF, 2018). Infants require a proper diet at the appropriate time to develop and grow to their full potential. It is at this same period when the role of the mother or caregiver is as important as the food itself. Mothers or caregivers must start to make verdicts on the kind of food they need to purchase. Complementary foods mostly consumed in South Africa include maize meal porridge and commercial infant cereals (Faber *et al.*, 2016; Ntila *et al.*, 2017; Swanepoel *et al.*, 2019). The infants are introduced to foods such as sugar, tea, and concentrated juices (Ntila *et al.*, 2017). The cost of these complementary foods; for instance, commercial infant cereals, is assumed to be high (Faber *et al.*, 2016) but have a high nutrient density as mostly are fortified (Klerks *et al.*, 2019). Still, mothers in resource-limited settings may not be able to afford them. On the other hand, the cost of maize meal porridge may be low but low in nutrient density, and mothers may opt for it due to the low price.

Against the background of the high prevalence of HIV and poor breastfeeding practices in South Africa, as well as concerns raised on the cost and type of complementary feeding given to infants

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at this young age group, there is a need to investigate the practices and the cost of feeding HEU infants.

1.2 MOTIVATION FOR THE STUDY

Despite the fact that HEU infants show similar growth patterns to their HUU counterparts (Ramokolo *et al.*, 2013), HEU infants are high-risk group because of *in utero* antiretroviral drugs exposure and increased postnatal exposure to pathogens from contacts with immunocompromised households (Slogrove *et al.*, 2009). These put HEU infants prone to severe infections and are at a higher risk of contracting tuberculosis (Slogrove *et al.,* 2009). Observations have shown transient differences in growth between HEU and HUU infants (Makasa *et al.*, 2007; Ramokolo *et al.*, 2013). The increased exposure to infections, suboptimal infant feeding and care practices, as well as deteriorated health of the caregiver, attribute to suboptimal growth of HEU infants in developing countries (Ramokolo *et al.*, 2013). Further, HEU infants are at risk of low nutritional status than their HUU counterparts (Brink *et al.*, 2014; Filteau, 2009), signifying that HIV exposure increases the risk of developing malnutrition (Haile *et al.*, 2015). Although the cause of the poor nutritional status is uncertain, exposure to infectious pathogens and lower socio-economic backgrounds were speculated to be the contributing factors (Brink *et al.*, 2014). Haile and co-workers (2015) pointed out that a complementary diet for HEU infants should ensure that infants survive freely from HIV infections while enhancing and maintaining improved health and nutritional status. Diet of HEU infants needs to be well planned to ensure adequate nutrition. Diet cost can enhance better planning. However, there is a gap of knowledge and documentation on the cost of the diet to the family of six-months-old infants and comparison to their HUU counterparts. The cost of diet in terms of breast milk substitutes purchasing may be high. Mothers of HEU infants are more often ailing and may find it uneasy to cope in terms of cost (Slogrove *et al.*, 2018). Therefore, because of the decline in duration of breastfeeding and financial constraints, we hypothesize that HEU infants are being fed diets high in energy but low in nutrient density, despite their proneness to malnutrition and increased disease vulnerability. Besides, because of nutrition transition, the infants are regularly fed sweets, soft drinks, salty crisps and processed meats, which may lead to obesity and non-communicable diseases in later life (Sayed and Schönfeldt, 2018).

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1.3 AIM AND OBJECTIVES

This study forms part of the bigger study namely the Siyakhula study, which focuses on the impacts of maternal HIV infection on a child's growth and development, and the effects of maternal breastfeeding practices in relation to *in utero* HIV exposure and infants' outcomes. For this quantitative sub-study, the aim was to determine and compare the cost of diet in relation to nutrient intake and feeding practices of six-month-old HEU versus HUU infants at South-West Tshwane, Gauteng Province. The study achieved its aim through the following objectives:

For the cost of diet;

a) Determined the socio-economic status of caregivers of infants.
b) Determining food items mostly consumed by 6-months-old infants in the community.
c) Collected prices of food consumed by infants.
d) Compared foods consumed by HEU versus HUU infants.
e) Determined the infant's nutrient intake using the South Africa Medical Research Council (SAMRC) Food Finder program™.
f) Compared the cost of foods and nutrient intake between HEU versus HUU infants.
g) Determined and compared the cost and nutrient density of common food items consumed.

For feeding practices;

h) Determined the feeding practices of infants 0 – 6 months old in the study community based on an adapted WHO questionnaire.
i) Compared the feeding practices of HEU versus HUU infants.

1.4 THE RATIONALE OF THE STUDY

Global data reported that the exclusive breastfeeding level is low, and mothers started to introduce complementary feeds already before the age of 6 months. The complementary feeding period is a critical period of rapid development and advancement of infants (Tafesse *et al.*, 2018). It is during this period when malnutrition, including stunting and wasting strike many infants, and HIV-exposed infants, are at higher risk (Haile *et al.*, 2015). The growth and organ development impairments during this period are irreversible (Tafesse *et al.*, 2018). It is of great importance to investigate the feeding practices and the diet cost of infants during this period so that caregivers can be well-advised and guided better on planning and selecting complementary foods, as well as proper feeding practices. The study will lead to the development of modules for complementary feeding guidelines in terms of the cost of diet, which will benefit caregivers when planning infants' diets.

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CHAPTER 2: LITERATURE REVIEW

2.1 THE IMPACTS OF HIV EXPOSURE ON INFANT AND CHILD NUTRITION

HIV infection remains among the leading global health issues (Rahman *et al.*, 2018). The literature showed a strong relationship between HIV infection, poverty, food insecurity, and malnutrition. HIV indirectly affects the nutrition of exposed but uninfected infants born from HIV-positive mothers. The HIV infection affects general maternal health and overall quality of life, resulting in reduced ability to perform daily activities, which include income generation (Ladzani, 2015), adequate infant care, and feeding practices. Studies reported that the inadequate growth of HEU infants in resource-limited countries could be triggered by insufficient infant feeding and care practices as well as maternal illness (Ramokolo *et al.*, 2013). Small or no household income is associated with limited food purchasing power, the resulting food insecurity disposes infants and children to inadequate food and nutrient intakes and eventually to poor nutritional outcomes (Ladzani, 2015). The intake of poor-quality diets, lower in essential nutrients is attributed to household food insecurity (Ladzani, 2015). The major determinant of food security is the household socio-economic status; the household economic status determines food purchasing power (Ladzani, 2015). Increasing food prices unfavourably affect financially limited households.

Rosala-Hallas and co-workers (2017) reported that maternal HIV infection may affect the quantity and quality of breast milk. The breast milk of the HIV-positive mothers contains lower concentrations of iron, folate, riboflavin, copper, vitamin B and vitamin C, as compared with HIV-negative mothers (Rahamon *et al.*, 2018). Fouché *et al.* (2016) reported that the breast milk of HIV-infected mothers receiving ART contains lower levels of carbohydrate and zinc compared with those of HIV-uninfected mothers. The HIV-positive women were found to have reduced milk production with a high prevalence of subclinical mastitis, and this was associated with low weight and poor growth among their HEU infants (Rosala-Hallas *et al.*, 2017). Besides, there are concerns that the maternal low CD4+ cells, high plasma and breast milk viral load (due to non-adherence to (ART)) and prolonged duration of breastfeeding increase the risk of transmission of HIV through breast milk (American Academy of Pediatrics, 2013; Davis *et al.*, 2016). In response to such concerns to avoid postpartum HIV infections, the WHO feeding guidelines in HIV settings still recommend EBF for six months and continued breastfeeding to increase the survival of HEU infants (WHO *et al.*, 2010; WHO and UNICEF, 2016). The findings from the study done in Cape Town showed that the median breastfeeding duration of HEU children is too short; around 3.9

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months, compared to HUU children which are about 9.0 months (le Roux *et al.*, 2019). Women with high plasma and breast milk viral load may be advised to terminate breastfeeding. The reduced duration of breastfeeding, however, deprives HEU infants of adequate nutrition, particularly in low-income households that cannot afford commercial infant formula and nutrient-dense feeds or lack adequate nutrition knowledge on home food fortification to ensure the proper nutrient intake. These lead to persistent infant and child malnutrition.

2.2 THE PREVALENCE OF MALNUTRITION IN HIV SETTINGS GLOBALLY AND IN SOUTH AFRICA

The HIV epidemic adversely affects the region of sub-Saharan Africa, including South Africa. The African continent has a massive burden of paediatric HIV-infection (Ubesie, 2012). Infant malnutrition is a big challenge in the settings of HIV. The burden of malnutrition is exceptionally high in African countries (Penda *et al.*, 2018; Ubesie, 2012) and infant malnutrition remains a health threat in an infant born to HIV-infected mothers in Africa (Buonomo *et al.*, 2012). Compared to their HUU counterparts, the HEU children's early and later growth is suboptimal (Rosala-Hallas *et al.*, 2017). In addition, HEU infants develop malnutrition, specifically growth faltering, in resource-poor regions (Lartey *et al.*, 2014; McGrath *et al.*, 2012). Literature reported that the growth and development of infants exposed to HIV in Africa is tremendously affected by monetary factors such as low household income (Lartey *et al.*, 2014). These result in food insecurity and ultimately inadequate consumption of fruit and vegetables, milk and milk products (Ladzani, 2015), iron and protein-rich foods. Osterbauer and colleagues (2012) stated that the levels of malnutrition among HEU infants are alarming in Africa. In Kenya, the prevalence of malnutrition is high among uninfected infants born to mothers infected with HIV; the majority (58%) of children under the age of 24 months were stunted, about 18% were wasted while 29% were underweight (McGrath *et al.*, 2012). The findings from Uganda reported that the rates of malnutrition; stunting, wasting and underweight were higher among HEU compared to HUU infants; 10%, 7% and 3% respectively (Osterbauer *et al.*, 2012). In addition, 12% of infants exposed to HIV had moderate-severe anaemia (Osterbauer *et al.*, 2012).

Furthermore, in the pilot study in Malawi, Buonomo and co-workers (2012) displayed that 33% of children exposed but uninfected to HIV were severely malnourished, while 67% were moderately malnourished. Ghanaians study revealed that the incidence of underweight and

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stunting was higher (27.5% and 26.5%) among HEU infants than in HUU (6.6% and 6.0%) at 12 months of age (Lartey *et al.*, 2014). Micronutrient deficiencies including zinc, iron, vitamin E and vitamin A are common in the HIV environment (Monteiro *et al.*, 2014). The raised prevalence of macro-and micro-nutrient deficiencies in high HIV prevalence settings may be due to suboptimal dietary intake and infant feeding practices, as HIV-positive mothers are often socio-economically underprivileged and mostly are living under conditions of food insecurity (Lartey *et al.*, 2014). Food insecurity has been linked with maternal depression and anxiety (Gray *et al.*, 2015) and the knowledge of having HIV itself may cause depression and, eventually, alter the maternal feeding and care practices (Lartey *et al.*, 2014).

Generally, the prevalence of malnutrition in the settings of the HIV epidemic is disquieting in Africa, including South Africa; a country that has the peak number of individuals infected with HIV in the world and is at rank four in the world HIV prevalence, with HIV prevalence of 18.9% (Ubesie, 2012; UNAIDS, 2018). The rates of malnutrition in South Africa among six-months-old uninfected and infected infants born to mothers infected with HIV were relatively high, with children Z-scores (weight-for-age, weight-for-length and length-for-age) below -2 SDs (Venkatesh *et al.*, 2010). In the study conducted on six-months-old infants in Soweto, Johannesburg and Cape Town, findings showed that 20% of HIV-uninfected and HIV-infected infants were underweight, almost 19% were stunted, and 29% were wasted (Venkatesh *et al.*, 2010). In another study which was conducted in the Mpumalanga Province on 12 to 59 months old HIV-infected and uninfected children, the rates of stunting were 18% (Kimani-Murage *et al.*, 2011), which depicts the unexceptional reduction in stunting rates as compared to the percentage (mentioned above) reported in 2010 by Venkatesh *et al.* (2010). However, there was a massive rise in stunting and underweight levels (Z<-2 SDs) in the HIV context in 2014 (Brink *et al.*, 2014). The cross-sectional survey piloted in Soweto on the prevalence of malnutrition in HIV environment revealed that the stunting rates were extremely high around 39.3% and underweight levels were 31.3% while wasting rates were 25.9% among HIV-exposed and -infected children, between 0 – 1 year of age (Brink *et al.*, 2014). About 16.1%, 20.5% and 12.5% of 0 – 1-year-old children were severely (Z<-3SDs) underweight, stunted and wasted, respectively (Brink *et al.*, 2014). Few of the children (10.8%) were HIV infected (Brink *et al.*, 2014). A prospective study conducted in Cape Town on trajectories of growth of breastfed HEU and HUU children benefiting from PMTCT reported lower mean for underweight and stunting Z-scores among HEU compared to HUU children (le Roux *et*

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al., 2019). The stunting (Z<-2SD) rate was higher (10%) among HEU than HUU (4%) (le Roux *et al*., 2019). On the other hand, the incidence of malnutrition in HIV-infected children is higher, more specifically, underweight and stunting, without antiretroviral therapy (Brink *et al.*, 2014). A cohort study explored in Pretoria on under five years children infected with HIV indicated that the levels of malnutrition prior to antiretroviral treatment are extremely high; about 73% of children had growth faltering, 50% were underweight while 19% were wasted (Feucht *et al.*, 2016). Studies showed that suboptimal infant feeding practices attributed to poor nutritional outcomes among South African infants residing in the HIV environment (Rossouw *et al.*, 2016). These include low adherence to breastfeeding recommendations and poor dietary diversification (Rossouw *et al.*, 2016). In addition, exposure to infectious pathogens and poorer socio-economic backgrounds were also speculated to be the drivers of poor nutritional outcomes of HEU infants (Brink *et al*., 2014). The causes of child undernutrition are illustrated in the UNICEF conceptual framework of the determinants of child undernutrition (Figure 2.1).

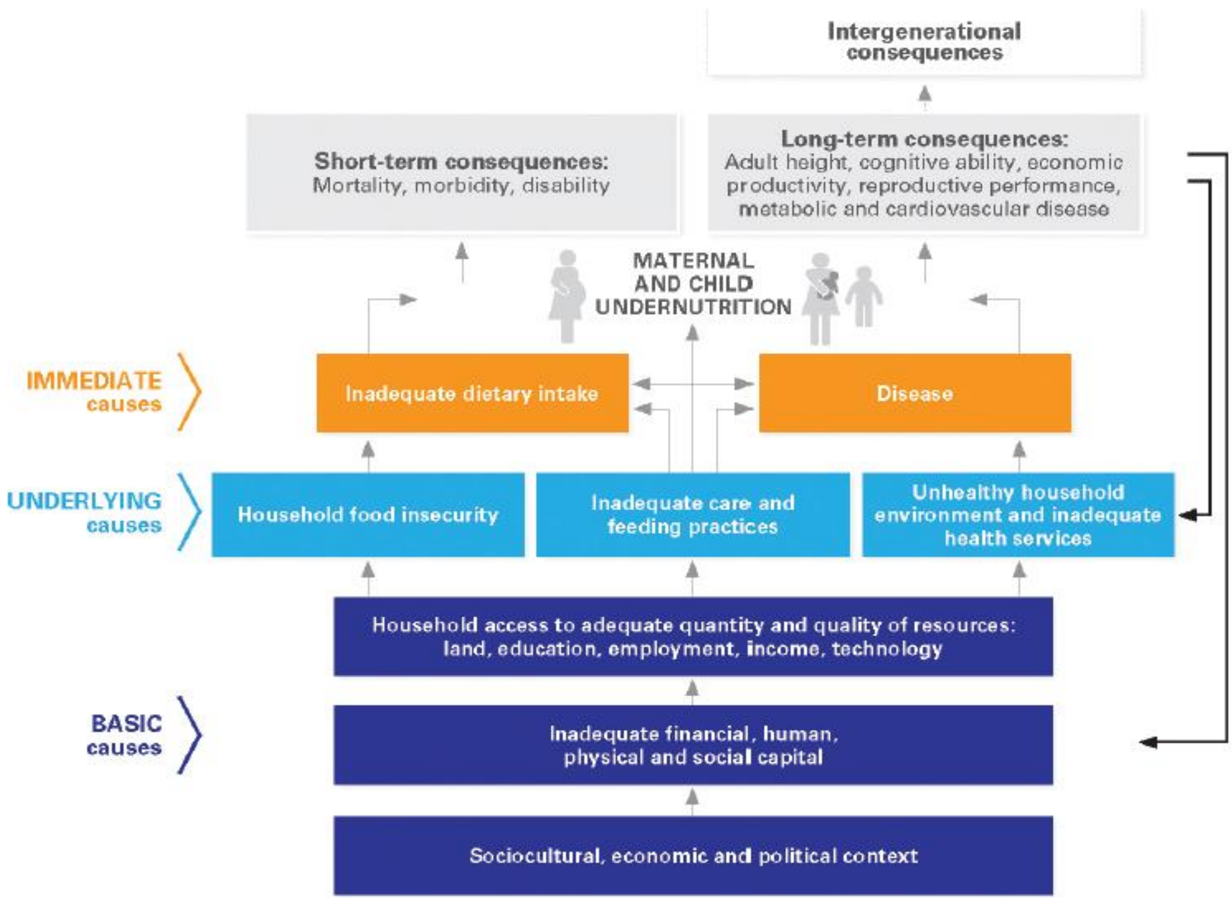

Figure 2.1: *The UNICEF conceptual framework of child undernutrition.*

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Source: UNICEF (2013). Improving Child Nutrition: The achievable imperative for global progress. United Nations Children's Fund.

Figure 1 above shows the basic, underlying and immediate causes of undernutrition. The basic causes of poor nutrition include the socio-economic conditions that influence household food availability and access. Thus, leading to household food insecurity; lack of availability, access and utilization of a diverse diet, inadequate care and feeding practices for children and unhealthy household and surrounding environments, collectively known as underlying factors. Immediate causes of undernutrition involve inadequate dietary intake and disease. The dietary intake of the child and exposure to disease is affected by underlying factors (UNICEF, 2013).

The benefits of breastfeeding and optimal breastfeeding practices concerning child health and nutrition in the HIV context have been well documented (Sint *et al.*, 2013).

2.3 THE BENEFITS OF BREASTFEEDING IN HIV SETTINGS

Breastfeeding benefits are incomparable, even in HIV settings. The six months exclusive breastfeeding followed by the introduction of good quality and quantity of complementary feeding and supplementary breastfeeding, ensures proper health, advancement and development of infants living in an HIV-exposed environment (WHO *et al.*, 2010). One study showed that exclusive breastfeeding accompanied by adherence to maternal ART promotes HIV free infant survival (Gupta *et al.*, 2010). The WHO (2010) pointed out that with appropriate antiretroviral interventions, exclusively breastfed HEU infants have the tremendous fortuity of HIV free survival. The WHO added that even in circumstances where ART is not available, exclusive breastfeeding of uninfected HIV-exposed infants still ensures higher chances of infants' survival with reduced HIV transmission (WHO *et al.*, 2010; WHO and UNICEF, 2016). The literature revealed that mothers who take antiretroviral treatment during the lactation period increase the likelihood of infant HIV free survival by 89.8% to 91% (Chikhungu *et al.*, 2016). Evidence suggests that exclusive breastfeeding reduces HIV vertical transmission rates to less than 5%, while acceptable, feasible, affordable and sustainable exclusive replacement feeding accompanied by clean, safe water supply reduces MTCT to less than 2% (Luzuriaga and Mofenson, 2016; Nlend *et al.*, 2018; WHO, 2015). In the absence of correct breastfeeding practices and antiretroviral

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interventions, the rates of MTCT ranged within 15% to 25% and 25% to 40% for formula feeding and breastfeeding respectively (De Cock *et al.*, 2000; Luzuriaga and Mofenson, 2016).

Globally, the WHO reported a 58% drop of new MTCT of HIV between 2000 and 2014, and 41% between 2010 and 2014 due to antiretroviral interventions and more optimal breastfeeding practices (WHO, 2015). In a retrospective cohort study explored in Cameroon, the HIV vertical transmission was high among mixed fed infants, and lower in exclusively replacement fed and breastfed infants; 21.4%, 3.8% and 2.7% respectively (Nlend *et al.*, 2018). The evidence suggests the efficiency of optimum breastfeeding practices in lowering risks of HIV vertical transmission. The risk of mother to child HIV transmission is 5 to 7 greater with mixed feeding as compared to exclusive replacement feeding and exclusive breastfeeding (Nlend *et al.*, 2018), while with exclusive breastfeeding, the risk is 3 to 4 fold lower (UNICEF, 2015). Nonetheless, the effect size of antiretroviral therapy is much more robust in lowering the chances of MTCT of HIV.

Debatably, studies indicated that the levels of HIV free survival in HEU infants are higher in exclusive replacement feeding than exclusive breastfeeding, more especially if the infants are exclusively replacement fed from birth (Chikhungu *et al.*, 2016; Ciaranello *et al.*, 2014). Whereas a recent study pointed out that rates of HIV free survival are higher in breastfeeding (90%) than in non-breastfeeding (83%) practices (Mallampati *et al.*, 2018). Additionally, formula-fed HIV-exposed-uninfected infants are four times more likely to die than breastfed HEU infants (Ajibola *et al.*, 2018). Safer breastfeeding practices result in reduced non-HIV mortality and morbidity rates (Piwoz *et al.*, 2007; Taha *et al.*, 2006). Furthermore, the 2010 WHO recommendation of the 12-months duration of breastfeeding in the context of increased prevalence of HIV has made breastfeeding even safer (Doherty and Ciaranello, 2013; Luzuriaga and Mofenson, 2016; WHO *et al.*, 2010). Evidence suggests that the rates of HIV free survival are higher (90.2%) for the 12-months duration of breastfeeding coupled with proper use of maternal antiretroviral therapy (Figure 2) (Mallampati *et al.*, 2018). Observations indicated that the prolonged period of breastfeeding is enormously (72.7% to 89%) associated with a decrease in HIV free survival (Ciaranello *et al.*, 2014). Nevertheless, the updated 2016 WHO guidelines regarding infant feeding in the settings of HIV stated that the period of breastfeeding should be unrestricted if HIV infected mothers are provided with full lifelong ART support and counselling on adherence by health services (WHO and UNICEF, 2016). According to these updates, mothers are recommended to

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breastfeed even beyond 24 months while adhering to ART drugs (discussed in Chapter 1) (WHO and UNICEF, 2016).

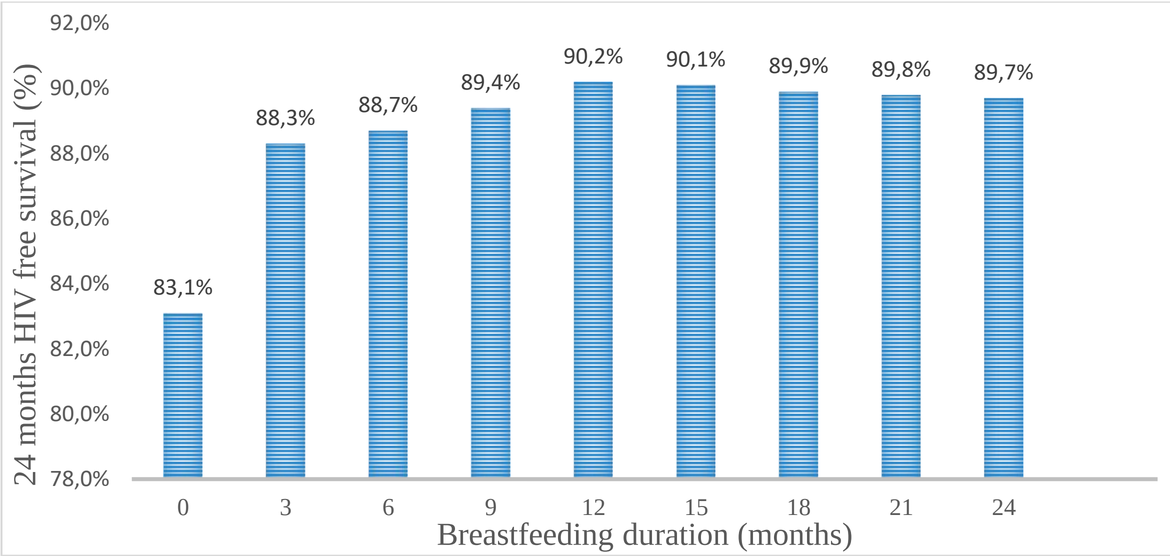

Figure 2.2: *The rates of HIV-free survival in accordance to breastfeeding duration for HEU infants and the use of antiretroviral therapy (ART) by the mother through the period of breastfeeding.*
Source: Mallampati *et al*., 2018.

The duration of breastfeeding and HIV-free survival are shown on the horizontal axis and the vertical axis, respectively. The rates of HIV free survival increase from birth up to 12 months of breastfeeding and start to decrease from 15 – 24 months of breastfeeding.

Breast milk benefits are innumerable; in addition to HIV free survival, breast milk protects against numerous infectious and chronic diseases.

2.3.1 Breastfeeding protection towards infectious and chronic diseases

Breast milk has anti-inflammatory, anti-microbial and anti-infective properties because of protective agents it contains, such as white blood cells, lactoferrin, leukocytes, lysozyme and antibodies such as IgM, IgA IgD, IgG and IgE (Table 2.1) (Lars, 2006; Palmeira and Carneiro-Sampaio, 2016). Antibodies, especially secretory IgA, in breast milk, provide direct protection for infants against mild to severe infections (Palmeira and Carneiro-Sampaio, 2016). According to Anatolitou (2012), antibodies and proteins present in breast milk help infants to fight germs in their early life while their defence system is still immature. Lars (2006) showed that some anti-

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infective factors could make the intestinal conditions amiable to useful bacteria, microflora, and unfriendly to harmful bacteria and viruses. Infants who are optimally breastfed have lower respiratory, gastrointestinal and ear infections, diarrhoea, leukaemia, and pneumonia due to the antibodies protection effect (Anatolitou, 2012). Besides, breastfeeding results in less occurrence of allergies (Anatolitou, 2012).

Furthermore, Kelishadi and Farajian (2014) pointed out that breastfeeding has long term protective effects on chronic disease such as obesity, diabetes mellitus and hypertension, since these diseases origins in early life. Studies have shown that the prolonged period of breastfeeding is associated with the decrease of 13% in developing overweight and obesity later in life, and a 35% decline in the occurrence of type 2 diabetes mellitus (WHO, 2018). Breast milk contains a high content of polyunsaturated fatty acids and fewer proteins that are high in biological value than breast milk substitutes. These breast milk compositions promote normal insulin secretion and inhibition of adipocytes formation, and consequently prevention of development of obesity (Stolzer, 2011) and the protection against diabetes mellitus type II (Horta *et al.*, 2007; Kelishadi and Farajian, 2014). Breast milk also contains hormones such as leptin that balances fat reserves and prevents adipocyte formation, thereby protecting against obesity (Kelishadi and Farajian, 2014). Lastly, the low content of sodium and high levels of unsaturated fats in breast milk protects against hypertension in later life (Kelishadi and Farajian, 2014). Breastfeeding benefits are boundless; they extend to the household and the nation.

Cost-effectiveness

Breastfeeding possesses economic benefits to the family, society and the country. Weimer (2001) stated that optimal breastfeeding reduces costs related to doctor and health care visits as well as laboratory tests, this is because optimally breastfed infants are less likely to get sick due to mother's antibodies protection. Besides, the family bears no cost for purchasing infant formula for the first six months (Kuma, 2015; Weimer, 2001). Breastfeeding also contributes to the country's economy due to reduced costs for public health programs (Kuma, 2015). The nutritional composition of breast milk has been intensively studied.

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2.3.2 Breast milk nutritional composition and bioactive factors

In resource-poor regions like sub-Saharan Africa, breastfeeding remains the keystone for infant nutrition (Luzuriaga and Mofenson, 2016). Breast milk nutritional composition and non-nutritive bioactive factors make it uniquely suitable for the infant (Ballard and Morrow, 2013). The macro- and micro-nutrients in colostrum and breast milk provide complete nutrition to the infants, and the bioactive components that include soluble and cellular components and microbiota provide immunity against diseases (Table 2.1) (Palmeira and Carneiro-Sampaio, 2016; Sint *et al.*, 2013). Macronutrient content is estimated to 3.5g per 100ml fats, 7g per 100ml carbohydrates, and 0.9g per 100ml proteins (Ballard and Morrow, 2013; Sint *et al.*, 2013). Breast milk contains the vast number of micronutrients that enhance linear growth and development; however, the content of most of the micronutrients depends on maternal diet and body stores (Ballard and Morrow, 2013). Studies showed that vitamin E content is low in breast milk regardless of maternal diet (Ballard and Morrow, 2013; Sint *et al.*, 2013).

Table 2.1: The constituents of colostrum and breast milk

Components	Benefits
Macronutrients	
Fats: 3.5 g for each 100 ml [polyunsaturated omega-6 fatty acid and docosahexaenoic acid (DHA)]	Required for neurons and brain development
Carbohydrates: 7 g for each 100 ml (oligosaccharides, lactose)	Provide energy as well as protection towards infection
Protein: 0.9 g for each 100 ml (α-lactalbumin, casein)	Support optimal growth and development
Micronutrients	
Vitamins: All except for vitamin K and vitamin D	Ensure proper growth and development
Minerals: Calcium, potassium, iron, chlorine, sodium, phosphorus magnesium,	Ensure proper growth and development
Soluble components	
Anti-inflammatory and anti-infective factors: antibodies (especially IgA), lactoferrin, leukocytes, lysozyme, free secretory component, lactoferrin, k-casein, lactoperoxidase, sCD14, α-lactoglobulin, haptocorrin, osteoprotegerin, cytokines and chemokines	Enhance immunity and protection against bacteria, inflammation and other pathogens

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Components	Benefits
Cellular components Macrophages, CD4+ T cells, CD8+ T cells	Immunity
Microbiota Probiotics: Lactococcus, bifidobacterium, streptococcus, lactobacillus (main genera)	Improve the health and functioning of the infant's gastrointestinal tract, Protect against infections of the upper respiratory and gastrointestinal tract.
Other biologically active factors: epidermal growth factor and bile salt stimulated lipase, growth factors, hormones	Digestion and maturity of the infant's intestinal lining Growth and development of the tissues of the infant including differentiation

Adapted: Sint *et al.* (2013); Lars (2006); Palmeira and Corneiro-Sampaio (2016); Erick (2018)

The breast milk protection against HIV infection is due to the action of proteins it contains; secretory immunoglobulin A (Lars, 2006) that act locally as immunity against HIV entry, and T (CD4+ and CD8+ cells) and B-lymphocytes (white blood cells) that perform the antiviral activity. Glycoconjugates and oligosaccharides form viral ligands to prevent the mucosal entry of free HIV, and ά defensins reduce the risk of intrapartum and postpartum MTCT of HIV (Bode *et al.*, 2012; Kuhn *et al.*, 2001; Lohman-Payne *et al.*, 2010). The high nutrient content and immunological benefits of breast milk defend infants against death from malnutrition, pneumonia and diarrhoea, throughout the first 12 months of lifetime (Table 2.1) (Sint *et al.*, 2013).

The benefits of breast milk are fully optimised by adherence to breastfeeding practices. For this reason, the rates of breastfeeding practices are discussed in the following section.

2.3.3 The rates of breastfeeding practices globally and in South Africa

UNICEF and WHO (2018) indicated that breastfeeding rates are below the target worldwide. According to the 2018 Global Nutrition Report, the prevalence of early initiation of breastfeeding is still far below the WHO 70% target globally as only 42% of new-borns are breastfed within the first hour following birth (Fanzo *et al.*, 2018). The evaluation in 129 countries showed that only a few (22%) countries are approaching the target (Fanzo *et al.*, 2018). However, the rates of exclusive breastfeeding have a significant increase from 38% in 2012 to 41% in 2017, worldwide. Similarly, there are some ameliorations in continued breastfeeding (71.1%) until the first birthday, but sustained breastfeeding at two years of age have vividly dropped to 45% globally (Fanzo *et*

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al., 2018). Issaka et al. (2017) pointed out that there are noticeable improvements in the prevalence of EIBF (69.3%, 61.8%) in Southern Africa and East Africa, respectively. Issaka and co-workers added that the progress for improving EBF practices is slow in Southern Africa (56.6%) and East Africa (53.5%) (Issaka *et al.*, 2017). Sub-Saharan Africa has the highest levels of breastfeeding globally; nevertheless, the EBF rates are still not improved (37%) (Ogbo *et al.*, 2017; Victora *et al.*, 2016). In addition, there are improvements in continued breastfeeding at one year in about 70 countries, in Africa (Global Breastfeeding Collective, 2017).

South Africa has a remarkable increase from 45% in 1998 to 80% in 2012, in terms of the prevalence of EIBF (Martin-Wiesner, 2018; Shisana *et al.*, 2013). Martin-Wiesner (2018) stated that there is also a significant increment in practices of EBF from 7% in 1998 to 32% in 2016; nevertheless, the gain is still far below the average and the minimum United Nations Decade of Nutrition target of 50% (WHO, 2014). Martin-Wiesner added that the rates of exclusive breastfeeding practices diminish with the age of infants; below average (44%) rate in the first month, unacceptable drop to 28% at 2 to 3 months old and 24% at 4 to 5 months old (Figure 2.3) (Martin-Wiesner, 2018; National Department of Health (NDoH) *et al.*, 2018). The South African Demographic and Health Survey of 2016 reported plainly that only 32% of children are EBF (National Department of Health (NDoH) *et al.*, 2018). Additionally, South Africa is the lowest worldwide (UNICEF and WHO, 2012). The rates of EBF, periodically within six months, are summarised in Figure 2.3.

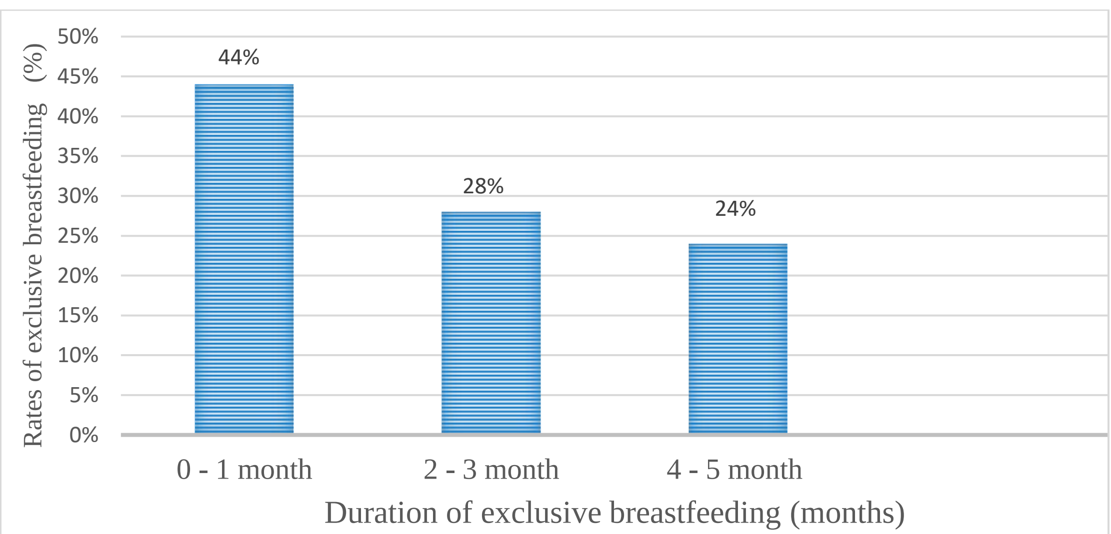

Figure 2.3: *The rates in respect to duration of exclusive breastfeeding in South Africa*

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The rates of exclusive breastfeeding declined with increasing infant age groups in months, in South Africa (according to South Africa Demographic and Health Survey 2016). During the first month of life, the rates are projected to 44% (Martin-Wiesner, 2018). There is a remarkable fall to 28% between 2 to 3 months and a 4% drop from 4 to 5 months (National Department of Health (NDoH) *et al.*, 2018).

WHO (2018) pointed that the adherence to the breastfeeding policies and programs is relatively low globally; merely 44% of new-borns start breastfeeding within a one hour following birth and about 40% of under six months infants are exclusively breastfed (WHO, 2018). Several factors influence the optimum practices of breastfeeding; these include lack of knowledge, environmental and socio-cultural factors, health systems, short maternity leave allowance and marketing of breast milk substitutes (Al-Nuaimi *et al.*, 2017). The ten steps to successful breastfeeding abridge a bundle of policies and procedures which should be implemented in maternal and new-born health facilities to support breastfeeding (WHO, 2018). In 1991, UNICEF and WHO introduced the Baby-friendly Hospital Initiative (BFHI), intending to aid to stimulate health facilities to implement the ten steps to successful breastfeeding (WHO, 2018). Adherence to WHO breastfeeding recommendations can save 823,000 child deaths annually (UNICEF and WHO, 2018). The importance of optimal infant feeding practices for HEU infants has been explored as they are more vulnerable to malnutrition.

2.4 THE IMPORTANCE OF CORRECT INFANT FEEDING AND PRACTICES IN THE HIV SETTINGS

Williams and co-workers indicated that infant feeding is central to maternal and infant health (Williams *et al.*, 2016). Globally, the recommendations for infant and young child feeding (IYCF) comprise exclusive breastfeeding within the first six months (described in section 2.3) and opportune initiation of varied complementary foods for mothers infected with HIV in low-income regions (WHO, 2007; WHO *et al.*, 2010). Optimal IYCF preserves the nutritional status and health of infants exposed to HIV (Williams *et al.*, 2016). Generally, optimal infant feeding reduces the susceptibility to diseases and death resulting from undernutrition in HIV-exposed infants (Black *et al.*, 2008). To optimise desired nutrition outcomes, WHO have established guidelines for infant feeding practices (WHO *et al.*, 2010; WHO and UNICEF, 2016), including the proper introduction

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of complementary feeds for both HIV-infected, -exposed and -unexposed infants. For the present study, only complementary feeding in the context of HIV exposure will be reviewed.

2.4.1 Introduction of complementary feeding at the age of six months

WHO describes complementary feeding as "the transition from exclusive breastfeeding to family foods" (WHO, 2019) or "family foods for breastfed children" (WHO, 2000). Steward and colleagues defined complementary feeding as "a complex set of behaviours, comprising timing of introduction, food choices and dietary diversity, preparation methods, quantity, feeding frequency, responsiveness to infant cues, and safe preparation and storage of foods" (Stewart *et al.*, 2013). Steward and co-worker's definition is more specific and broad; it encompasses factors to be taken into account during the introduction of complementary feeds. The appropriate introduction of adequate complementary foods begins from the first six months to 12 months in the HIV setting and 24 months in HIV-unexposed environment (WHO, 2019; WHO and UNICEF, 2016). At the age of 6 months, breast milk alone does not suffice to meet the infant's increasing nutritional needs; it is at this age also when the infant's gastrointestinal system is well developed to handle the digestion of semi-solid and solid foods (Tafesse *et al.*, 2018). Hence, WHO commends the introduction of healthy, safe and age-appropriate complementary feeds at this age to fill the gap of insufficient breast milk (WHO, 2002; WHO and UNICEF, 2016).

Moreover, the complementary feeding period is a critical and highly vulnerable period when malnutrition including wasting and retarded growth strike the majority of the infants thereby impairing their development and advancement (Tafesse *et al.*, 2018). The growth and organ development impairment during the period of the complementary feeding are irreversible and have a lifelong disadvantage on health (Michaelsen *et al.*, 2017; Tafesse *et al.*, 2018). The proper complementary diets during the period of complementary feeding offer a "window of opportunity" to avert growth retardation, undernutrition and overweight while promoting optimal health (Michaelsen *et al.*, 2017). Bhutta and colleagues indicated that appropriate complementary feeding could save approximately 100 000 lives per year of under five years of children (Bhutta *et al.*, 2013). Therefore, caregivers should ensure proper practices of complementary feeding, including the provision of safe and adequate amounts of nutritious complementary foods. It is of great importance for caregivers to know types of food items to give, with what quantity and how frequently (WHO, 2002). At six months and above, the maturing gut of the infant hinders the

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passage of the virus, and HIV transmission risk slows down, so mixed feeding no longer carries the same MTCT risk as before (Sint *et al.*, 2013). Therefore, WHO recommends that frequent breastfeeding should be continued to supplement complementary feeding (WHO, 2019). Infants should be fed proper quality and quantity of complementary diet, starting with small amounts and gradually increasing amount as the infant grows; 2 to 3 meals daily at 6 to 8 months, 3 to 4 meals each day between 9 to 11 months and at 24 months. Nutritious snacks can be given from 12 to 24 months, at least 1 to 2 times per day (WHO, 2000; WHO, 2019). Appropriate complementary diet provides energy, protein and micronutrients including iron, vitamin A, calcium, zinc and folate in adequate amounts; 200 Kcal (840 Kilojoules (KJ)) daily at 6 to 8 months, 300 Kcal (1260 KJ) each day at 9 to 11 months and 550 Kcal (2310 KJ) per day from 12 to 23 months, in addition to breast milk for breastfed infants and children (Figure 3) (WHO, 2002; WHO, 2009). Complementary foods can be categorized into foods specially prepared for infants and normal family foods with improved nutrition quality. These foods are needed to satisfy nutritional needs, such as energy, protein, iron, zinc and vitamin A intakes of the growing infant (WHO, 2002).

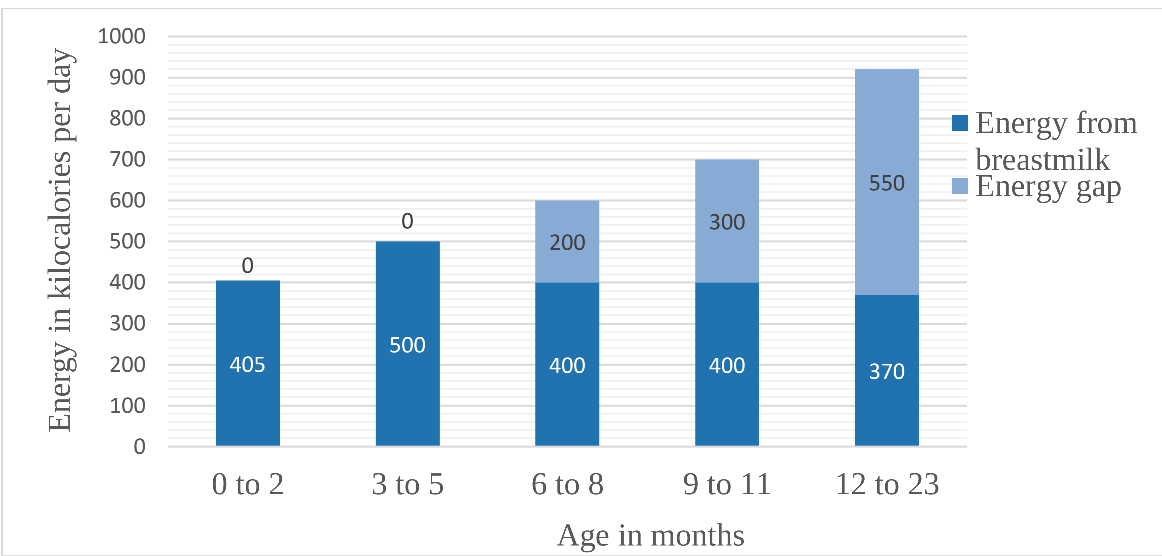

Figure 2.4: *Energy needed to fill the gap of breast milk energy from 6 to 23 months for children who are breastfed*

Energy (kcal) per day is shown on the vertical axis, while the age of infants is on the horizontal axis. Breast milk provides adequate energy requirements for up to six months. At 6 – 8 months, 200 Kcal (840 KJ) per day is required from complementary foods to meet infants' energy requirements, as well as 300 Kcal (1260 KJ) and 550 Kcal (2310 KJ) daily at 9 – 11 months and 12 – 23 months, separately. *Source:* WHO, 2009.

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Given the importance of complementary feeding period and risk associated with non-adherence to infant feeding recommendations, literature reported poor adherence to complementary feeding guidelines with infants being introduced to complementary feeds of little variety and insufficient quantities too early or too late, more especially in limited-resource settings (Sint *et al.*, 2013). Sint and co-workers (2013) also stated that HEU infants may suffer from factors that affect their intake of food or increase nutrients loss, and this makes the provision of complementary foods more challenging in HIV settings.

2.4.2 Complementary feeding at the age of six months in the HIV settings

The 2010 WHO recommendations on infant feeding for HIV-exposed infants warranty the safe, nutritious and adequate complementary feeding, however, breastfeeding should be continued for up to 12 months or halt provided complementary diet is of appropriate quality and quantity (WHO *et al.*, 2010). As mentioned in section 2.3, with ART adherence, breastfeeding can be continued up to 24 months and beyond (WHO and UNICEF, 2016). The infant formula is recommended only if the acceptable hygiene practices are met, which include safe and clean water supply. Because HIV exposure intensifies the jeopardy of developing malnutrition (Haile *et al.*, 2015), the energy-dense and high nutrient density complementary foods need be provided at least 4 to 5 times each day to satisfy the nutritional needs of the infants exposed to HIV (WHO *et al.*, 2010). Haile *et al*. (2015) pointed that complementary foods for infants exposed to HIV should ensure that infants survive freely from the HIV-infections while enhancing and maintaining the improved quality of life (Haile *et al.*, 2015). The household food insecurity has an undesirable impact on infants' health and nutritional status, more especially the HIV-exposed infants due to their proneness to malnutrition and diarrhoea (Alemu and Bezabih, 2008). Harris and co-workers (2019) indicated that the level of income and extent of urbanization, coupled with prices of food are the two key factors that determine the affordability of nutritious diets.

2.5 EVIDENCE ON THE BENEFITS OF OPTIMAL INFANT FEEDING IN THE HIV CONTEXT

According to Sanitation, Hygiene, Infant Nutrition Efficacy (SHINE) study conducted in rural areas of Zimbabwe, the evaluation of effects of IYCF showed that correct complementary feeding positively impacts linear growth and concentration of haemoglobin among HEU infants and diagnosed with anaemia and stunting (Kuhn, 2019; Prendergast *et al.*, 2019). Evidence suggests

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that correct complementary feeding alleviated stunting by 10% and anaemia by 7%, and promoted linear growth and 4.3g/L increase of haemoglobin concentration among HEU infants aged 6 to 18 months (Prendergast *et al.*, 2019). The SHINE study showed that the reduction in stunting level and anaemia cases were due to caloric and micronutrients rich infant diets (Prendergast *et al.*, 2019). Further, the SHINE study indicated that 50% of HEU infants that did not receive correct infant feeding were stunted by the age of 18 months compared to 40% of stunting in groups with improved infant feeding (Prendergast *et al.*, 2019). Proper complementary feeding enhances additive growth, improves head circumference and haemoglobin concentration (Humphrey *et al.*, 2019).

Moreover, the cross-sectional Groupe Haitien d'Etude du Sarcome de Kaposi et des Infections Opportunistes (GHESKIO) study in Urban Haiti showed that correct infant feeding intervention decreased prevalence of underweight, wasting and stunting by 67.3%, 69.7% and 54.7%, respectively, among HEU and non-breastfed infants aged 6 to 12 months (Heidkamp *et al.*, 2012). Furthermore, the observational study from Tanzania reported that optimal complementary feeding in HEU children resulted in decreased risk of growth retardation and undernutrition (Kamenju *et al.*, 2017). Besides, the prospective cohort Ditrame Plus study conducted in Cote d'Ivoire Abidjan indicated that correct infant feeding at six months of age promoted improved linear growth and averted stunting rate among HIV-exposed children (Becquet *et al.*, 2006). The study from Tanzania and Ditrame Plus study used infant and child feeding index (ICFI) and child feeding index (CFI) aided by 24-hour dietary recall and food frequencies respectively, to assess the nutrition adequacy of the complementary feeding and its impact on the nutritional status of HIV-exposed infants (Becquet *et al.*, 2006; Kamenju *et al.*, 2017). There is scarce literature available on the evidence of optimum infant feeding practices in the HIV environment in South Africa.

2.6 COMPLEMENTARY FOODS WORLDWIDE AND NATIONWIDE

According to WHO (2002), suitable complementary foods include enough amounts of protein-rich foods; poultry, meat, fish and eggs; vegetables and fruits rich in vitamin A and fortified foodstuffs for infants. Abeshu and co-workers (2016) pointed out that due to cost implications, low-income households are regularly unable to purchase commercially fortified infant foods. Therefore, normal family foods are commonly used as complementary foods (Abeshu *et al.*, 2016). Nonetheless, a finding in Ethiopia reported that unfortified homemade plant-based complementary diets are low

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in vital micronutrients such as iron, calcium, and zinc (Abeshu *et al.*, 2016). The complementary foods mostly consumed in South Africa include maize meal porridge, infant cereals (Swanepoel *et al.*, 2019), commercially jarred baby foods, porridge other than maize meal, rice, butternut, potatoes (Faber *et al.*, 2016; Ntila *et al.*, 2017). Literature also reported high consumption of snacks that high in salt such as niknaks and chips at a young age (Faber *et al.*, 2016). South African children have low micronutrient intake, especially for those living in rural areas (Swanepoel *et al.*, 2019). Faber and co-workers reported inadequate amounts of zinc, calcium and iron in a complementary diet of South African infants and toddlers (Faber *et al.*, 2016). Du Plessis *et al.* (2013) pointed out that low micronutrient intake in South Africa is due to increased intake of low nutrient density foods such as cool drink, tea and salty, fatty and sugary snacks. Besides their low nutritional value, these food items may be costly (Du Plessis *et al.*, 2013). The insufficient consumption of fruits, vegetables, animal and dairy products among 6 to 24 months old children was also reported in South Africa (Faber *et al.*, 2016). Additionally, complementary diets of low quality may lead to massive stunting rates and undernutrition in South Africa (Du Plessis *et al.*, 2013).

The increased consumption of high-calorie and low nutrient-dense foods high in fats, sugar and salt is a growing concern that occurs as a result of urbanization, globalization, mass media growth and increased production of ultra-processed foods (Harris *et al.*, 2019; Mbogori and Mucherah, 2019). These shifts in dietary patterns were first described as "nutrition transition" by Popkin in 1994 (Mbogori and Mucherah, 2019; Popkin, 1994). The nutrition transition is an increasing concern globally, particularly in low- and middle-income nations like South Africa (Mbogori and Mucherah, 2019). According to Harris *et al.* (2019), the national food price data confirmed that nutrient-dense foods are costlier compared to staple foods. The literature revealed that expenditure on processed foods, animal source foods, fruits, vegetables, sugars and fats is higher while costs of staple foods have declined in previous decades (Harris *et al.*, 2019). Also, ultra-processed foods snacks are less costly, and therefore it may be relatively cheaper to change toward diets built on foods that are highly processed rather than fresh foods (Harris *et al.*, 2019).

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2.7 IMPORTANCE OF DIET COST FOR OPTIMAL NUTRITION FOR INFANTS GROWING UP IN HIV SETTINGS

As mentioned above, the diet has a direct impact on the immune system and overall quality of life (Sztam *et al.*, 2010). The quality and quantity of a diet influence infant health, growth and survival. Food prices immensely influence the dietary quality, and consequently affect infant nutritional status, more especially in the situation of HIV (Sztam *et al.*, 2010). The principal cause of nutrient deficiencies is low-quality diets distinguished by increased consumption of food staples and low animal proteins, fruits and vegetable intake (Bouis *et al.*, 2011). High-calorie diets with low nutrient density are connected with low diet costs (Andrieu *et al.*, 2006; Darmon *et al.*, 2004; Kern, 2016). The selection of food is highly influenced by food prices (Andrieu *et al.*, 2006). The relationship exists between diet cost and quality of diet; more nutrients dense foods are connected with high diet costs, and positive health outcomes including linear growth particularly in settings with increased HIV prevalence (Rehm *et al.*, 2011; Rehm *et al.*, 2015). Andrieu *et al.* (2006) pointed that, "fruits, vegetables, meat and fish contribute more to diet cost than to dietary energy, whereas grain, fats and sweets contribute more to dietary energy than to diet cost". The higher the cost of energy, the lesser the total fat and increased quantities of dietary fibre, protein and vegetables, and the vice-versa (Appelhans *et al.*, 2012).

Generally, diet costs may aid in determining affordable foods, which are low in energy contents but high in nutrient density (Andrieu *et al.*, 2006). Healthier diet cost promote optimal health and growth of infants exposed to HIV and living in poor resource settings (Andrieu *et al.*, 2006). Darmon *et al.* (2006) suggested that a healthier diet cost include liver, milk, beans, peas, cabbage, carrots and canned fish. Diet cost can help to meet nutrient adequacy at a reasonable price if initiatives to change eating habits or behaviour are taken into consideration (Andrieu *et al.*, 2006; Darmon *et al.*, 2006).

Recently, several indicators showing the cost of nutritious diets have been developed in order to indicate the cost of foods needed to meet nutritional goals. These indicators can be used to raise awareness and advocacy about a nutritious diet. Some indicators include Optifood, Cost of Diet tool, Fill the Nutrient Gap, and some metrics include Cost of Nutrient Adequacy, Cost of Recommended Diet and the Cost of a Diverse Diet (Cost of Nutritious Diets Consortium, 2018). It was found that these tools can be used to enhance infant and young child feeding programmes both at sub nation and nationwide (Untoro *et al.*, 2017). In line with this study, literature will focus

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more on the Cost of the Diet (CotD) tool, which was developed upon the realization of economic barriers affecting food access as well as the intake of nutritious and balanced diets (Cost of Nutritious Diets Consortium, 2018). The CotD is defined as "a method and software developed by Save the Children to estimates the amount and combination of local foods that are needed to provide individuals or a family with foods that meet their average needs for energy and their recommended intakes of protein, fat and micronutrients" (Save the Children, 2017; Untoro *et al.*, 2017). The indicator uses current market food prices to enable estimation of the cost of sufficing energy and nutrients recommendations (Untoro *et al.*, 2017). The food price data employed consist of different food groups, with food prices collected from local markets at the time and place of sale (Cost of Nutritious Diets Consortium, 2018).

Input requirements involved in CotD tool comprise; (1) food list consisting of local foodstuff; (2) prices per 100 grams collected from local markets; (3) information on income and expenditure to estimate affordability of nutritious diets; and (4) normal individual or household dietary habits (Untoro *et al.*, 2017). The tool results cover estimation of lowest cost and quantity of standard diets per day, week and year. These include energy-dense diet, macronutrient rich diet, nutritious and food habit nutritious diets. CotD enables calculation of diet for target population such as infant and young children, and identify individuals that can access local foods needed to meet their energy, protein, fats and micronutrients recommendations (Cost of Nutritious Diets Consortium, 2018; Save the Children, 2017; Untoro *et al.*, 2017). The ways to increase access to nutrients can be identified through CotD (Untoro *et al.*, 2017).

2.8 THE NUTRIENT COSTS OF SIX MONTHS OLD INFANTS GLOBALLY AND IN SOUTH AFRICA

Globally, nutrition adequacy during complementary feeding continues to be a health priority (Dewey, 2013). The challenges of sustaining nutrient requirements of infants and young children have been of decades, and this includes inadequate dietary quality. Certain vegetables can provide various necessary nutrients, including fibre, potassium, and vitamin C at a low cost (Drewnowski, 2013; Drewnowski and Rehm, 2013). With the combined use of national food prices data and nutrient profiling methods, researchers have identified vegetables and legumes that offer better nutritional value with less money. These include dark green vegetables, beans, peas, lentils, carrots, white and sweet potatoes (Drewnowski and Rehm, 2013). In terms of nutrient costs per

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100g of individual, fibre and potassium cost 0.19 USD and 0.14 USD for potatoes and 0.05 USD and 0.10 USD for beans respectively, the cost for vitamin C were 0.10 USD for potatoes and 0.12 USD for dark-green vegetables. Dark green vegetables had the lowermost cost for vitamin K and A (Drewnowski and Rehm, 2013). Incorporating these foods in children's diets can improve dietary diversity and nutrient density of complementary diets with lesser costs, and ultimately children's nutrient intake. Literature has stressed the importance of canned over fresh foodstuffs such as fish, beans, fruits and vegetables in providing numerous nutrients at a lesser cost (Kapica and Weiss, 2012). The cost (in USD) per nutrient (total cost for each edible portion over the nutrient quantity present in that portion) of canned over fresh foods is illustrated in Table 2.2 below. Canned beans, fish, spinach and peaches have the lower cost per gram of nutrient comparative to when fresh or dried. In addition, canned foodstuffs require less energy (per cost) and time for preparation. Therefore, opting for canned foodstuffs will also improve the dietary variety of complementary diets and ensure adequate nutrients intake of infants at an affordable price.

Table 2.2: Comparison of cost (USD) of nutrient of canned vs fresh or dried food stuffs

Food	cost/ edible portion	cost/g protein	cost/g fibre	cost/mg potassium	cost/IU vitamin A	cost/mg vitamin C	cost/mcg folate
Beans							
Canned	1.08	0.09	0.12	0.00	-	-	0.03
Dried	18.05	1.29	1.29	0.03	-	-	0.07
Fish							
Canned	0.44	0.01	-	-	0.02	-	0.15
Fresh	1.68	0.19	-	-	0.08	-	1.68
Spinach							
Canned	1.45	-	0.36	0.00	0.00	0.06	0.01
Fresh	2.21	-	0.55	0.00	0.00	0.13	0.01
Peaches							
Canned	0.60	-	0.72	0.00	0.00	0.14	0.05
Fresh	2.97	-	0.99	0.01	0.00	0.21	0.37

Source: Kapica *et al.* (2012).

On the other hand, centrally processed fortified foods play a crucial role in ensuring adequate nutrient intake of complementary feeds (WHO, 2002). Nevertheless, literature has reported that due to the cost of fortified infant food products (Faber *et al.*, 2016), South African mothers dilute

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infant fortified cereals and this results in the consumption of deficit quantities (Faber *et al.*, 2016; Oelofse *et al.*, 2002) with insufficient nutrient intake.

2.9 CONCLUSION

The maternal HIV infection negatively impacts income generation and infant care and the feeding practices, resulting in poor infant nutrition and ultimately undernutrition. Malnutrition remains a health risk among six-months-old infants residing in HIV settings, both globally and South Africa. The benefits of breastfeeding are boundless, even for infants born to HIV-infected mothers, yet the rates are low globally and in South Africa. Optimal infant feeding ensures holistic growth and development of infants. The cost of diet and nutrient intake enables the identification of less costly nutrient-dense food by relating the price of food item with the nutrients within the food item, and this is more useful in low resource settings with inadequate nutrient intake. There is limited literature in South Africa for the cost of diet, including cost per nutrient, both in HIV-exposed and -unexposed settings.

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CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

The chapter covers the detailed description of the study settings, population and discussion on study design, sample size, ethical considerations, training of fieldworkers and methods for data collection. The data analysis methods and data management are also outlined in this chapter.

3.2 STUDY SETTINGS AND POPULATION

The study forms part of the Siyakhula study conducted in Kalafong Provincial Tertiary Hospital, South-West Tshwane, Gauteng Province, led by a study team from the University of Pretoria. The overall aim of the Siyakhula study is to assess factors affecting foetal and infant immunity, growth and neurodevelopment in HIV and antiretroviral-exposed uninfected children. Kalafong Hospital is a public tertiary health centre affiliated with the University of Pretoria, Faculty of Health Sciences. The hospital serves approximately two million people and offers a range of health care services including maternity, mother and child and HIV care and health support services. The focused population for this study was six months old HEU and HUU infants in South-West Tshwane.

3.3 STUDY DESIGN

The study utilised a cross-sectional descriptive domain to explore the breastfeeding practices, and the cost of the diet and nutrient intake of six months old infants residing in an HIV exposed and unexposed environment. Data collection for six months old infants begun in October 2018 for the Siyakhula study and continues, while for this sub-study, data was continuously collected from January 2019 to May 2020. However, this study used all the available data collected at the six-month visit. The food cost questionnaire was introduced to the study in May 2019.

3.4 SAMPLE SIZE AND SAMPLE SIZE DETERMINATION

The Siyakhula study recruits low-risk pregnant HIV-infected and HIV-uninfected women in the Tshwane District. The study longitudinally follows up their HEU and HUU children for two years. In May 2020, about 236 of recruited eligible participants had six months old infants. Of these, 135 mother-infant pairs either did not complete the questionnaires (n = 11) or dropped out of the study (n = 123). An infant who tested positive were excluded (n = 1). Mother-infant-pairs (n=101) with complete infant feeding practices and dietary data were studied (HEU (n=46); HUU (n=55)). However, only infants with breast milk substitutes and food items intake were considered for the

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cost of feeding analysis; HEU (n = 39) and HUU (n = 55) (Figure 3.1). The food cost questionnaire was administered to only 23 participants in the HEU group and 27 participants in HUU group.

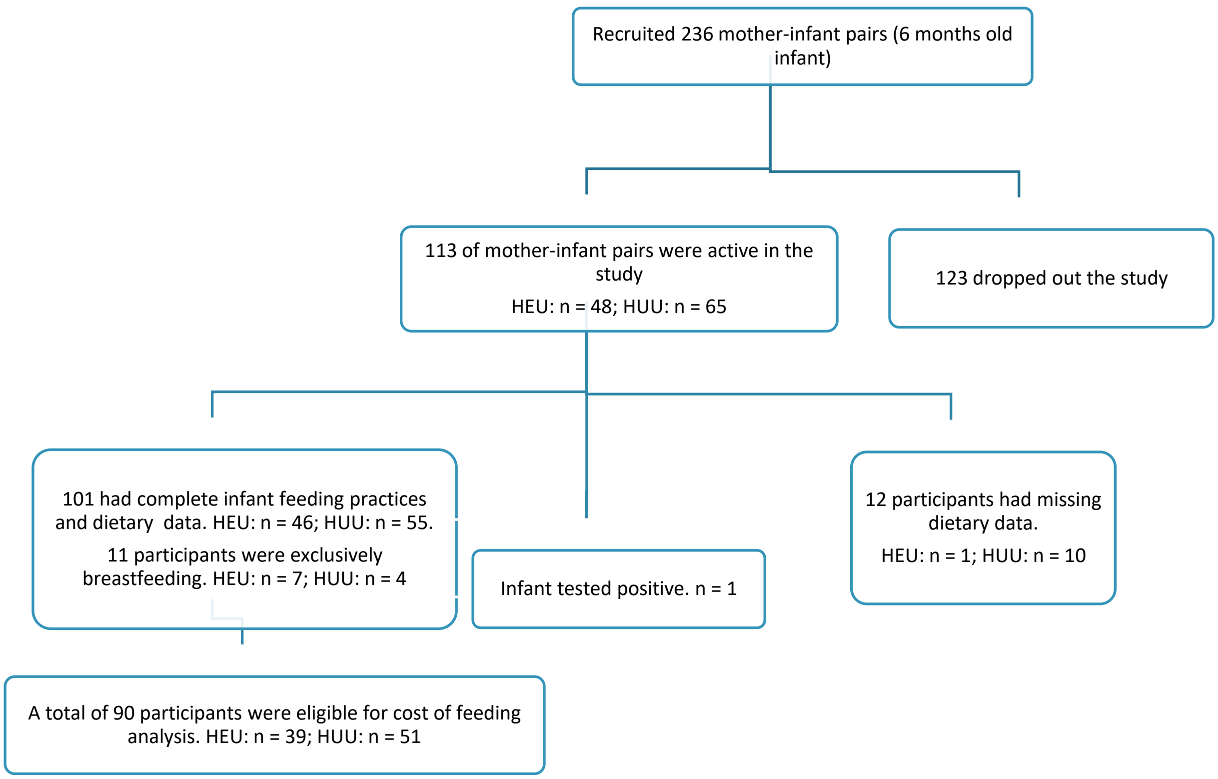

Figure 3.1: *Participants flow diagram*

3.5 VARIABLES

<u>Categorical independent variables</u>: *In utero* HIV exposure.

<u>Dependent variables:</u> 1) Infant feeding practices; Exclusive breastfeeding, Early initiation of breastfeeding, Formula/replacement and Mixed feeding

2) Cost of feeding; cost per nutrient intake and cost of diet

3.6 DATA COLLECTION METHOD

The estimation of diet cost utilised supermarket food prices and diet diaries method. According to Monsivais *et al*. (2013), supermarket food prices and diet diaries method involves matching food items coded in 24-hour recall with foods in the supermarket food prices list. The supermarket food prices list comprises food items that are not on special offer and are of lowest prices from three

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supermarkets (Monsivais *et al.*, 2013). The lowest prices of food items were collected in February 2019 from three local supermarkets (three prices for each food item) (Appendix A), chosen because of their vast market share in Pretoria and most of the mothers were doing their shopping there, as they are closer to their homes. The food prices were then converted to a price per 100g of raw food. To estimate the cost of diet, complementary foods mostly given to infants in the Tshwane community were coded in 24-hour dietary recall structured questionnaires and then matched with food prices on the supermarket prices list. A one-day diet cost was computed. After that, the findings were compared between the two groups.

The infant feeding practices from 0 – 6 months of age were recorded in a standardised questionnaire that was previously used and compared the findings among the groups.

<u>For the determination of the cost of diet</u>

For food intake - A single 24-hour dietary recall structured questionnaire, based on previous studies (Smuts *et al.*, 2005), was utilized. Prices of food items mostly consumed by infants were collected from three local supermarkets in the region, during store visits. For estimating and recording the reported amount of food eaten, the standardized dietary kit that contains samples of food and food containers, family unit utensils, and photographs was utilized. Furthermore, dry oats were used in dish-up and measure, for estimating and recording the quantity eaten, mostly for prepared food. The portion of leftovers was also noted and factored in the determination of the estimated actual consumption. Lastly, the breast milk substitutes, and infant cereals were noted per dry quantity and liquid while maize meal and sorghum porridge were recorded as soft or crumbly (Swanepoel *et al*., 2018) (Appendix B, section C).

<u>For the determination of household food access: Food Cost Questionnaire</u> – (Appendix B, section B – part 2).

For describing the household socio-economic status and characteristics associated with food insecurity, the structured food cost questionnaire was developed. The development of the questionnaire was aligned with the Household Food Insecurity Access Scale (HFIAS) and Children Food Insecurity Access Scale (CFIAS). Inadequate quality and quantity food, worry and uncertainty about the supply of food are domains measured in HFIAS (Ntila *et al.*, 2017). However, for the present study, the questionnaire was focusing on household food access. Questions entailed seeking information on household income and source, whether the household

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was having salary or relied on grants, grocery shopping including shops where grocery was done and reasons behind the choice of the shop. Questions on household expenditure on milk feed for the infants were also included. Fieldworkers were well trained about this questionnaire. Both the researcher and fieldworkers interviewed caregivers.

Also, structured socio-demographic questions were used to describe the background (Appendix B, section B – part 1).

For infant feeding practices: breastfeeding data was gathered using a structured questionnaire; comprised of breastfeeding practices based on adapted WHO questionnaires (WHO, 2010) (Appendix B, Section A).

Mother-infant pairs were interviewed when the baby was six months old by trained fieldworkers in English or their local language. Trained field workers were given a detailed manual for administering a 24-hour dietary recall. The 24-hour recall method is most used in dietary surveys. This method has been validated and adapted for use with mothers in low-and-middle-income countries to report their own and their child's intake (Arsenault *et al.*, 2020). A systematic review on validity of methods of dietary assessment for accurate measurement of energy intake in children and adolescents showed that a 24-hour recall interview is the most accurate methods at the group level for children, where the parents are the reporters (Walker *et al.*, 2018).

3.7 DATA MANAGEMENT

Trained fieldworkers collected data. The data collected was entered into a REDCap database. The researcher performed data quality checks and cleaning. Obvious mistakes were corrected through consultations with the fieldworkers. In some cases where the flavour of food, fruit eaten or type of soft porridge drank were not specified, the commonly consumed food flavour (for instance, banana flavour), fruit (for instance, banana) or soft porridge (for instance, soft maize meal porridge) were used. Excel spreadsheet was used for capturing data. The coding of questionnaires and quantitative data was used.

3.8 DATA ANALYSIS

Any reported household food intake measurements were converted to weight in grams using SAMRC Food Quantities Manual (SAFOODS, 2018). The SAMRC FoodFinder™ program was used for the analysis of the food intake of groups of individuals; to quantify macro- and micro-

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nutrient intake. The FoodFinder™ program is updated with fortification amounts. The dietary intake included food, beverages and breast milk substitutes consumed by infants. For this study, the definition of the complementary diet involved all foods, breast milk substitutes and beverages consumed, excluding breast milk. Therefore, the nutrient density of macronutrients; carbohydrate, protein and fat, and micronutrients; total iron, calcium, zinc, vitamin C and vitamin B_{12}, of each food item consumed by each infant was determined and recorded on excel sheet. The average amounts of each nutrient from combined complementary diets were calculated for all infants and infants in their respective HEU and HUU groups and were considered as the total daily nutrient intake for all and per HEU and HUU infant, respectively. All the collected food prices were converted to a price per 100g of raw food using excel convert function, and the average of three prices for each food item was calculated. To calculate the mean cost of diet, the average prices of all food items consumed by all infants, and infants in their respective HEU and HUU groups was calculated and regarded as total mean daily diet cost and mean daily cost per HEU and HUU infant, respectively. For cost per nutrient intake determination, calculations considered the total amount (of the appropriate unit) per nutrient and the cost per 100g for each food item and calculating the amount across the different food items per infant. Further, the nutrient intakes and costs were compared between HEU and HUU groups. The study used SPSS statistics software version 25 and R software version 3.6.3 and performed analysis through descriptive statistics. The results and analysis of the quantitative findings of the study are presented (Chapter 4). Shapiro Wilk test was employed for testing for normality. The null hypothesis set out that the data is distributed normally. If the *P*-values are below 0.05, the null hypothesis can be rejected inferring that information is not normally distributed. For the present study, the hypothesis of normality was rejected, and a non-parametric Mann Whitney U test was employed to test for significant differences. Besides, the *P*-values tested on a 5% level of significance using Pearson's Chi-squared test were also calculated in analysis of the socio-demographic data, feeding practices and nutrient intake adequacy (EAR, AI and EER), to determine the statistically significant differences among the HEU and HUU groups. The null hypothesis states that there is no difference between the two groups. The null hypothesis can be rejected if the *P*-values are sufficiently small (less than 0.05). $P < 0.05$ indicates that evidence of a relationship or significant difference between groups exists. The findings yielding a *P*-value of 0.05 are on the borderline of statistical significance. Results are statistically

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significant or highly significant if *P*-value is below 0.01 and 0.005, respectively. Mann Whitney U test was used for continuous variables while Chi-squared test for categorical investigations.

Infants who were still exclusively breastfed (11%) were excluded from the cost of diet analysis because the cost cannot be calculated, and it is the primary outcome of the thesis (section 4.5). Food cost questionnaire was implemented in the middle of the study, therefore for food purchasing practices and few questions on socio-demographic data: n = 23 (HEU) and n = 27 (HUU) (section 4.2). Socio-economic information (income per month) of 7% of caregivers of HEU infants was missing (section 4.2.4); their partners did not disclose their income. Both groups were receiving child support grants except for the 4% of HUU households who did not know kind of grants they were receiving (section 4.2.5). About 13% of HEU and 11% of HUU infant's EIBF data was missing (4.3.2) because mothers could not recall how long after birth was the baby put on breast. For the following missing data: rates of breastfeeding (7% of HEU and 6% of HUU) (section 4.3.3), duration of breastfeeding (15% HEU and 7% HUU infants) (section 4.3.4) and infant feeding (6% of HUU and 9% of HEU) (section 4.3.5), the researcher could not identify valid reasons. For section 4.5.4, the goal was to investigate whether data captured was within bounds or any of the results which seemed odd (too low or too high).

Additionally, the study explored nutrient densities and their cost of mostly consumed food items and were compared as follows; commercial infant cereals vs maize meal and sorghum porridge, and bottled baby foods vs fresh fruit and vegetables. The aim was to identify the most nutrient-dense food item and its cost per nutrient in each comparison category. The data has been reviewed for outliers, and the results displayed were confirmed to be correct values. Outliers for all nutrients were above the largest sample value and were not deleted.

3.9 ETHICAL CONSIDERATION

This study was approved by the University of Pretoria Faculty of Natural and Agricultural Sciences Research Ethics Committee and Faculty of Health Sciences Research Ethics Committee with the reference number NAS164/2019. The Siyakhula study reference number is 294/2017. The process of data collection was voluntary and confidential. Only researchers had access to the information. Minors (younger than 18 years) did not form part of the inclusion criteria of the Siyakhula study. The permissions to conduct the study in the hospital and Tshwane area were granted by Kalafong Hospital and Tshwane District Health Department.

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3.9.1 Risks associated

No risks were associated with completing the questionnaires. Participants were ensured that their information would be treated as confidential, and the identification number allocated upon recruitment will be used not names. Participants were allowed to stop answering questions and participating in the study whenever they wished to.

3.9.2 Benefits to participants

Children received additional screening for growth and development. Anaemia was also being diagnosed, and any problems with development early and children were treated. Children also got all the required immunizations, which means that they were not going to the clinic as well. Dietary counselling was provided for mothers if needed. Mothers/caregivers were reimbursed with transport money (R100) to come to the centre, and a light snack and tea were provided on the station.

3.9.3 Benefits associated with the research project

Data generated will be presented at National and International Conferences. Valuable data will be generated in terms of feeding practices, nutrient intake and the cost of the diet in relation to nutrient intake. Data generated will identify nutritional shortcomings in terms of nutrient intake and will also be used as a guideline for nutrition education for mothers in order to inform them what the most nourishing, cost-effective meal for their child is.

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CHAPTER 4: STUDY RESULTS

4.1 INTRODUCTION

Mother-infant pairs (n =101) were interviewed in the present study and grouped into HEU (n = 46) and HUU (n = 55). The results comprise the socio-demographic and food cost information of the caregivers to understand the infant's background fully. The following findings formed the major part of this study; complementary foods introduced to these infants, including milk feeds, and the mean cost of diet and nutrients intake per infants per day, and to lesser extend breastfeeding practices from birth up to six-month of age. The data for exclusively breastfed infants and the nutritional value of breast milk for those that were still receiving breast milk were excluded. The study focused on infants' total protein, total fat, total carbohydrate, total iron, calcium, zinc, vitamin B_{12} and vitamin C intake. These nutrients are vital for proper growth and development.

4.2 THE SOCIO-DEMOGRAPHIC AND FOOD PURCHASING INFORMATION

4.2.1 Introduction

This section entails descriptive statistical results socio-demographic information of infants and their caregivers. The results presented include the socio-economic status and food purchasing practices of caregivers of HEU and HUU infants (Table 4.1). The frequencies and percentages, including *p*-value, are presented in Table 4.1. The results are interpreted in detail in sections to follow.

Table 4.1: The socio-demographic characteristics and food purchasing practices of caregivers

Variables	HEU (n = 46)	HUU (n = 55)	*P*-value
Age of infants (months. days)			0.53
Mean (SD)	6.5 ± 1	6.6 ±1	
Median (IQR)	6.3 (6.1,6.6)	6.4 (6.1, 6.9)	
Sex of infants (%)			0.10
Male	65.2	49.1	
Female	34.8	50.9	
The educational level of the mother (%)			**0.04**
No educational qualifications	52.2	29.1	
NSC/Matric/Grade 12	28.3	40.0	
Certificate/Diploma	19.6	21.8	
Undergraduate degree	0.0	9.1	
Number of children in the household (%)[a]			0.80
One to two children	66.7	62.9	
Three to five children	33.3	37.0	

[a] For number of children in the household: n = 23 (HEU) and n = 27 (HUU)

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Variables	HEU (n = 23)	HUU (n = 27)	*P*-value[a]
Household income per month (%)[b]			**<0.002**
R0 – R4000	69.8	36.4	
R4000 – R8000	25.6	38.2	
More than R8000	4.7	25.5	
Income from the primary source (%)			**0.03**
R0 – R4000	77.3	40.7	
R4000 – R8000	18.2	40.7	
More than R8000	4.5	18.5	
Number of people in the household earning income (%)			**0.05**
One	52.2	55.6	
Two	13.0	29.6	
More than two	4.3	11.1	
None	30.4	3.7	
Households receiving social grants (%)			0.07
Yes	75.6	89.8	
No	24.4	10.2	
Type of social grants (%)			0.21
Child support grants	100	95.5	
Others/ unknown	0	4.5	
Number of children receiving grants (%)			0.80
One to two children	75.7	70.2	
Three or more children	24.3	29.7	
Buy in bulk or daily (%)			0.31
Bulk	78.3	88.9	
Daily	21.7	11.1	
Buy only when the food is on special (%)			0.56
Yes	26.1	18.5	
No	17.4	29.6	
Sometimes	56.5	51.9	
Buy food from (%)			0.64
Local producer (on-street)	4.3	7.4	
Big hypermarkets	8.7	14.8	
Local shops	87.0	74.1	
Other	0	3.7	
Reason for the choice of the shop (%)			0.12
Distance from home	47.8	22.2	
Prices	30.4	55.6	
Quality	21.7	22.2	
Quality of fruits and vegetables sold on streets (%)			0.89
Fresh most of the times	34.8	25.9	
Sometimes	56.6	63.0	
Never	4.3	7.4	
Other	4.3	3.7	

[a] The Pearson's Chi-squared was used to determine differences. P < 0.05 indicates significant differences and is formatted in bold type.
[b] For household income per month: n = 46 (HEU) and n = 55 (HUU)

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4.2.2 Sex distribution of infants

More boys were observed in HEU group (65% vs 49%) while the HUU group had a large number of girls (51% vs 35%). Comparison of the proportions of males and female in each group showed that no significant difference exists between the HEU and HUU groups (p-value = 0.10).

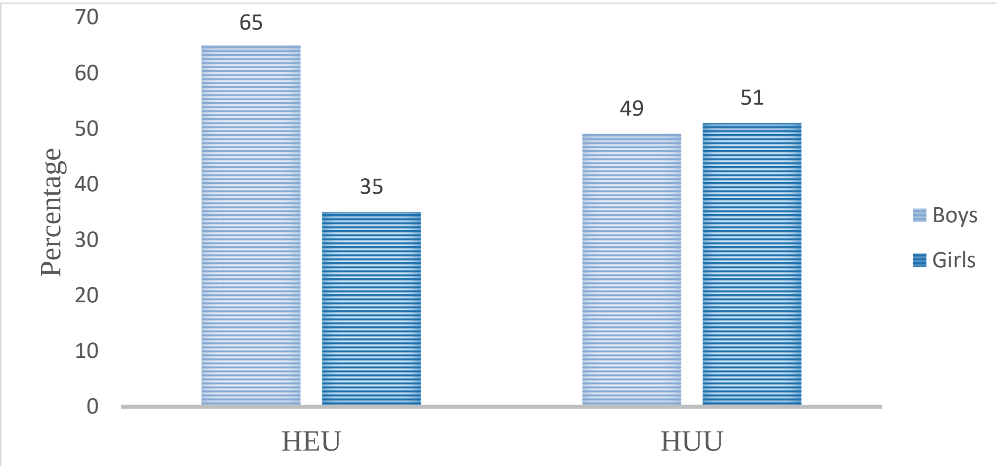

Figure 4.1: *Sex distribution between HEU and HUU infants (n = 101)*

4.2.3 The highest educational level attained by the caregivers

More than fifty percent of the caregivers of HEU infants had no educational qualifications, dropped school at primary and high school level (52% vs 29%). About 40% of HUU and 28% of HEU caregivers had achieved National Senior Certificate (NSC) or matric. There was a significant difference between caregivers of HEU and caregivers of HUU infants (p = 0.04).

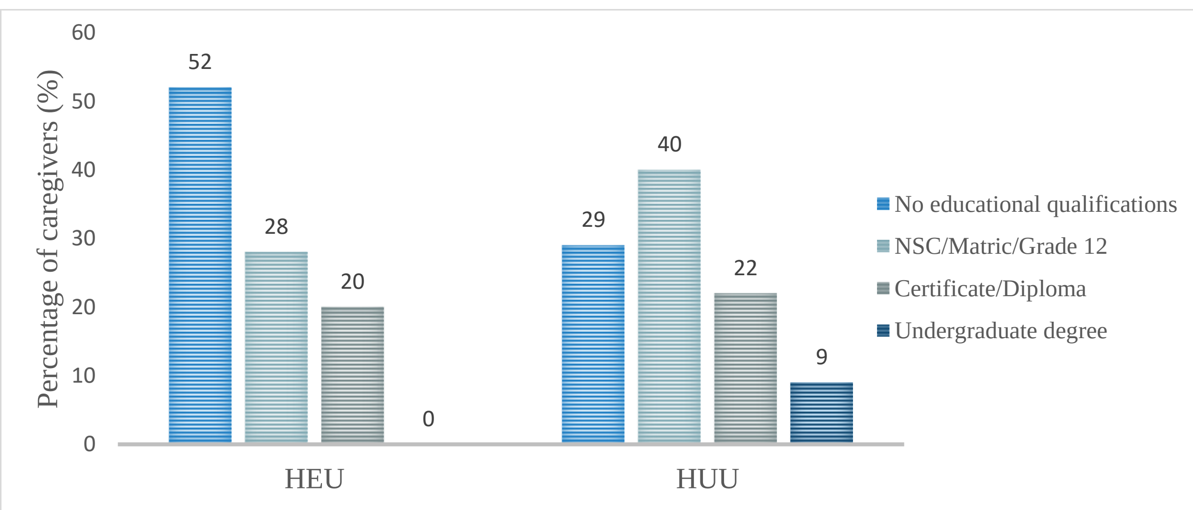

Figure 4.2: *The caregiver's highest education level attained amongst caregivers of HEU and HUU groups (n = 101).*

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4.2.4 The caregivers' household socio-economic information

The household income reported included income from grants. A higher percentage of the caregivers of HEU infants had the lowest income per month, ranging from R0 – R4000 (70% vs 36%). A larger portion of the caregivers of HUU infants had the highest monthly income of more than R8000 (26% vs 5%). The interpretation is that the mean income was between R0 – R4000 for HEU group and R4000 – R8000 for HUU group. There was a significant difference between HIV-infected and HIV-uninfected caregivers in terms of monthly income ($p < 0.01$). Caregivers living with HIV had a lower overall income.

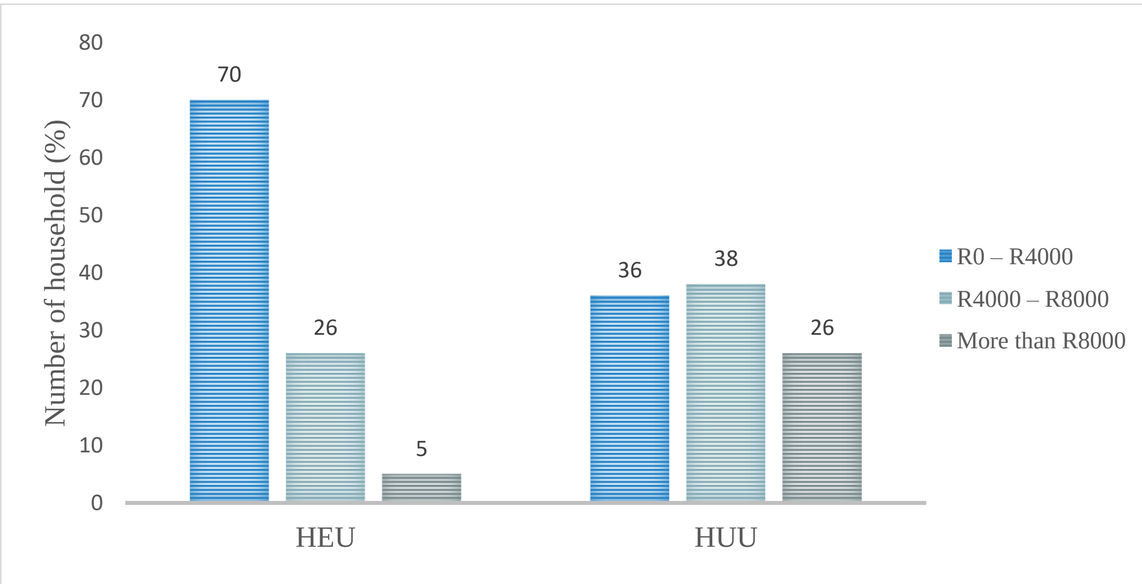

Figure 4.3: *The overall household's monthly income, including social grants, were studied and compared between the caregivers of HEU and HUU infants*

The monthly household income from the prime source, for instance; salary, was investigated (Figure 4.4). Income from any sort of social grants was excluded. A higher number of HEU households (77%) had the lowest income from the primary source, compared to HUU households (41%). Comparatively, more of HUU households (41% vs 18%) had the middle-income range, and the more significant proportion was earning more than R8000 (19% vs 5%). A considerable difference exists between the HEU and HUU infants at a level of $p = 0.03$.

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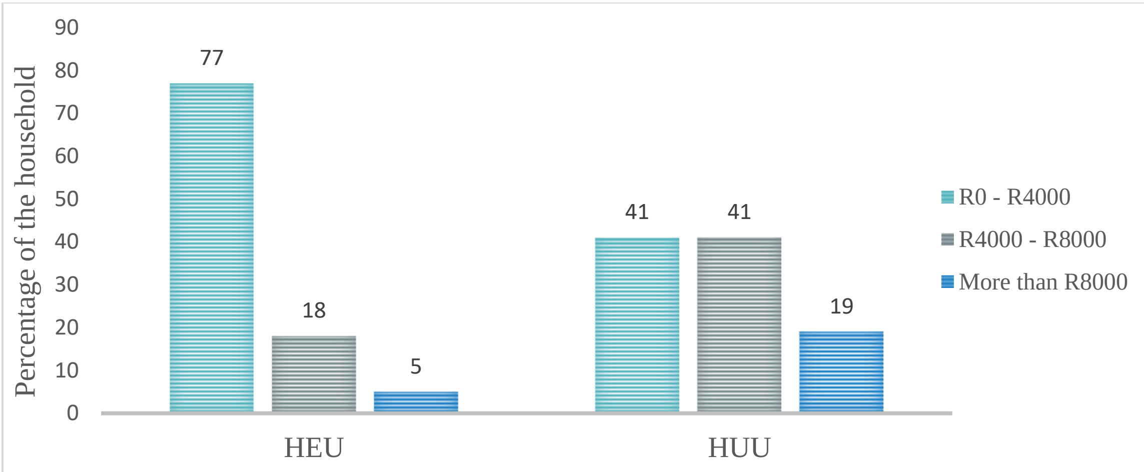

Figure 4.4: *The monthly household income from the primary source was investigated and compared between HEU and HUU groups*

Many HEU households did not have a monthly salary (30% vs 4% for HUU households). More than fifty percent of both HUU and HEU households had had one person's earning salary per month (56% vs 52%). The statistical significance differs at a level of p = 0.05, between the HEU and HUU group.

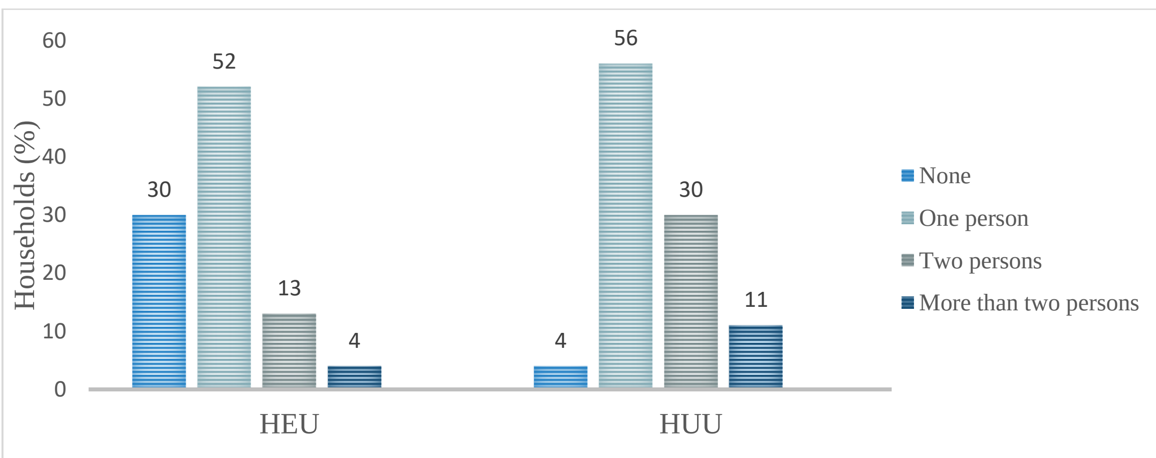

Figure 4.5: *The number of persons earning a monthly income in both HEU and HUU households was also investigated and compared between the groups*

4.2.5 The household information on social grants

The household information pertaining the social grants, kind of social grant received, as well as the number of children per household who were receiving the social funding, is reported (Table 4.1). A large proportion of both HEU and HUU households (76% vs 70%) were receiving social grants (90% vs 76%), the difference was nonsignificant (p = 0.07). Majority of HEU and HUU

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households were receiving grants for one to two children (24% vs 30%), while a few of these households were receiving grants for three or more children. No statistical differences between the groups, *p*-value = 0.80.

4.2.6 The food purchasing practices of the mothers or caregivers

This section describes the findings of food purchasing practices of mothers or caregivers. Information on grocery purchasing method, grocery shops used, as well as the reason for the choice of the shop, are included in this section. The perception of caregivers on the quality of fruits and vegetables sold on-street formed part of this section.

A relatively high proportion of caregivers of HEU and HUU infants were buying food in bulk (89% vs 78%). A double the percentage of caregivers of HEU infants (22% vs 11%) were purchasing food on a daily basis, no significant difference between the groups ($p = 0.31$). A lesser percentage of the caregivers of both infants were buying food only when on special. More than half of caregivers of HEU (57%) and HUU infants (52%) sometimes purchased food only when on special. Majority of caregivers were buying from local stores (87% HEU and 74% HUU). Nearly half of the caregivers of HEU infants (48%) chose shopping stores due to distance from their homes, and below a quarter were due to quality (22%). More than half of HUU caregivers chose a store because of food prices (56% vs 30%). More than half of caregivers perceived that fruits and vegetables sold on-street were sometimes fresh, while a few perceived that fruits and vegetables sold on-street were fresh most of the time. There are no significant differences ($p > 0.05$) in terms of food purchasing practices between HEU and HUU groups.

4.3 INFANT FEEDING PRACTICES

4.3.1 Introduction

The present section reports breastfeeding practices of infants from birth up to six months old and compare between HEU and HUU infants. The objective was to determine and compare infants breastfeeding practices from 0 – 6 months of age in the study community. These involve feeding practices from birth up to the current period of six months, the age of the baby when the caregiver stopped breastfeeding or introduced breast milk substitutes, as well as the reasons behind these decisions. These findings are presented in Table 4.2 below, and results are interpreted in sections following Table 4.2.

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Table 4.2: The breastfeeding practices of HEU and HUU infants from 0 – 6 months of age[a]

Variables [b]	HEU (n = 46)	HUU (n = 55)	*P*-value
Early initiation of breastfeeding (%)			0.96
Within an hour after delivery	75.0	75.5	
After an hour following delivery	25.0	24.5	
Ever breastfed the baby (%)			0.11
Yes	90.7	98.1	
No	9.3	1.9	
Reason for "No" (%)			**0.03**
Maternal health; high HIV viral load	100	0	
Insufficient breastmilk	0	100	
Currently breastfeeding (at six-months) (%)			0.37
Yes	61.5	70.6	
No	38.5	29.4	
Infants age when stopping breastfeeding (%)			0.39
0 months	26.7	11.8	
1 – 2 months	33.3	23.5	
3 months	20.0	47.1	
4 – 5 months	13.3	17.6	
6 months	6.7	0	
Infants age when introducing breast milk substitutes (%)			0.49
0 months	25.0	8.8	
1 – 2 months	31.3	23.5	
3 months	25.0	35.3	
4 – 5 months	12.5	23.5	
6 months	6.3	8.8	
Reasons for introducing breast milk substitutes (%)			0.38
Breastfeeding took too long / too tiring	6.3	0	
Needed to return to work	25.0	36.4	
Insufficient milk to satisfy the baby	25.0	18.2	
Convenience or to allow others to feed	0	6.1	
A baby wouldn't suck / for no apparent reason	0	6.1	
Painful breasts or sore nipples	18.8	6.1	
Job searching and schooling reasons	25.0	27.3	
Infant feeding practices during the first six months (%)			**0.02**
Breast milk only directly from the breast	30.4	14.5	
Breast milk only with some feeding directly from the breast and some from expressed milk	15.2	16.4	
Breast milk (from breast/expressed and **donor** breast milk) but no formula	0	1.8	
Breast milk and formula feeding (formula before current age and direct/expressed and donor milk)	2.2	1.8	
Breast milk and formula feeding (formula before current age and direct or expressed breastmilk)	4.3	29.1	
Breast milk substitutes only, previously also breastmilk	28.3	29.1	
Formula feeding only (no breast milk from birth till current age)	10.9	1.8	
Unknown	8.7	5.5	
Clustering of infant feeding practices within the first six			
Exclusive breastfeeding	45.6	32.7	0.15
Formula feeding	39.2	30.9	0.16
Mixed feeding	6.5	30.9	**0.01**
Unknown	8.7	5.5	

[a] Pearson's Chi-squared was used. P<0.05 indicates significant differences and is formatted in bold type

[b] The table includes infants who were still exclusively breastfed at 6 months; however, such infants were excluded for the cost of diet analysis.

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4.3.2 The rates of breastfeeding between HEU and HUU infants

The breastfeeding rates were higher among HUU infants (98% vs 91%). It was reported that 9% of HEU infants were never breastfed in their lifetime compared to 2% of their counterparts. No considerable difference (p = 0.11) between the groups. The poor maternal health status with high viral load and insufficient breast milk were cited as the top reasons for not breastfeeding in HEU and HUU groups, respectively. The significance differed between the HEU and HUU groups; p = 0.03, regarding reasons for not breastfeeding.

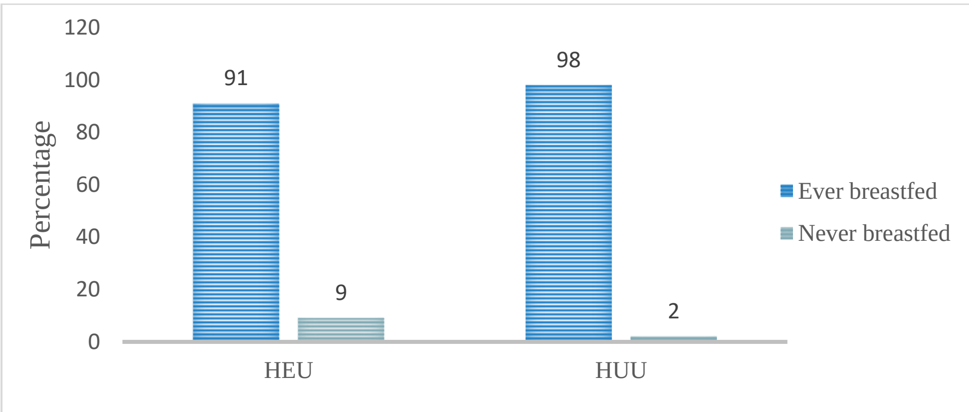

Figure 4.6: *The rates of ever breastfeeding among HEU versus HUU infants*

4.3.3 The duration of breastfeeding between HEU versus HUU infants

Above seventy percent of HUU and 62% HEU infants were currently breastfed (any breastfeeding) (71% vs 62%). The rates of six months breastfeeding duration were lower in HEU group compared to their counterparts (38% vs 29%). Overall, no statistically significant difference among HEU and HUU groups (p = 0.37) concerning the duration of breastfeeding.

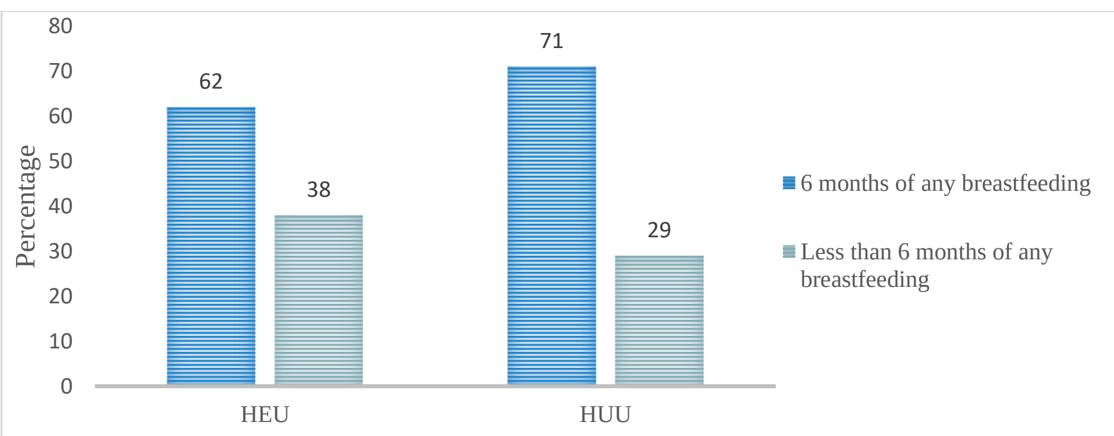

Figure 4.7: *The six months duration of breastfeeding among HEU versus HUU infants*

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The rates of early cessation of breastfeeding are reported periodically within six months and compared between HEU and HUU infants. Caregivers stopped breastfeeding from as early as one week (27% vs 12%). In the HEU group, most caregivers (33%) reported breastfeeding cessation when the infant was 1 – 2 months old, while in the HUU group, most caregivers (47%) reported cassation at three months. Similarly, in the HEU group, most infants (31%) were introduced to breast milk substitutes at 1 – 2 months old, while in most of HUU infants (35%) were introduced to breast milk substitutes at three months old. The *p*-values were not significant at the level of 0.39 and 0.49, respectively.

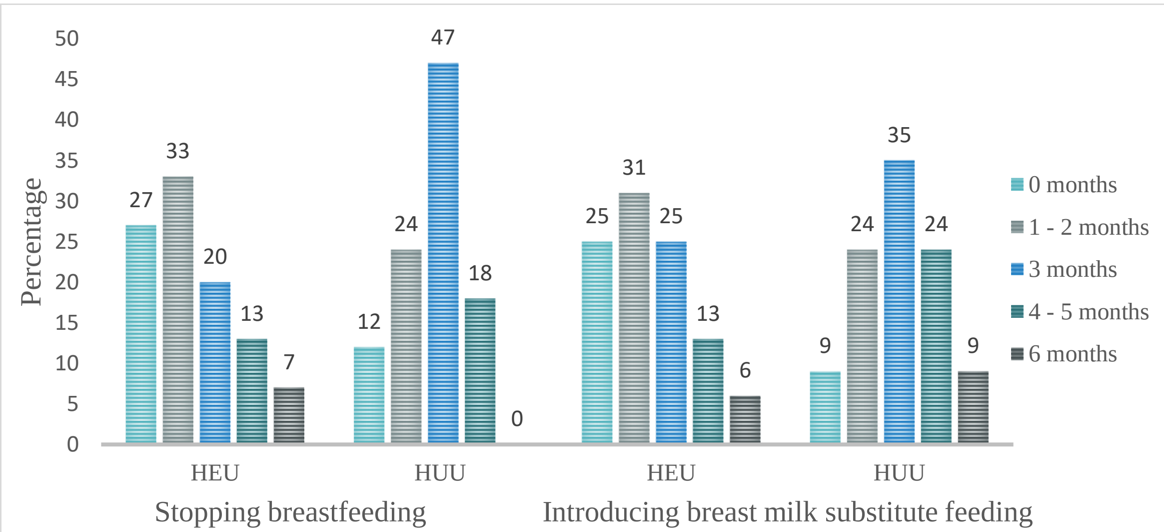

Figure 4.8: *The rates of the duration of breastfeeding in the first six months and the time of the introduction of breast milk substitutes*

The first two clusters indicate the rates of the duration of breastfeeding or age of infants when stopping breastfeeding, followed by the timing of introducing breast milk substitutes.

Both HEU and HUU caregivers introduced formula earlier because they wanted to return to work (25% vs 37%). The HEU and HUU infants were not breastfed because of perceived insufficient breast milk to satisfy the baby (25% vs 18%), and others were due to painful breasts or sore nipples of the mother (19% vs 6%). About 27% of caregivers of HUU and 25% of HEU infants introduced formula feeding because of other reasons including low health status, schooling, job searching and family matters. The *p*-value was 0.38; thus, no significant difference between HEU and HUU groups (Figure 4.9).

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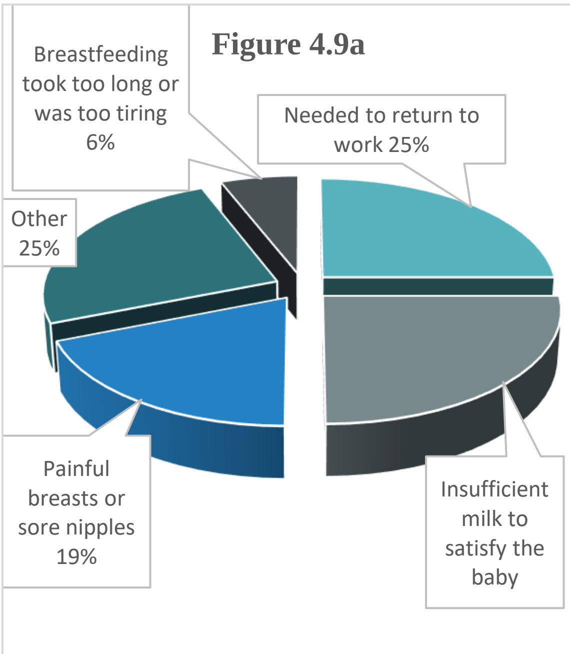

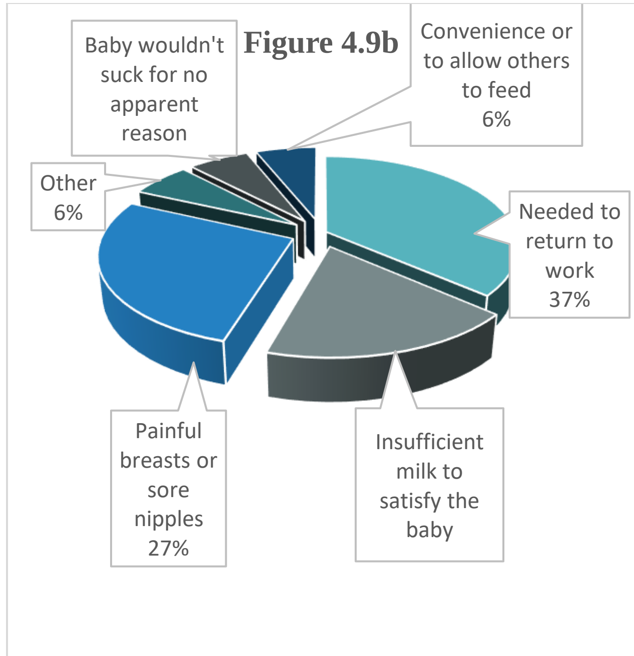

Figure 4.9: *The reasons cited by the caregivers for stopping breastfeeding or introducing breast milk substitutes are illustrated in the figures above. Figure 4.9a presents HEU group while 4.9b presents the HUU group.*

4.3.4 The infant feeding practices of HEU versus HUU caregivers

The information was compiled by combining results of how caregivers fed their infants from birth up to the age of six months, before the introduction of complementary foods. The findings were categorised into three methods of infant feeding; 1) Exclusive breastfeeding which entails: breast milk only directly from the breast; breast milk only with some feeding directly from the breast and some from expressed milk; and breast milk (from breast/expressed and donor breast milk) but no breast milk substitutes. 2) Mixed feeding encompasses breast milk and formula feeding (formula before current age and direct/expressed and donor breastmilk); and breast milk and formula feeding (formula before current age and direct or expressed breastmilk). Lastly, 3) Formula feeding incorporates: breast milk substitutes only, but previously also breast milk and; and formula feeding only – no breastmilk.

The rates of exclusive breastfeeding within six months were below 50% average in both groups (46% vs 33%). The *p*-value was 0.15, inferring no significant difference between the HEU and HUU groups. The mixed feeding rates were high among HUU infants (33%) compared to HEU infants (7%). The statistical significance of differentiation between HEU and HUU groups was *p*

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= 0.01. The levels of formula feeding were 39% in HEU infants and 31% among their counterparts. No significant difference in terms of formula feeding between the two groups (p = 0.16). The general infant feeding practices within the first six-months differed among HEU and HUU infants (p = 0.02).

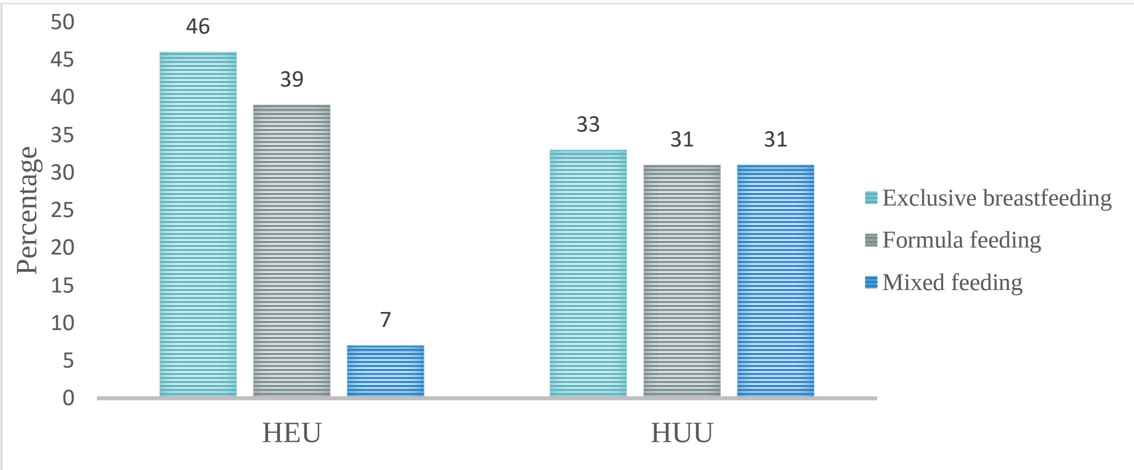

Figure 4.10: *The comparison of infant feeding practices between HEU and HUU infants*

4.5 THE COMPLEMENTARY FOODS, COSTS AND NUTRIENTS INTAKE

4.5.1 Introduction

The section reports the common complementary foods consumed and cost of diet and nutrient intake of six-months-old infants. The objective was to determine and comparing foods items consumed, food prices of these food items and analyse for nutrient intake among the HEU and HUU infants. The mean and standard deviation (SD) or median and interquartile range (IQR) of the nutrient intake, cost per nutrient and cost of diet per infant per day is reported and compared between the two groups.

4.5.2 The intake of complementary foods and gender distribution

The findings on infant's introduction to complementary foods and those given breast milk substitutes or breast milk only with no soft or solid food are reported in Table 4.3 below. An overall of 89% of infants was introduced to complementary foods, including breast milk substitutes at six months of age. Around 11% of infants (15% of HEU and 7% of HUU infants) were not yet introduced to complementary foods and were receiving breast milk only. In comparison, 93% of HUU and 85% of HEU infants started liquid, soft, semi-solid or solid foods. There was no

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significant difference between the groups concerning the introduction of complementary feeding (p = 0.20). Also, from 89.1% of infants introduced to food items, 13% of HEU and 10% of HUU infants were only given breast milk substitutes, no statistical differentiation between the groups (p = 0.65). There was a statistical difference (p = 0.003) regarding food intakes between the groups, large proportion of boys in HEU group (69%) while more girls in HUU group (53%) started taking foods at six months of age.

Table 4.3: The food intakes of infants; proportion introduced to complementary feeding and their sex distribution, and those who only fed on formula or breast milk (HEU vs HUU)

Variables	Total (n = 101)	HEU (n = 46)	HUU (n = 55)	*P*-value[a]
Food intake (%)				
Complementary foods[b]	89.1	84.8	92.7	0.20
Breast milk substitutes only[c]	11.3	12.8	9.8	0.65
Breast milk only[d]	10.9	15.2	7.3	0.20
	(n = 90)	(n = 39)	(n = 51)	
Sex of infants (%)[e]				**0.003**
Male	56.7	69.2	47.1	
Female	43.3	30.8	52.9	

4.5.3 The common complementary foods introduced to infants

The typical food items introduced to HEU and HUU infants at the age of six months to complement breast milk or breast milk substitutes are reported in Table 4.4. These foods were determined from the 24-hour recall. A higher number of infants introduced to commercial infant cereals were in HUU group (71% vs 49%; p-value = 0.04). Many HEU infants were introduced to fruits and vegetables compared to HUU infants (33% vs 16%), which is a significant difference between the groups with a p-value of 0.05. The most consumed fruits were banana and orange, and vegetables included mashed potatoes, sweet potato and butternut. Soft or hard margarine, a pinch of salt and cooking oil were added to butternut and potatoes by some caregivers in both groups. There was no statistically significant difference between the HEU and HUU groups regarding intake of maize

[a] Pearson's Chi-squared was used. P<0.05 indicates significant differences and is formatted in bold type.
[b] Including intake of breast milk substitutes only.
[c] Just to give an idea of % of infants who fed on breast milk substitutes only, from 89.1% % reported.
[d] Excluded from feeding cost analysis (delayed introduction of food items).
[e] Sex distribution of infants who were introduced to complementary foods including breast milk substitutes only.

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meal porridge (p = 0.24), and sorghum porridge (p = 0.58). Caregivers were adding either breast milk substitutes, peanut butter, cooking oil, margarine or brown sugar to infant's porridge. Both HEU and HUU infants were introduced to baby bottled or jarred foods and juices and tea (baby rooibos). There was no association in terms of intake of baby bottled foods and juices and tea between HEU and HUU infants; p = 0.12 and p = 0.37, respectively. The baby bottled or jarred foods were either banana, apple, pear, sweet potato, butternut or yoghurt flavours. Intake of animal food products or protein source foods was low (2.6%) or not consumed at all.

Table 4.4: The common complementary foods introduced at six months of age and comparison between HEU and HUU infants

Complementary foods	HEU (n = 39) Food items = 67	HUU (n = 51) Food items = 96	*P*-value[a]
Commercial infant cereals	48.7%	70.6%	**0.04**
Maize meal porridge	25.6%	15.7%	0.24
Sorghum porridge	17.9%	13.7%	0.58
Bottled baby food	25.6%	41.2%	0.12
Fruits and vegetables	33.3%	15.7%	**0.05**
Juices and tea	7.7%	13.7%	0.37
Savoury snacks or biscuits	0.0%	7.8%	0.07

4.5.4 The summary of nutrients across all food items consumed by infants at six months

The total of 245 food items that formed infant's complementary diet, including breast milk substitutes, were analysed for total protein, total fat, total carbohydrates (CHO), calcium, total iron, Zinc, vitamin C and Vitamin B_{12}. Table 4.5 reports the summary of the findings regarding mean (SD) and (95%CI) and median (IQR) for nutrient intake across all food items for both HEU and HUU infants. The US DRI (Dietary Reference Intakes) values included the estimated average requirement (EAR) values for total protein, total iron, zinc, calcium, vitamin B_{12} and vitamin C

[a] Pearson's Chi-squared was used. P<0.05 indicates significant differences and is formatted in bold type.

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intakes for the six-month-old infant (Institute of Medicine, 1998, 2000, 2001, 2005 and 2011). The DRI for the total fat and carbohydrates intakes involved adequate intake (AI) reference values established by Food and Nutrition Board for the Health and Medicine Division, formerly Institute of Medicine (Institute of Medicine, 2005; United States Department of Agriculture, Food and Nutrition Service, 2019).

The food items consumed, including breast milk substitutes, by infants in the study community were lower in essential nutrients; fat, carbohydrates, calcium, iron, zinc, vitamin C and vitamin B_{12}.

Table 4.5: The summary of nutrients across all food items consumed by six-months-old infants and comparison with DRI and AI

Nutrients	Food items (n = 245)	DRI (6 months) [a]
Protein[b] (g)		1.0 g/kg/d
mean (sd)	4.30 ± 5.63	
median (iqr)	1.90 (0.70, 5.90)	
mean (CI)	4.30 (95% CI: 3.59, 5.00)	
Fat (g)		30g
mean (sd)	4.77 ± 8.77	
median (iqr)	1.00 (0.10, 4.80)	
mean (CI)	4.77 (95% CI: 3.67, 5.87)	
Carbohydrate (g)		95g
mean (sd)	27.74 ± 30.29	
median (iqr)	16.20 (7.20, 36.50)	
mean (CI)	27.74 (95% CI: 23.95, 31.53)	
Calcium (mg)		260mg
mean (sd)	131.24 ± 219.11	
median (iqr)	22.00 (4.00, 175.00)	
mean (CI)	131.24(95%CI:103.81,158.68)	
Iron (mg)		6.9mg
mean (sd)	3.16 ± 5.20	
median (iqr)	1.00 (0.20, 3.90)	
mean (CI)	3.16 (95% CI: 2.50, 3.81)	
Zinc (mg)		2.5mg
mean (sd)	1.57 ± 2.22	
median (iqr)	0.56 (0.13, 2.37)	
mean (CI)	1.57 (95% CI: 1.29, 1.85)	
Vitamin B_{12} (µg)		0.5µg
mean (sd)	0.31 ± 0.61	
median (iqr)	0.00 (0.00, 0.40)	
mean (CI)	0.31 (95% CI: 0.24, 0.39)	
Vitamin C (mg)		50mg
mean (sd)	28.46 ± 42.24	
median (iqr)	13.00 (0.00, 38.00)	
mean (CI)	28.46 (95% CI: 23.17, 33.75)	

[a] All reference values are EAR except for carbohydrates and fat, which are AI.
[b] Mean protein intake was adequate.

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4.5.5 The daily nutrient intake per infant and comparison between HEU and HUU group

In this section, the nutrient intake per infant was combined for all food items consumed per infant and reported per group. Table 4.6 below present findings of the mean (SD) and (95%CI) and the median (IQR) nutrient intake per infant for each group and compares between HEU and HUU infants.

Table 4.6: The infant's nutrient intake per day and comparison between HEU and HUU infants[a]

Nutrients [b]	Total (n = 90)	HEU (n = 39)	HUU (n = 51)
Protein g			
mean (sd)	11.70 ± 8.28	11.06 ± 8.77	12.19 ± 7.94
median(iqr)	10.50 (5.00, 15.90)	9.50 (4.10, 15.15)	10.80 (6.50, 16.40)
mean (CI)	11.70(95%CI:9.99,13.41)	11.06(95%CI:8.31,13.81)	12.19(95%CI:10.01,14.37)
Fat (g)			
mean (sd)	12.99 ± 12.53	12.25 ± 12.85	13.55 ± 12.39
median(iqr)	9.40 (3.12, 19.28)	9.30 (1.75, 17.30)	10.60 (4.30, 20.80)
mean (CI)	12.99(95%CI:10.40,15.58)	12.25(95%CI:8.22,16.28)	13.55 (95% CI: 10.15, 16.95)
CHO (g)			
mean (sd)	75.51 ± 48.69	70.08 ± 49.61	79.67 ± 48.05
median(iqr)	66.85 (35.32, 104.85)	63.30 (25.60, 100.50)	69.10 (40.10, 107.80)
mean (CI)	75.5(95%CI:65.45, 85.57)	70.08(95%CI:54.50,85.65)	79.67 (95% CI: 66.48, 92.85)
Calcium(mg)			
mean (sd)	357.28 ± 318.32	324.82 ± 331.53	382.10 ± 308.84
median (iqr)	271.00 (101.75, 498.00)	240.00 (38.00, 505.00)	304.00 (154.50, 477.00)
mean (CI)	357.28(95%CI:291.51,423.04)	324.82(95%CI:220.77,428.87)	382.10(95%CI:297.34,466.86)
Iron[c](mg)			
mean (sd)	8.59 ± 7.62	6.92 ± 6.70	9.87 ± 8.08
median (iqr)	6.30 (3.32, 11.24)	5.00 (2.10, 10.30)	7.10 (4.95, 13.70)
mean (CI)	8.59 (95% CI: 7.02, 10.16)	6.92 (95% CI: 4.82, 9.02)	9.87 (95% CI: 7.65, 12.08)
Zinc (mg)			
mean (sd)	4.27 ± 3.21	3.89 ± 3.21	4.55 ± 3.21
median (iqr)	3.77 (1.64, 5.99)	3.35 (1.38, 5.55)	4.38 (1.94, 6.49)
mean (CI)	4.27 (95% CI: 3.60, 4.93)	3.89 (95% CI: 2.88, 4.90)	4.55 (95% CI: 3.67, 5.44)
VitaminB_{12}µg			
mean (sd)	0.85 ± 0.85	0.78 ± 1.03	0.90 ± 0.69
median (iqr)	0.65 (0.10, 1.30)	0.40 (0.00, 1.25)	0.80 (0.30, 1.30)
mean (CI)	0.85 (95% CI: 0.67, 1.02)	0.78 (95% CI: 0.46, 1.11)	0.90 (95% CI: 0.71, 1.09)
VitaminC[d]mg			
mean (sd)	77.47 ± 69.18	58.77 ± 58.13	91.76 ± 73.97
median (iqr)	54.00 (23.00, 114.75)	43.00 (14.00, 98.50)	70.00 (35.00, 124.50)
mean (CI)	77.47 (95% CI: 63.17,91.76)	58.77 (95% CI: 40.53, 77.01)	91.76 (95% CI:71.47,112.06)

[a] Mann Whitney U test was used to determine differences. $P < 0.05$ indicates significant differences.
[b] *P*-values for protein = 0.34, fat = 0.36, CHO = 0.26, calcium = 0.27, zinc = 0.24 and vitamin B_{12} = 0.08
[c] The total iron intake significantly differs between HEU and HUU groups at a level of ***p* = 0.03**
[d] The vitamin C intake differs significantly between the two groups at a level of ***p* = 0.01**

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The daily mean (SD) and median (IQR) nutrient intake per infant in each group was investigated and compared among HEU and HUU infants (Table 4.6). The mean iron intake was lower in HEU infants compared to their HUU counterparts; 6.92 ± 6.70mg vs 9.87 ± 8.08mg, the further investigation also indicated lower median (IQR) iron intake in HEU infants than HUU infants; 5.00mg (2.10, 10.30) vs 7.10mg (4.95, 13.70); $p = 0.03$. The median (IQR) vitamin C intake was lower in HEU infants compared to HUU infants; 43.00mg (14.00, 98.50) vs 70.00mg (35.00, 124.50) and mean: 58.77 ± 58.13mg vs 91.76 ± 73.97mg, with 32.99mg difference. The significant differences between the HEU and HUU infants exist ($p = 0.01$). There are no statistically significant differences in terms of macronutrients intake between HEU and HUU infants (p-value > 0.05). Likewise, there was no difference regarding calcium, zinc and vitamin B_{12} intakes between the groups (p-value > 0.05).

4.5.6 The daily cost of food per infant

The following section reports the daily cost of a complementary diet, including breast milk substitutes per infant. The calculations considered the total amount of food and breast milk substitutes consumed as well as the price per 100g for each food item and calculating the amount (across the different food items) per infant. These will give an idea of the overall daily cost per infant.

Table 4.7: The overall daily cost of diet (ZAR) and comparison between the HEU and HUU infants

Variable	Total (n = 90)	HEU (n = 39)	HUU (n = 51)
The overall cost per infant (ZAR)			
mean (sd)	34.29 ± 36.28	40.55 ± 41.72	29.51 ± 31.10
median (iqr)	23.46 (8.60, 46.09)	25.56 (9.21, 69.63)	20.51 (7.87, 35.61)
mean (CI)	34.29(95%CI:26.80,41.79)	40.55(95%CI:27.46,53.64)	29.51(95%CI:20.98,38.05)

The overall mean (SD) and median (IQR) cost of diet per day for each infant is reported (Table 4.7). The price entails the cost of all the nutrients reported in Table 4.8 for each group. The daily mean cost of a diet of HEU infant was ZAR 40.60 ± 41.72 while for HUU infant was ZAR 29.50 ± 31.10. No significant difference exists regarding the daily cost of diet between the groups (p-value = 0.43). Mann Whitney U test was used to determine differences.

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4.5.7 The daily cost of each nutrient intake and comparison between HEU and HUU infants

The following section reports the daily cost per nutrient intake for each infant and compares between the infants (Table 4.8). The calculations considered the total amount of nutrient and the cost per 100g for each food item and calculating the amount (across the different food items) per infant. These will give an idea of the cost per infant for each of the nutrients.

Table 4.8: The daily cost (ZAR) per nutrient intake for each infant and comparison between HEU and HUU infants[a]

Nutrients (ZAR)[b]	Total (n = 90)	HEU (n = 39)	HUU (n = 51)
Protein (ZAR)			
mean (sd)	1.28 ± 1.09	1.15 ± 1.12	1.38 ± 1.07
median (iqr)	0.97 (0.40, 1.84)	0.87 (0.14, 1.83)	1.24 (0.53, 1.86)
mean (CI)	1.28(95%CI:1.05,1.51)	1.15(95%CI:0.79,1.50)	1.38(95%CI: 1.09, 1.67)
Fat (ZAR)			
mean (sd)	1.73 ± 1.77	1.50 ± 1.70	1.91 ± 1.82
median (iqr)	1.26 (0.19, 2.96)	0.93 (0.06, 2.43)	1.52 (0.34, 3.20)
mean (CI)	1.73(95%CI:1.37,2.10)	1.50(95%CI:0.97,2.03)	1.91(95%CI:1.41, 2.41)
CHO (ZAR)			
mean (sd)	6.91 ± 5.16	5.90 ± 4.78	7.67 ± 5.35
median (iqr)	6.11 (2.32, 10.42)	5.67 (2.00, 8.95)	6.77 (3.52, 11.01)
mean (CI)	6.91(95%CI:5.84,7.97)	5.90(95%CI:4.40,7.40)	7.6 (95% CI: 6.21, 9.14)
Calcium (ZAR)			
mean (sd)	0.04 ± 0.04	0.04 ± 0.04	0.05 ± 0.04
median (iqr)	0.04 (0.01, 0.07)	0.03 (0.00, 0.06)	0.04 (0.01, 0.07)
mean (CI)	0.04(95%CI:0.04,0.05)	0.04(95%CI:0.03,0.05)	0.05(95%CI:0.04, 0.06)
Iron (ZAR) [c]			
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00,0.00)	0.00(95%CI:0.00,0.00)	0.00(95%CI: 0.00, 0.00)
Zinc (ZAR)			
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00,0.00)	0.00(95%CI:0.00,0.00)	0.00(95%CI: 0.00, 0.00)
Vitamin B_{12} (ZAR)			
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00,0.00)	0.00(95%CI:0.00,0.00)	0.00(95%CI:0.00, 0.00)
Vitamin C (ZAR) [d]			
mean (sd)	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
median (iqr)	0.01 (0.00, 0.01)	0.01 (0.00, 0.01)	0.01 (0.00, 0.01)
mean (CI)	0.01(95%CI:0.01,0.01)	0.01(95%CI:0.00,0.01)	0.01(95%CI: 0.01, 0.01)

[a] Mann Whitney U test was used to determine differences. $P < 0.05$ indicates significant differences.
[b] *P*-values for cost: protein = 0.19, fat = 0.14, CHO = 0.09, calcium = 0.15, zinc = 0.10 and vitamin B_{12} = 0.07
[c] The cost of total iron significantly differs between the groups at a level of $\boldsymbol{p = 0.02}$
[d] The cost of vitamin C significantly differs between the groups at a level of $\boldsymbol{p = 0.02}$

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The cost of each nutrient intake (reported in Table 4.6) for each infant was investigated and compared between the HEU and HUU infants (Table 4.8). A significant difference exists for the mean cost for total iron intake between the groups at a level of *p*-value = 0.02. The statistically significant differed between HEU and HUU infants, for the cost of vitamin C intake, at a level of *p*-value = 0.02. For the cost of total protein, fat and carbohydrate intakes, there was no significant differences between the groups; protein: $p = 0.19$, fat: $p = 0.14$ and carbohydrates: $p = 0.09$. There were no statistical differences concerning the cost for calcium, zinc and vitamin B_{12} between HEU and HUU infants.

4.5.8 The cost per nutrient in 100g of each food item consumed by infants

The price per nutrient within 100g of each food items commonly consumed by infants was investigated, and comparison is made between commercial infant cereals, maize meal porridge and sorghum porridge, and bottled or jarred baby food and fresh fruits and vegetables. The calculations involved determining the cost per nutrient, per infant, for each of the commonly introduced complementary foods. The mean costs of the nutrients per food item are reported (Table 4.9). Important to note, this comparison includes both HEU and HUU populations.

The goal was to determine the possible variances in the mean cost of nutrients within infant cereals, maize meal and sorghum porridge. The mean (SD) or median (IQR) costs of nutrients within commercial infant cereals were costliest than in maize meal porridge. The significant differences exist for all cost of nutrients between infant cereals and maize meal porridge ($p < 0.001$). When comparing the cost of each nutrient between commercial infant cereals and sorghum porridge, costs of calcium and vitamin C in infant cereals were higher than the costs of these nutrients in sorghum porridge. The significant difference at a level of *p*-value < 0.001 exists between the groups. The significant differences exist between the mean costs of iron ($p = 0.002$), zinc ($p = 0.02$) and vitamin B_{12} ($p < 0.001$) within infant cereals and sorghum porridge.

The costs of per nutrient within bottled baby food and fresh fruits and vegetables consumed in the study population are also reported (Table 4.9). The most ingredients used in bottled baby foods consumed were fruits and vegetables (section 4.5.3); thus, a comparison of bottled fruits and vegetables with fresh fruits and vegetables. The goal was to investigate the discrepancy in terms of the mean (SD) or median (IQR) cost of nutrients in these food items. The costs of protein and

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carbohydrates were higher in bottled baby foods than fresh fruits and vegetables. The significant difference exists ($p < 0.001$) between the two food items. The following nutrients; calcium, iron, zinc and vitamin C were costing ZAR 0.00 ± 0.00 in bottled baby foods and fruits and vegetables. Findings reported that there was a significant difference when considering calcium, iron, zinc and vitamin C between the costs of these nutrients in bottled baby food and fruits and vegetables (vitamin C; $p < 0.001$, calcium; $p = 0.001$, iron; $p = 0.005$ and zinc; $p = 0.004$).

4.5.9 The nutrient density of complementary food items consumed by infants

Further, the nutrients content per 100g of each food item was investigated and compared between food items under consideration. Table 4.10 presents the density of nutrients for the commonly introduced complementary food items. The commercial infant cereals had a higher nutrient density compared to maize meal porridge. The significant levels of differentiation are $p = 0.002$ for protein, $p = 0.006$ for fat, $p = 0.008$ for carbohydrates and $p <0.001$ for calcium, iron, zinc, vitamin B_{12} and vitamin C. When comparing commercial infant cereals with sorghum porridge, calcium ($p < 0.001$), iron ($p = 0.004$), vitamin B_{12} and vitamin C ($p < 0.001$) differed significantly between the two food items. These nutrients, except vitamin B_{12}, were higher in commercial infant cereals than sorghum porridge. Bottled baby foods had higher values of carbohydrates (14.29 ± 8.75g vs 10.73 ± 13.43g; 12.70g (9.25, 14.85) vs 6.35g (2.48,15.20)) and vitamin C (18.33 ± 13.57mg vs 7.90 ± 10.39mg; 16.50mg (5.00, 26.00) vs 3.00mg (2.00, 10.00)) compared to fresh fruits and vegetables. The nutrient density of bottled baby foods (carbohydrates; $p = 0.03$ and vitamin C; $p = 0.002$) differed significantly to those in fresh fruits and vegetables. (Table 4.10).

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Table 4.9: The cost per nutrient (ZAR) per 100g of each food item and comparison between commercial infant cereals vs maize meal and sorghum porridge, bottled or jarred baby foods vs fresh fruits and vegetables

Nutrients	Infant cereals (n = 58)	Maize meal porridge (n =18)a	Sorghum porridge (n = 14)b	Bottled baby foods (n = 30)	Fruits and Vegetables (n = 20)c
Protein					
mean (sd)	0.53 ± 0.75	0.00 ± 0.00	0.25 ± 0.20	0.12 ± 0.12	0.03 ± 0.05
median (iqr)	0.28 (0.08, 0.58)	0.00 (0.00, 0.01)	0.20 (0.06, 0.40)	0.08 (0.06, 0.11)	0.01 (0.00, 0.04)
mean (CI)	0.53(95%CI:0.34, 0.73)	0.00(95%CI:0.00,0.01)	0.25(95%CI: 0.15, 0.35)	0.12 (95% CI: 0.08, 0.16)	0.03 (95% CI: 0.01, 0.06)
Fat					
mean (sd)	0.26 ± 0.47	0.00 ± 0.00	0.08 ± 0.07	0.01 ± 0.01	0.07 ± 0.12
median (iqr)	0.09 (0.02, 0.21)	0.00 (0.00, 0.00)	0.07 (0.02, 0.13)	0.01 (0.01, 0.01)	0.00 (0.00, 0.09)
mean (CI)	0.26(95%CI:0.14, 0.38)	0.00(95%CI:0.00,0.00)	0.08 (95% CI: 0.05, 0.12)	0.01 (95% CI: 0.01, 0.02)	0.07 (95% CI: 0.01, 0.12)
CHO					
mean (sd)	3.57 ± 3.79	0.05 ± 0.03	1.85 ± 1.47	1.31 ± 0.72	0.35 ± 0.53
median (iqr)	2.50 (0.85, 4.92)	0.05 (0.02, 0.07)	1.49 (0.48, 3.03)	1.08 (0.91, 1.55)	0.19 (0.07, 0.46)
mean (CI)	3.57(95%CI:2.60, 4.55)	0.05(95%CI:0.03,0.06)	1.85 (95% CI: 1.10, 2.59)	1.31 (95% CI: 1.05, 1.57)	0.35 (95% CI: 0.12, 0.58)
Calcium					
mean (sd)	0.02 ± 0.03	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.01 (0.00, 0.02)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.02(95%CI:0.01, 0.03)	0.00(95%CI:0.00,0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)
Iron					
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00, 0.00)	0.00(95%CI:0.00,0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)
Zinc					
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00, 0.00)	0.00(95%CI:0.00,0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)
Vitamin B12					
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00, 0.00)	0.00(95CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: -0.00, 0.00)
Vitamin C					
mean (sd)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
median (iqr)	0.00 (0.00, 0.01)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.00(95%CI:0.00, 0.01)	0.00(95%CI:0.00,0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)

[a] Cost of all nutrients differed significantly between commercial infant cereals and maize meal porridge **(p<0.001)**

[b] Cost of nutrients significantly differed for iron (**p=0.002**), zinc (**p=0.02**), calcium, vitamin B_{12} and vitamin C (**p<0.001**) between commercial infant cereals and sorghum porridge

[c] Cost of protein, CHO, vitamin C (**p<0.001**), calcium (**p=0.001**), iron (**p=0.005**) and zinc (**p=0.004**) differed significantly between bottled baby foods and fresh fruits and vegetables. Mann Whitney U test was used to determine differences. P < 0.05 indicates significant differences.

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Table 4.10: The nutrient density per 100g of each of the complementary food items consumed and comparison between these food items given to infants at six months of age[a]

Nutrients	Infant cereals (n = 58)	Maizemeal porridge (n =18)[b]	Sorghum porridge (n = 14)[c]	Bottled baby foods (n = 30)	Fruits and vegetables (n =20)[d]
Protein (g)					
mean (sd)	6.03 ± 5.83	1.80 ± 1.10	5.03 ± 4.00	1.42 ± 1.76	0.92 ± 1.26
median(iqr)	4.35 (1.88, 7.50)	1.55 (1.07, 2.48)	4.10 (1.30, 8.25)	0.80 (0.70, 1.08)	0.45 (0.30, 1.15)
mean (CI)	6.03 (95% CI: 4.53, 7.53)	1.80 (95% CI: 1.23, 2.37)	5.03 (95% CI: 3.00, 7.05)	1.42 (95% CI: 0.80, 2.05)	0.92 (95% CI: 0.37, 1.48)
Fat (g)					
mean (sd)	2.53 ± 3.27	0.70 ± 0.41	1.68 ± 1.33	0.13 ± 0.18	1.83 ± 3.10
median(iqr)	1.25 (0.72, 3.00)	0.60 (0.43, 0.93)	1.40 (0.45, 2.75)	0.10 (0.10, 0.10)	0.10 (0.00, 3.18)
mean (CI)	2.53 (95% CI: 1.69, 3.37)	0.70 (95% CI: 0.49, 0.91)	1.68 (95% CI: 1.00, 2.36)	0.13 (95% CI: 0.07, 0.20)	1.83 (95% CI: 0.47, 3.20)
CHO (g)					
mean (sd)	48.89 ± 42.54	18.33 ± 11.31	37.71 ± 29.96	14.29 ± 8.75	10.73 ± 13.43
median(iqr)	35.20 (19.00, 67.73)	15.75 (11.07, 25.00)	30.40 (9.80, 61.90)	12.70 (9.25, 14.85)	6.35 (2.48, 15.20)
mean (CI)	48.89(95%CI:37.94,59.84)	18.33(95%CI:12.41,24.25)	37.71(95%CI:22.54,52.87)	14.29(95%CI:11.16,17.43)	10.7(95%CI:4.85, 16.62)
Calcium (mg)					
mean (sd)	200.33 ± 224.84	2.79 ± 1.72	10.00 ± 8.00	14.03 ± 17.80	14.40 ± 22.07
median(iqr)	107.50 (27.75, 246.50)	2.50 (2.00, 3.75)	8.00 (2.50, 16.50)	6.00 (4.00, 13.00)	5.00 (2.00, 17.50)
mean (CI)	200.33(95% CI:142.46,258.19)	2.79 (95% CI: 1.89, 3.69)	10.00 (95% CI: 5.95, 14.05)	14.03 (95% CI: 7.66, 20.40)	14.40 (95% CI: 4.73, 24.07)
Iron (mg)					
mean (sd)	7.99 ± 8.26	0.70 ± 0.41	2.19 ± 1.74	0.32 ± 0.26	0.56 ± 0.77
median(iqr)	4.95 (1.55, 12.68)	0.60 (0.43, 0.93)	1.80 (0.60, 3.60)	0.25 (0.20, 0.30)	0.25 (0.18, 0.60)
mean (CI)	7.99 (95% CI: 5.87, 10.12)	0.70 (95% CI: 0.49, 0.91)	2.19 (95% CI: 1.31, 3.07)	0.32 (95% CI: 0.22, 0.41)	0.56 (95% CI: 0.23, 0.90)
Zinc (mg)					
mean (sd)	2.53 ± 2.50	0.70 ± 0.43	1.32 ± 1.05	0.15 ± 0.14	0.19 ± 0.23
median(iqr)	1.68 (0.73, 3.32)	0.60 (0.42, 0.95)	1.07 (0.34, 2.17)	0.08 (0.07, 0.20)	0.12 (0.05, 0.25)
mean (CI)	2.53 (95% CI: 1.89, 3.18)	0.70 (95% CI: 0.47, 0.92)	1.32 (95% CI: 0.79, 1.86)	0.15 (95% CI: 0.10, 0.20)	0.19 (95% CI: 0.09, 0.29)
Vitamin B_{12} µg					
mean (sd)	0.35 ± 0.59	0.00 ± 0.00	0.00 ± 0.00	0.05 ± 0.14	0.01 ± 0.04
median(iqr)	0.10 (0.00, 0.40)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
mean (CI)	0.35 (95% CI: 0.20, 0.50)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	0.05 (95% CI: 0.00, 0.10)	0.01 (95% CI: -0.01, 0.03)
Vitamin C (mg)					
mean (sd)	55.78 ± 59.60	0.00 ± 0.00	0.00 ± 0.00	18.33 ± 13.57	7.90 ± 10.39
median (iqr)	33.50 (9.00, 88.50)	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	16.50 (5.00, 26.00)	3.00 (2.00, 10.00)
mean (CI)	55.78 (95% CI: 40.44, 71.11)	0.00 (95% CI: 0.00, 0.00)	0.00 (95% CI: 0.00, 0.00)	18.33 (95% CI: 13.48, 23.19)	7.90 (95% CI: 3.35, 12.45)

[a] Mann Whitney U test was used to determine differences. P < 0.05 indicates significant differences.

[b] Nutrient density differs significantly between commercial infant cereals and maize meal porridge at a level of ***p* = 0.002, 0.006, 0.008** and the rest <**0.001**, singly.

[c] Only calcium (***p*<0.001**), iron (***p* = 0.004**), vitamin B_{12} and vitamin C (***p*<0.001**) differed significantly between commercial infant cereals and sorghum porridge.

[d] Only carbohydrates (***p* = 0.03**) and vitamin C (***p* = 0.002**) differed significantly between bottled or jarred baby foods and fresh fruits and vegetables.

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4.5.10 Nutrient intake adequacy of complementary foods and breast milk substitutes consumed by HEU versus HUU infant

The section considered the combined nutrient intake per infant and compared the amount per nutrient with the EER, AI and the EAR established by the WHO and US Institute of Medicine and investigated the proportion of infants who were below or above the minimum recommended values. The estimate of the energy required from food intake for six to an eight-month-old infant is 1126 KJ in developing countries (Michaelsen, 2000). The US Institute of Medicine DRIs were described in section 4.5.4.

Table 4.11: Investigating the adequacy of nutrient intake and energy among the infants (HEU vs HUU) by comparing with the DRI of US Institute of Medicine in the form of EER, EAR and AI.

Nutrients[a]	DRI	Total (n = 90)	HEU (n =39)	HUU (n =51)	*P*-value
Energy	1126KJ				0.56
Above		64 (71.1%)	26 (66.7%)	38 (74.5%)	
Below		26 (28.9%)	13 (33.3%)	13 (25.5%)	
Protein	1g/kg/d				0.88
Above		35 (38.9%)	16 (41.3%)	19 (37.2%)	
Below		55 (61.1%)	23 (59.0%)	32 (62.8%)	
Fat	30g				1
Above		7 (7.8%)	3 (7.7%)	4 (7.8%)	
Below		83 (92.2%)	36 (92.3%)	47 (92.2%)	
Carbohydrate	95g				0.63
Above		29 (32.2%)	11 (28.2%)	18 (35.3%)	
Below		61 (67.8%)	28 (71.8%)	33 (64.7%)	
Iron	6.9mg				1
Above		89 (98.9%)	39 (100.0%)	50 (98.0%)	
Below		1 (1.1%)	0 (0.0%)	1 (2.0%)	
Zinc	2.5mg				0.21
Above		90 (100.0%)	39 (100.0%)	51 (100.0%)	
Below		0 (0.0%)	0 (0.0%)	0 (0.0%)	
Vitamin B_{12}	0.5µg				**0.03**
Above		69 (76.7%)	25 (64.1%)	44 (86.3%)	
Below		21 (23.3%)	14 (35.9%)	7 (13.7%)	
Vitamin C	50mg				0.81
Above		87 (96.7%)	37 (94.9%)	50 (98.0%)	
Below		3 (3.3%)	2 (5.1%)	1 (2.0%)	
Calcium	260mg				0.21
Above		90 (100.0%)	39 (100.0%)	51 (100.0%)	
Below		0 (0.0%)	0 (0.0%)	0 (0.0%)	

[a] Pearson's Chi-squared test with Yates' continuity correction. P < 0.05 indicates significant differences and those are written in bold type.

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The findings on infant's nutrient intake adequacy are reported and compared between HEU and HUU infants (Table 4.11). The breast milk was excluded because this information is intended to be used as the background information to describe the nutrient density of food items and breast milk substitutes which can be purchased. The proportion of infants below and above the minimum required values is stated. No differences exist between the groups regarding the percentage of nutrients intake ($p > 0.05$) except for vitamin B_{12} ($p = 0.03$).

Similarly, the rate of vitamin B_{12} intake was reported to be higher in HUU infants than HEU infants (86% vs 62%). The level of energy intake below EER (1126KJ) was 33% among HEU infants and 25% in HUU infants. The intake of macronutrients: protein, fat and carbohydrates were low throughout the groups. About 61%, 92% and 68% of the population had protein, fat and carbohydrate intakes below reference DRI values, respectively. The micronutrient intakes were high in both groups. None of the infants had intake below the EAR for zinc and calcium. Few of the HUU infants had low iron intake while a small number of HEU infants had vitamin C intake.

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CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

The following chapter presents the discussion for the results of the study. The findings are discussed in accordance with the aim and objectives of the study. The overall aim of this study was to determine the breastfeeding practices and discuss and compare the cost of diet in relation to nutrient intake of six-month-old HEU versus HUU infants. Thus, the main findings of the study centred on the cost of diet and nutrient intake, and to a lesser extent, feeding practices.

5.2 KEY FINDINGS

The results showed no significant difference between the daily cost of a diet of HEU and HUU infants. However, there are variations in terms of cost of iron and vitamin C and their intakes between these infants. The low iron and vitamin C intakes among HEU infants, despite the equal daily cost of diet, reveal inequity in the cost of feeding between the HEU and HUU infants. In fact, because of the high iron requirements and its role during this period of rapid growth, it is believed that there is a disparity in the cost of feeding HEU and HUU infant. HEU infant's caregivers spend more on less infant's iron intake. The breastfeeding outcomes contribute to the existing documentation by signifying low rates of exclusive breastfeeding in HIV-free and infected mothers, as well as low rates of mixed feeding among HIV-infected mothers.

5.3 SOCIO-DEMOGRAPHIC CHARACTERISTICS AND FOOD PURCHASING PRACTICES

The objective involved the determination of the socio-demographic information of the caregivers. The findings indicated that HIV-infected women had lower educational attainment compared to their HIV-uninfected counterparts. According to Hargreaves *et al*. (2008), the prevalence of HIV in sub-Saharan Africa is high amongst the least educated individuals. The low level of education of women was linked to inadequate knowledge of HIV (Yaya *et al.*, 2016). Education is key in controlling HIV transmission and infection (Mwamwenda, 2014). Mostly the HIV campaigns are done in schools and, therefore, better school attendance can upsurge the contact with health-promoting messages and ultimately lessen the risk of infection (Hargreaves *et al.*, 2008). Besides, maternal HIV infection was strongly associated with lower household monthly income. The reduced ability to generate revenue in households affected by HIV was reported (Naidoo *et al.*, 2017). The HIV infection affects an individual's overall health including ability to generate income

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(Ladzani, 2015) or to go to work routinely, hence reducing the income of the household (Sibanda *et al.*, 2006). Low educational attainment is as well associated with no or low income and eventually food purchasing restrictions (Ladzani, 2015).

Further, the findings indicated a high percentage of HEU infants residing in households without monthly income. Pienaar and co-workers (2017) reported that the rate of unemployment is high among HIV-infected adults compared to HIV-uninfected adults. The increased unemployment rate in HIV settings was also reported by Naidoo *et al.* (2017). Majority of households in both groups had one to two children to care for and were receiving the social support grants, namely child support grants. According to Ladzani (2015), South Africa is the only country in the sub-Saharan region that supports its citizens with state pension and social assistance. The child support grants are aimed at reducing poverty throughout the population (Patel, 2011) and are offered to eligible resident children regardless of HIV background.

The findings on food purchasing practices did not differ statistically throughout the HEU and HUU groups, despite the lower-income status of HEU households. However, the amount of food purchased was not reported. So, it may be that due to food insecurity HEU household bought less food. The key determining factor for household food security is economic status; it controls the household’s food purchasing power (Ladzani, 2015) and practices, and accordingly ensuring household food access. In contrary to the present findings, the study that used HFIAS for determination of household food security reported high levels of moderate and severe food insecurity among households affected by HIV (Baiyegunhi and Makwangudze, 2013). The difference with the current study may be due to small household sizes, as most of the HEU households had few numbers of children, and also due to the small overall sample of this study. Baiyegunhi and Makwangudze (2013) reported the strong relationship between family size and food insecurity; large household size is more liable to be food insecure.

5.4 INFANT FEEDING PRACTICES

The objectives were to determine the feeding practices of infants 0 – 6 months old and compare between HEU and HUU infants in the study community. It was found that the prevalence of early initiation of breastfeeding was high in the study population with no significant difference between HEU and HUU groups. The common rates of breastfeeding initiation between HIV-positive

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(56.6%) and negative mothers (61.2%) were reported in South Africa (Nieuwoudt *et al.*, 2018). The rates were higher than the findings reported globally and nationwide: 57.6% from WHO global survey (Takahashi *et al.*, 2017) and 58.3% in Ethiopia (Ekubay *et al.*, 2018), of the general population, and in South Africa by Nieuwoudt and colleagues (2018). The EIBF rates also surpass the WHO global target of 70% by approximately 5% and 5.5% among HEU and HUU groups, respectively. The high prevalence of breastfeeding initiation might be due to increased support and promotion of breastfeeding, as most certainly are these practices contributing to these results. However, recall bias might be a concern here; many caregivers may not recall. Nevertheless, these rates were slightly lower than the 80% reported among HIV-negative mothers (Martin-Wiesner, 2018; Shisana *et al.*, 2013) and 82.3% among HIV-positive mothers in South Africa (Muluye *et al.*, 2012). The delivering through caesarean section (Nieuwoudt *et al.*, 2018), complications during pregnancy (Takahashi *et al.*, 2017), maternal ill health at delivery (Sharma and Byrne, 2016) and discarding of colostrum were reported to affect breastfeeding initiation (Tongun *et al.*, 2018).

Further, the prevalence of ever breastfed infants was universally high in both groups. Similarly, high rates between HIV-positive and -negative mothers were reported in the country (Nieuwoudt *et al.*, 2018). The increased prevalence of ever breastfed infants in South Africa might be attributed to improved breastfeeding support and promotion. The maternal high HIV viral load (VL) and insufficiency of breast milk were the main reasons for never breastfeeding in HEU and HUU groups, respectively. The high HIV VL in mothers living with HIV lessens chances of infant HIV free survival. It is believed that increased HIV VL is associated with poor adherence to maternal ART. Robert and colleagues (2014) associated perceived insufficiency of breast milk with a low level of education and disregarding the recommendations of WHO. Additionally, only 1 to 5% of mothers can be affected by the actual lack of breast milk (Robert *et al.*, 2014).

In this study, more than fifty percent of both HEU and HUU infants were currently breastfed at the age of six months and beyond. The rates of current breastfeeding were higher than those reported, at different periods throughout six months, by Nieuwoudt and co-workers (2018). However, the prevalence of exclusive breastfeeding was similarly low in the study population during the first six months. The rates were lower than the 50% target of the United Nations Decade of Nutrition in both HEU and HUU groups. Still, this was higher than the 12% rate reported in

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2013 (Siziba *et al.*, 2015) and 13% in 2015 (Budree *et al.*, 2017) in other areas of the country. A South African study also reported similar rates between HIV-uninfected (42.8%) and infected mothers (44.7%) (Reimers *et al.*, 2018). Conversely, the higher rates were reported among mothers living with HIV infection in Ethiopia (63.4%) (Belay and Wubneh, 2019), Nigeria (68.3%) (Adejuyigbe *et al.*, 2008) and South Africa (83.8%) (Muluye *et al.*, 2012). The high prevalence among HIV-free mothers (58%) than their counterparts (37%) was also reported in the country (West *et al.*, 2019). One study stressed on low rates of EBF (37%) in low- and middle-income countries (Victora *et al.*, 2016). The lower rates of EBF might be because of the lack of supportive society and enabling environment for mothers to breastfeed and increasing industry of breast milk substitutes (Rollins *et al.*, 2016). Moreover, the timing for early cessation of breastfeeding was universal in both groups. The percentage was high at 1 – 2 months among HIV-infected mothers, while in HIV-uninfected mothers, the percentage was high at three months. Nonetheless, the percentage was higher in stopping breastfeeding at 1 – 2 months among HUU group as compared to the 40% rate that was reported by Siziba and co-workers (2015) in 2013. The common percentage of stopping breastfeeding at three months were reported among South African HIV-infected and -uninfected mothers (Horwood *et al.*, 2018). Contrarily, studies reported high of EBF at some point during six months among South African HIV-uninfected mothers, in comparison to their HIV-infected counterparts; 92.9% vs 81.4% at 6 – 8 weeks and 72.6% vs 61.8% at 3 – 4 months of age (Rollins *et al.*, 2013). A recent study also reported similar results; 86% vs 63 at six weeks, 85% vs 58% at ten weeks and 81% vs 55% at 14 weeks (West *et al*., 2019). It was noted also that there were more HEU mothers who were still exclusively breastfeeding at the six months visit, in line with the infant feeding recommendations and counselling.

Furthermore, the rates of formula feeding were similarly low in both HEU and HUU study populations. Ellis (2013) stated low rate among women living with HIV. The low rate was also reported among HIV-uninfected (1.4%) mothers compared to their HIV-infected counterparts (13%) (Ghuman *et al.*, 2009). Likewise, the timing for introducing formula feeding did not differ between the HEU and HUU populations. Similar findings were reported in the country by Ellis (2013). Nevertheless, Rollins and colleagues (2013) reported high rates of formula feeding in HEU group compared to HUU group, within the first six months; 15.2% vs 4.8% at 6 – 8 weeks and 24.1% vs 11.6% at 3 – 4 months. In the present study, reasons for introducing formula feeding were linked with insufficient breast milk and employment purpose, for both HEU and HUU

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groups. Factors affecting optimal breastfeeding practices were stated to be the perception of inadequate supply of breast milk, needing to return to work (Siziba *et al.*, 2015) and prenatal depression (Tuthill *et al.*, 2017). Besides, the prevalence of mixed feeding was significantly lower in the HEU group compared to their HUU counterparts. Studies reported similar results among South African women living with HIV compared to their HIV-uninfected counterparts; 30.5% vs 86.2% (Ellis, 2013) and 11% vs 63% (Ghuman *et al.*, 2009), respectively. Muluye *et al*. (2012) stated 10.5% rates among HEU group. Also, the lower rates (23.1%) among HIV-positive mothers were recently reported in Ethiopia (Belay and Wubneh, 2019). Unsurprisingly, high rate of mixed feeding (70%) was reported in the country among HIV-uninfected mothers (Siziba *et al*., 2015). But, the common rates between the groups were also reported in South Africa (Nieuwoudt *et al*., 2018). The possible reason for lower mixed feeding rates among HEU group might be because of the counselling offered through PMTCT programmes on safe infant feeding practices (Goga *et al.*, 2012) and possibly the maternal fear of infecting the child.

5.5 COMMON COMPLEMENTARY FOODS IN THE STUDY POPULATION

The section's objectives were to determine food items consumed by six-months-old infants in the study community and compare between HEU and HUU infants. Majority of infants in the study population were already introduced to complementary feedings while a few (11%) delayed. This finding is in accordance with 90.7% documented in Tanzania (Hussein, 2005), except a few that only received either formula or breast milk. Findings differed from those in Ethiopia, 60.5% rate of food intake, and 21% delayed commencement of complementary foods (Semahegn *et al.*, 2014). The difference might speak to the improved knowledge of the timely initiation of complementary feeding among South African women. Semahegn *et al*. (2014) and Rao *et al*. (2011) indicated that the common reason for delayed initiation of complementary feeding is the mother's perception that their breast milk is adequate for the baby. Literacy has also been associated with the introduction of complementary feeding (Rao *et al*., 2011). Delayed initiation and insufficient quantity of complementary feeding are associated with poor nutritional outcomes (Duggal *et al.*, 2020). According to Areja *et al.* (2017), a significant contributor to child malnutrition is inappropriate complementary feeding.

There was no literature found on the comparison of rates of intake of complementary foods between HEU and HUU infants. A significantly higher proportion of HUU infants consumed

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commercial infant cereals in contrast to their HEU counterparts. Multiple South African studies reported higher consumption of commercial infant cereals at six months of age; 70% (Swanepoel *et al.*, 2019); 92% (Budree *et al.*, 2017) and those without consumption statistics (Faber, 2005; Goosen *et al.*, 2014; Mushaphi *et al.*, 2008; Sayed and Schönfeldt, 2018). High intake was also reported in Ghana (80.9%) (Abizari *et al.*, 2017). The findings differed in both HEU and HUU groups to those noted (23.4%) by Faber and colleagues (2016). The possible reason for lower intake among HEU infants might be due to the cost of these food items as HIV-infected mothers were found to be economically disadvantaged (section 5.2). Consumption hinge on affordability (Katepa-Bwalya *et al.*, 2015). Underprivileged families cannot afford the cereal-based complementary foods (Dewey and Brown, 2003; Owino *et al.*, 2008; Shisana *et al.*, 2013). Besides, the consumption of fresh fruits and vegetables was higher among HEU infants. This is consistent with those reported in Ethiopia (37.4%) (Haile *et al.*, 2015) and Uganda (40.3%) (Bukusuba *et al.*, 2009) among infants of HIV-positive mothers. High intakes of fruits (53.5%) and vegetables (36%) were previously reported in the country (Mushaphi *et al.*, 2008). But lately, the intakes were said to be inadequate (Faber *et al*., 2016; Goosen *et al.*, 2014; Ntila *et al.*, 2017). Fruits; bananas and oranges were stated as the common complementary foods in South Africa (Faber *et al.*, 2016; Ntila *et al.*, 2017) and Zambia (Katepa-Bwalya *et al.*, 2015) Faber *et al*. (2016) and Ntila *et al*. (2017) also reported regular intakes of butternut. Consumption of sweet potato among HEU infants as a weaning food was reported in Malawi (Parker *et al.*, 2011).

The introduction of bottled or jarred baby food did not differ between the groups. The HEU infant's findings were in line with those observed (28%) by Swanepoel and colleagues 2018. Faber *et al.* (2016) also marked the popular consumption of jarred baby foods.

Maize meal and sorghum porridge intakes did not differ between the HEU and HUU groups. The duo is described as traditional weaning foods in sub-Saharan Africa, and Tanzania, Ghana, Benin, Kenya and Nigeria (Kayodé *et al.*, 2006). The findings for maize meal porridge intake are common to 23% (Swanepoel *et al.*, 2018) and 20% (Budree *et al.*, 2017) reported in the country. Higher consumptions have been exceedingly reported in South Africa: sorghum porridge (71.7%) and maize meal porridge (45.3%) (Mamabolo *et al.*, 2004), 88.7% (Ntila *et al*., 2017), 69.6% (Faber *et al*., 2016), and 71% (Mushaphi *et al*., 2008). Maize meal is the most available and affordable food item (Owino *et al.*, 2008). Enrichment of porridges with either sugar, peanut butter, breast

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milk substitutes, oil, or margarine is common in South Africa (Faber, 2005), Zambia (Katepa-Bwalya *et al.*, 2015; Owino et al., 2008) and Nigeria (Sadoh *et al.*, 2008).

There was no statistical difference between the HEU and HUU infants regarding consumption of juices and tea, savoury snacks and biscuits. One South African study noted an increased intake of salt and sugar-containing snacks in both HEU and HUU infants (Rossouw *et al.*, 2016). Juice intake (13%) was described by Budree *et al.*, 2017. Findings differed to those reported by Ntila *et al*., 2017; 67% tea, 13.2% savoury snacks and 24.5% biscuits intakes and Mushaphi *et al*., 2008; 30% chips or sweets. Faber *et al*., 2016 also noted high intake of salty snacks. In other studies, intake of infant snacks such as biscuits was not observed, excluding 3% of baby juice intake (Swanepoel *et al*., 2018). The possible reason for the difference in the study outcomes might be because of the cost of these commercial infant snacks. The low or non-consumption of animal food sources among six-months-old HEU infants was reported in Tanzania (Williams *et al.*, 2016), Malawi (Parker *et al*., 2011) and Ethiopia (Haile *et al*., 2015).

5.6 THE TOTAL NUTRIENT INTAKE, INTAKE WITHIN THE GROUPS AND THE COST OF DIET AND NUTRIENT INTAKE OF HEU VS HUU INFANTS

The objectives involved the determination of infant's nutrient intake using the SAMRC FoodFinder program™ and compare the cost of foods and nutrient intake of HEU vs HUU infants. The summary of nutrients intake indicated low intake of the complementary foods by six months infants in the study community. A South African study that determined the nutrient density of the complementary diet reported higher medians (IQR) for macronutrient (except upper IQR) and some micronutrient values (Swanepoel *et al.*, 2018). The complementary diet was comprising commercial infant products such as infant cereals, bottled baby foods, juices and breast milk substitutes added to food. So, the findings might seem to be similar upon conversions. However, the inclusion of breast milk substitutes feeds in the present study make it different from that of Swanepoel and co-workers. It is believed that high upper IQR of macronutrients in the present study speaks to the inclusion of breast milk substitutes feeds. In the same study, the nutrient content of the complementary diet comprising fortified maize meal porridge (excluding breast milk substitutes feeds) was also higher than the present findings with similar values as above for carbohydrates and fat. These following nutrients values seemed to be similar; zinc, iron, vitamin C and vitamin B_{12}, to those reported by Swanepoel et al., 2018. Further, the study findings are

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likely to be consistent with those reported in Bangladesh in terms of iron, zinc and vitamin B_{12} (Kimmons *et al.*, 2005).

The complementary diets of infants in the study had low nutrient density despite predominant intake of commercial infant cereals and bottled baby foods in both HEU and HUU infants. This is unforeseen, taking into consideration also the mandatory fortification of maize meal with micronutrients in South Africa. The possible reason for the low nutrient density of these food items forming a complementary diet might be because of the addition of excess water to obtain soft texture for easy swallowing. The consumption of insufficient amounts due to typical feeding of diluted commercial infant cereals was described by Faber and Benadé (2001), Oelofse and co-workers (2002) and Faber and co-workers (2016). The cost of these food items was also mentioned as the contributing factor to improper preparations (Faber *et al*., 2016). Faber and Benadé (2007) described soft maize meal porridge as a low nutrient density and bulky food item. The typical dilution of maize meal with water to get a thin consistency was associated with further lowering the nutrient density of this food item (Faber, 2005). Also, maize meal contains high levels of phytate, which inhibit the absorption of zinc, iron and calcium (Gibson *et al.*, 2010).

Interestingly, the findings indicated nonsignificant differences for most of the nutrient intakes between the HEU and HUU infants except for iron and vitamin C. The intake of iron and vitamin C was lower among HEU infants compared to their HUU counterparts. The difference in intakes of these nutrients may be related to the low rate of consumption of commercial infant cereals by HEU infants. It was testified that commercial infant products contribute to 94% of iron intake at the period of six months (Swanepoel *et al*., 2018). An American study reported high median intake of iron (15.2mg (11.3, 20.8)) among HEU infants consuming infant cereals (Neri *et al.*, 2017).

There is limited or no documentation on nutrient intakes of HEU infants. Still, it is believed that the study findings are in line with the results documented by Swanepoel *et al.* (2018) on total nutrient intakes of six months infants. It is further indicated that the cost per nutrient differed only for iron and vitamin C between HEU and HUU infants. It is discovered that there is a correlation between nutrient intake and cost. The more the nutrient intake, the higher the cost of the nutrient, and vice versa. Differences in the cost of iron and vitamin C correlate to the differences in intakes of these nutrients between the HEU and HUU infants. Likewise, the universal costs for nutrients correspond to undifferentiated nutrient intakes between the groups. These differences in the cost

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of iron and vitamin C may be associated with the cost of commercial infant cereals. Oppositely, one American study, although it focused on two years and above children, mentioned fruits and vegetables as the cheapest source of vitamin C (Hess *et al.*, 2019). There is little documentation on the cost of nutrients in a complementary diet.

The findings showed that no significant differences between the HEU and HUU infants in terms of the daily cost of the diet. Argumentatively, this is implausible considering the high consumption of commercial infant cereals among HUU infants and given that these food items are costliest (Faber *et al*., 2016), as well as lower iron and vitamin C intakes by HEU group. It is well known that iron is vital during infancy; a sensitive period of rapid brain development, thus ensures optimal neurological and cognitive development (McCarthy and Kiely, 2019) and their functioning. Iron is highly essential for haemoglobin (Hb) synthesis at this early age (Wang *et al.*, 2019), and plays a crucial role in growth and development of multiple organ systems (McCarthy and Kiely, 2019). Vitamin C enhances iron absorption and builds and strengthens the infant's immunity. Also, vitamin C influence early brain development and stringently control the body's homeostasis processes (Tveden-Nyborg and Lykkesfeldt, 2009).

An in-depth view on the cost of diets of the two groups gives an impression that HEU infant's cost of diet was high compared to their counterparts (ZAR 40.60 ± 41.72 vs ZAR 29.50 ± 31.10; $p = 0.43$). This considers the aforementioned lower micronutrient intake among HEU infants. It is believed that there is inequity in the cost of diet between HEU and HUU infants. Iron intake may affect the overall cost of the diet. The HEU infant's diet cost does not equate to the micronutrient intakes; the caregivers of HEU infants spent more on less iron and vitamin C intakes. Possibly the inclusion of the breast milk substitutes feeds may be accountable for this discrepancy. However, for the sake of consistency and absoluteness, the study report will rely on statistically significant differences. A Kenyan diet for 6 – 8 months old infants was estimated to cost a total of ZAR 17.04[a] overall upon currency conversions[b] (Save the Children, 2017). According to Save the Children (2017), the mentioned diet cost was the highest, and higher iron requirement of 6 – 8 months infants was identified to be accountable for the high cost of the diet. The use of local food items

[a] This was the sum for cost of energy only (EO); 4 KES (Kenyan Shilling) (ZAR 0.50), nutritious (NUT); 72 KES (ZAR 9.10) and food habits nutritious (FHAB); 59 KES (ZAR 7.44)
[b] The currency conversions are as of June 2017 at the exchanges rate of ZAR 0.1261. Currency Converter available at https://currencies.zone/chart/kenyan-shilling/south-african-rand (Accessed: 17/09/2020)

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as complementary foods may be attributed to lower diet cost compared to the present findings. The documentation on the cost of a diet of six months infants is scarce.

5.7 COMPARISON OF NUTRIENT CONTENT AND COST BETWEEN COMMON COMPLEMENTARY FOOD ITEMS

Commercial infant cereals were the most nutrient-dense food item, and the nutrients were costliest compared to maize meal porridge and sorghum porridge. However, only calcium, iron, vitamin B_{12} and vitamin C contents and their cost, including of zinc, differed significantly between commercial infant cereals and sorghum porridge. A South African study reported that commercial infant products have a high content of iron (contributing to 94% of iron intake) and all essential nutrients, as well as protein and carbohydrates (Swanepoel *et al.*, 2018). In the same study, the fortified maize meal porridge was reported to contribute less than 33% of micronutrients to the total nutrient intake (Swanepoel *et al.*, 2018). The maize meal porridge had low nutrient content despite mandatory fortification and is the cheapest complementary food item. It was mentioned that the maize meal mandatory fortification has a small impact on infant nutrition because of the consumption of tiny quantities of maize meal porridge by infants (Faber, 2005).

The comparison between bottled baby foods and fresh fruits and vegetables indicated nonsignificant differences in nutrients content except for carbohydrates and vitamin C, and their cost, which were high in bottled baby foods. Surprisingly, the cost per day of protein, calcium, iron and zinc were high in bottled baby foods despite their equal nutrient density between the two food items. The findings were conflicting to those reported by Kapica and Weiss (2012), that canned food items such as fruits and vegetables have a lower cost per gram of nutrient comparative to when fresh. Besides, it was stated that canned baby foods have a low contribution (below 15%) to the overall micronutrient intakes (Faber, 2005). There is limited literature on the cost of nutrients within complementary food items.

5.8 PREVALENCE OF NUTRIENT INTAKE ADEQUACY

The vitamin B_{12} intake was sufficient in both groups, with higher percentage among HUU infants. The percentage of adequate energy and micronutrient intakes were satisfactory in the study population. The percentage of adequate intake of protein and carbohydrates were low in both groups, and fat had the lowest intake rate. The findings are in line with those reported in Guatemala

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by Vossenaar and Solomons (2012), in which children aged 6 – 24 months had an adequate intake of vitamin C and vitamin B_{12}. Unlike the present findings, the intakes of iron and calcium were low in Vossenaar and Solomons (2012) study. The findings are dissimilar to Swanepoel and colleagues (2018) findings as low rates of adequate iron (61.5%), and zinc (46.6%) intakes were reported in their study. A Malawian study that was comparing nutrient adequacies between HEU and HUU infants reported similar results for adequate energy and low-fat intakes; however, protein and carbohydrates were adequate while the percentage of zinc (23%) and iron (19%) intakes were low (Parker *et al.*, 2013). Another study in Zambia reported the same findings for energy among 6 – 8 months old infants (88%), but iron (33%) and calcium (30%) intakes were low (Owino *et al.*, 2008). A larger gap of iron intake in developing countries has been stressed by Dewey and Vitta (2013) but we found iron intake to be adequate.

5.9 STRENGTHS AND LIMITATIONS OF THE STUDY AND SUGGESTIONS FOR FUTURE STUDIES

The study determined the estimated daily cost of the complementary diet of HEU-exposed infants; who are likely to be vulnerable to food insecurities and are reported to be at greater risk of poor development (Chandna *et al.*, 2020). The researcher obtained information or responses from caregivers about complementary foods and ways to enrich family foods given to infants, through the infant's 24-hour recall. High dropouts of the Siyakhula study participants, limited the analysis, resulting in biased study population characterised by high HIV-negative participants. It is believed that imbalance in study participants influenced the study outcomes. The inclusion of breast milk substitutes might have limited precision for the determination of the estimated cost of complementary diets. Future studies should also consider using the Cost of the Diet (CotD) software designed by Save the Children, to estimate the cost of the complementary diet, and fully determine the factors and extent to which they affect the cost.

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CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

The daily cost of feeding a six-months-old infant residing in an HIV-exposed, as well as unexposed environment was derived. To some degree, the study has filled the gap of lack of knowledge on the estimated cost of diet for these infants. The estimated cost of diet will enhance informed decisions on food choices and complementary diet planning, as it allows identification of food items contributing to nutrient-dense diet and their cost, including food items that contribute to high cost but delivering low nutrients. There are no differences in terms of the cost of feeding (diet) HIV-exposed and -unexposed infants, however, the nutrient intake varies, lower iron and vitamin C intake were noticed among HIV-exposed infants than their counterparts. Besides, the costs of nutrient intakes were the same between HEU and HUU infants, except for costs of iron and vitamin C intakes. It is believed that there is inequality in terms of cost of diet between the groups, HEU infant's caregivers spent more on less iron and vitamin C intakes. However, it is the mother's choice of what to feed the infant, and several factors influence this choice. It is also concluded that the maternal HIV-infection has an impact on the infant's diet and ultimately, low iron intake. The feeding patterns established in the early complementary feeding phase is likely to influence later feeding practices. While the six-month time point for this assessment is early and probably not nutritionally relevant at that stage except in contexts of insufficient milk feeds, the information gathered in this study is crucial in understanding the feeding patterns in the early complementary feeding phase. A recommendation for further research would be to redo this research later point, together with the measuring of child anthropometry and growth

Furthermore, breastfeeding practices are suboptimal, with increased reliance on commercial breast milk substitutes, despite the given science-based evidence on benefits, and WHO breastfeeding guidelines are overlooked. Programs aimed at promoting and supporting breastfeeding should be strengthened to ensure adherence to the WHO breastfeeding guidelines, hence ensuring optimal growth and development of future leaders of South Africa. Based on the cost and nutrient density findings, commercial infant cereals are strongly recommended as a major part of the complementary diet to suffice infant nutrition. Maize meal porridge has a lower nutritional efficacy for infants; even with high intakes, the infant's nutrients demand will not be met, hence not appropriate to be used as a complementary food item. Diverse diets are, therefore, encouraged. Additionally, the use of commercial infant cereals may be cost-effective as they have high nutrient density.

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Key points

- No variances were found between HEU and HUU infants regarding the cost of diet, but iron and vitamin C intakes were lower among HEU infants compared to their HUU counterparts.

- The zinc, iron and calcium intakes from dietary intake, were adequate among six-months-old HEU and HUU infants.

- Commercial infant cereals may improve nutrient intake at age six months, but due to their high cost, diet diversification is highly encouraged to ensure adequate infant nutrition.

- Suboptimal breastfeeding practices show that more effort is required to strengthen support and promote breastfeeding.

- Mixed feeding is uncommon among HIV-infected women, and this may be attributed to counselling provided by PMTCT programmes

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APPENDIX A: LISTS OF FOOD PRICES

SAUCES, COFFEE, TEA, SUGAR	PICK AND PAY	CHECKERS	SHOPRITE
Instant coffee Ricoffee	26.99/ 150g	36.99 / 250g	36.99/ 250g
Cremora	34.99/ 750g	29.99/ 750g	28.99/ 750g
Ellis Brown	33.99/ 800g	32.99/ 800g	32.99/ 800g
Milo	33.99/ 250g	54.99/ 500g	32.99/ 250g
Nesquik	35.99/ 500g	29.99/ 250g	29.99/ 250g
Drinking chocolate powder	38.49/ 250g	37.99/ 250g	49.99/ 500g
Brown suger	17.99/ 1kg	32.99/ 2kg	33.99/ 2kg
White sugar	18.99/ 1kg	34.99/ 2.5kg	36.99/ 2kg
Syrup, golden	29.99/ 454g	19.99/ 300g	23.99/ 300g
Rooibos	25.99/ 20's	25.99/40's (100g)	31.99/ 40's
Tea, normal	16.99/ 200g	14.99/ 32's	15.99/ 20's
Amadumbe			
Apple, dried	12.99/ 46g	29.99/ 125g	
Jelly powder	8.99/ 80g	7.99/ 80g	7.99/ 80g
Pilchard in brine	26.99/ 120g	14.99/ 120g	14.89/ 120g
Pilchard in tomato sauce	19.99/ 400g	19.99/ 400g	19.99/ 400g
Sardine canned in oil	26.99/ 120g	14.99/ 120g	16.99/ 120g
Sardine canned in tomato sauce	22.99/ 120g	13.99/ 120g	16.99/ 120g
Tuna canned in oil	23.99/ 170g	14.89/ 170g	16.89/ 170g
Baked beans (canned)	11.49/ 410g	8.99/ 410g	8.99/ 410g
Haricot beans	20.99/ 500g	17.99/ 500g	35.99/ 1kg
Lentils	16.99/ 500g	19.99/ 500g	23.99/ 500g
Soybeans dried	20.99/ 500g	19.99/ 500g	26.99/ 500g
Sugar beans	40.99/ 1kg	19.99/ 500g	32.99/ 1kg
French salad dressing	22.99/ 340ml	23.99/ 340ml	28.99/ 340ml
Mayonnaise	37.99/ 750g	29.99/ 750g	27.99/ 750g
Gravy powder	14.99/ 125g	14.99/ 125g	16.99/ 250g
Soup mix	12.99/ 200g	3.49/ 50g	21.99/ 500g
Soya mince e.g knorrox	23.49/ 400g	15.99/ 200g	17.99/ 200g
Achar, mango	28.99/ 380g	24.99/ 400g	18.99/ 380g
Tomato paste	5.29/ 50g	9.99/ 115g	3.99/ 50g
Tomato puree	23.49/ 410g	19.99/ 800g	17.99/ 410g
Tomato sauce	26.99/ 700ml	24.99/ 700ml	26.99/ 700ml
Soup powder (packet soup)	4.99/ 50g	4.79/ 50g	4.99/ 55g
Soup Jabula powder	14.49/ 500g	4.59/ 50g	4.89/ 50g
SNACKS			
Chipniks	14.99/ 125g	15.99/ 125g	15.99/ 125g
NikNaks	9.99/ 135g	9.99/ 135g	9.99/ 135g
Peanuts, roasted, salted	18.99/ 150g	18.99/ 150g	18.99/ 150g
Popcorn, plain	69.99/ 6 *100g	29.99/ 3*91g	
Popcorn sugar coated/ candied	16.99/ 100g	9.99/ 80g	
Potato crisps	16.99/ 125g	15.99/ 125g	9.99/ 125g
SNACKS	**PICK AND PAY**	**CHECKERS**	**SHOPRITE**

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Sweets, chocolate, milk	26.99/ 375g	11.99/ 100g	15.99/ 125g
Sweets, fudge/toffee/caramel	19.99/ 1kg	7.99/ 100g	8.99/ 375g
Sweets, hard boiled and soft jelly type	16.99/ 120g	17.99/ 100g	15.99/ 100g
Sweets, marshmallows	50.99/ 792g	12.99/ 150g	14.99/ 150g
Cookies, commercial, plain (Marie)	8.99/ 200g	10.99/ 200g	10.99/ 200g
Cookies. Commercial, with filling	9.99/ 200g	15.99/ 200g	8.99/ 200g
Cookies, shortbread	43.99/ 450g	39.99/ 500g	36.99/ 450g
Fish paste			
Jam	23.99/ 600g	19.99/ 450g	21.99/ 900g
Peanut butter, smooth style	29.99/ 400g	29.99/ 400g	29.99/ 400g
MILK AND DIARY			
Milk powder, full fat (Klim)	61.49/599g	54.79/500g	134.99/900g
Milk powder, goat	187.99/400g		
Milk powder low fat		49.99/400g	
Milk powder skim			
Milk flavoured, low fat	26.99/1L	27.99/L	11.99/350ml
Milk full fat	13.99/1L	17.99/L	18.99/L
Milk low fat/2% fat	11.99/L	9.99/L	18.99/L
Cheese spread full fat	45.99/250g	34.99/250g	17.99/100g
Cheese chedder	29.99/200g	89.99/750g	38.99/300g
Cheese, goat, soft type		89.99/500g	
Holsum	7.99/25g		
Ultramel cusatard	30.99/1L	29.99/L	27.99/L
Buttermilk any	13.99/500ml	19.99/L	13.99/500g
Cream any	22.49/250g	19.27/250g	31.99/1kg
Ice cream, vanilla any	44.99/2L	54.99/1.5L	54.99/1.8L
Maas/ sour milk	29.99/2L	27.99/2L	27.99/2L
Mahewu/Magou	15.99/1L	14.69/L	14.69/L
Margarine,brick/hard	28.99/500g	14.99/500g	13.99/500g
Margarine, polyunsaturated	25.99/500g	29.99/500g	23.99/500g
Yoghurt, drinking, low fat, flavoured, sweetened	39.99/2L	24.99/385g	29.99/kg
Yoghurt fruit low fat sweetened	26.99/1kg	26.99/kg	34.99/kg
Yoghurt plain low fat	15.99/500g	29.99/kg	19.99/500g
Yoghurt, whole milk, plain	32.99/1kg	9.99/150g	18.39/500g
MEAT AND DAIRY			
Chicken liver	10.99/250g	13.99/ 250g	11.49/ 250g
Chicken pieces	69.99/ 2kg	62.99/ 2kg	72.20/ 2kg
Chicken feet	12.99/ 1kg	12.99/ 1kg	26.99/ 1kg
Chicken giblets	17.99/ 400g	16.99/ 400g	24.99/ 800g
Chicken heat	12.99/ 1kg	12.99/ kg	10.79/ 1kg
MEAT AND DAIRY	**PICK AND PAY**	**CHECKERS**	**SHOPRITE**

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Egg	47.99/ 30's	62.99/ 30's	47.99/ 30's
Fish, low fat		43.48/ 0.6kg	51.99/ kg
Fish, medium fat		70.67/ 0.5kg	49.99/ 800g
Bacon	28.99/ 200g	34.99/ 200g	32.99/ 200g
Beef kidney		22.19/ 1.6kg	
Beef liver		21.87/ 0.5kg	19.20/0.4kg
Beef lung			
Beef patty		9.99/ 100g	39.06/0.4kg
Beef tripe		54.03/0.7kg	27.90/0.3kg
Beef chuck	50.00/0.6kg	73.26/ 0.8kg	60.65/0.6kg
Beef minced	41.23/0.43kg	38.71/0.5kg	31.28/0.4kg
Beef minced lean	45.20/0.46kg	80.36/0.8kg	33.04/0.4kg
Beef rib	35.71/0.37kg	50.71/0.6kg	58.70/0.6kg
Beef rump	32.99/ 0.3kg	10.99/100g	104.47/1.3kg
Beef stew meat	154.63/2kg	121.10/1.5kg	91.83/1kg
Mutton curry		108.67/1kg	122.39/1.5kg
Mutton leg	68.95/0.4kg	13.99/100g	146/1.5kg
Mutton shoulder	110.35/0.7kg	113.29/1kg	52.62/0.4kg
Mutton stewing meat	100.12/0.6kg	149.87/1kg	110.87/1,5kg
Offal/ tripe		55.37/0.8kg	10.79/0.7kg
Porl leg	76.71/1kg	8.49/100g	65.59/1kg
Sausage, beef & pork	44.99/375g	54.99/375g	
Sheep lung			
Corned beef	18.99/300g	22.99/300g	22.99/300g
Frankturter	34.99/500g		
Ham,slice	91.99/450g	42.99/300g	41.99/300g
Polony	32.99/1kg	24.99/750g	24.99/750g
Russian	61.99/950g	59.99/500g	54.99/500g
Vienna	59.99/1kg	24.99/500g	24.99/500g
BAKERY			
Muffin, plain	27.99/4's	24.99/4's	19.99/pack
Brown bread	12.99/700g	12.49/700g	13.99/700g
Rye bread	17.99/ each	16.99/each	13.99/ each
White bread	13.99/700g	13.59/700g	14.99/700g
Plain sponge cake	79.99/each		
Scone, plain	14.99/6's	7.99/10's	16.99/pack
Vetkoek	16.99/6's	15.99/6's	
FRUITS			
Apple	34.99/1.5kg	32.99/1.5kg	29.99/1.5kg
Apricot	34.99/500g		
Avocado	49.99/2's	46.99/2's	16.99/smll
Banana	17.99/1.5kg	17.99/kg	12.99/kg
Grape	35.99/500g	29.99/500g	14.99/500g
Grapefruit	35.99/500g	19.99/300g	39.99/kg
FRUITS	**PICK AND PAY**	**CHECKERS**	**SHOPRITE**

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Mango	32.99/2's	28.99/bag	6.99/smll
Melon	69.99/large	49.99/smll	49.99/med
Naartjie		49.99/2kg	
Orange		6.99/med	29.99/kg
Pawpaw	19.99/2's	32.99/2's	32.99/2's
Peach	34.99/750g	19.99/kg	19.99/kg
Pear	23.99/kg	24.99/kg	17.99/1.5kg
Plum	39.99/750g	18.99/kg	34.99/kg
Strawberry		44.99/250g	
Beetroot	12.99/kg	11.999/kg	9.99/kg
Brinjal	18.99/kg	19.99/kg	
Butternut	37.99/3kg	14.99/500g	9.99/smll
Cabbage	15.99/med	16.99/med	18.99/ med
Carrot	13.99/750g	7.99/500g	9.99/kg
Gem squasch	22.99/4's	15.99/kg	12.99/med
Green beans	29.99/300g	24.99/600g	21.99/300g
Green pepper	37.99/1.5kg	9.99/2's	13.99/500g
Imifino/marog	12.99/pck	14.99/pck	
Lettuce	17.99/med	18.99/med	16.99/med
Mealie	16.99/400g	14.99/400g	14.99/400g
Mixed vegetables	21.99/500g	29.99/kg	29.99/kg
Onion	29.99/2kg	14.99/kg	6.99/kg
Peas	39.99/kg	32.99/kg	9.99/250g
Potato	59.99/7kg	46.99/7kg	12.99/kg
Pumpkin		16.99/500g	21.99/smll
Spinach	12.99/ pck	29.99/400g	13.99/pck
Sweet potato	22.99/500g	21.99/kg	21.99/kg
Tomato	18.99/750g	32.99/2kg	17.99/kg
BABY FOODS			
Nan Pelargon 1	147.99/900g	142.99/900g	74.99/400g
Infacare classic 1	44.99/400g	121.99/900g	121.99/900g
Infacare classic 2	44.99/400g	121.99/900g	121.99/900g
Infacare classic 3	44.99/400g	121.99/900g	121.99/900g
Infasoy 1	169.99/900g		
IsomilA® 1	189.99/850g	162.99/850g	87.99/400g
Lactogen 1	48.99/400g	109.99/900g	109.99/900g
Lactogen 2	48.99/400G	109.99/900g	109.99/900g
Lactogen 3	48.99/400g	109.99/900g	109.99/900g
Melegi	119.99/900g	109.99/900g	44.99/400g
Nan 1	168.49/900g	164.99/400g	164.99/900g
BABY FOODS	**PICK AND PAY**	**CHECKERS**	**SHOPRITE**

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NIDO 1+	70.99/400g	67.99/400g	78.99/500g
PreNan	221.99/800g	209.99/800g	198.99/800g
Prosobee			
S-26 Classic 1	159.99/900g	175.99/900g	156.99/900g
S-26-Infagro	159.99/900g	175.99/900g	175.99/900g
S26-Preemie	183.49/900g	175.99/900g	156.99/900g
SAM	159.99/900g		
Baby fruit juice	8.99/200ml	9.99/200ml	8.99/200ml
Cream of maize (Purity)	20.99/400g	19.99/400g	19.99/400g
Mabella soft porridge (Purity)	17.49/350g	16.99/350g	16.99/350g
Cerelac	36.99/250g	34.99/250g	34.99/250g
Nestum 6 months	21.99/250g	24.99/250g	17.99/250g
Nestum 7 months	21.99/250g	24.99/250g	17.99/250g
Purity - 125ml jar	9.99	9.99	9.99
- 200ml jar	12.99	12.99	12.99
- 250 ml jar	16.49	14.99	14.49
- 80 ml jar	9.99	8.99	8.99
BREAKFAST CEREALS			
Mabella	17.99/kg	17.99/kg	17.99/kg
Morvite	18.99/kg	21.99/kg	21.99/kg
Oats	33.99/kg	39.99/750g	42.99/kg
Tastee wheat	41.499/500g	34.99/500g	17.99/400g
Maltabella	33.99/kg	29.99/kg	32.99/kg
Corn flakes	44.99/kg	49.99//750g	49.99/750g
Future life smartfood for kids	35.30/500g	24.99/250g	37.99/500g
Pronutro Great Start	42.49/500g	23.99/250g	42.99/500g
Pronutro high energy	42.49/500g	23.99/250g	42.99k500g
Weet-bix	45.99/900g	45.99/900g	17.99/450g
MAIZE MEAL AND PASTE			
Sunflower oil	17.99/750ml	19.99/750ml	16.99/750ml
Macaroni	15.99/500g	9.89/500g	10.99/500g
Noodle	5.49/73g	4.39/85g	4.99/78g
Spaghettie	16.99/500g	14.99/500g	14.99/500g
Maize meal, Ace Instant	19.99/kg	39.99/5kg	39.99/5kg
Maize meal, special	39.99/5kg	36.99/5kg	69.99/10kg
Maize meal,super,porridge,stiff	33.99/5kg	44.99/5kg	44.99/5kg
Samp	10.99/500g	8.79/500g	8.99/500g
JUICE AND COOL DRINK			
Apple juice, Liquidfruit/Ceres	21.99/L	16.99/L	21.99/L
Apricot juice, Liquidfruit	23.49/L	16.99/L	21.99/L
JUICE AND COOL DRINK	**PNP**	**CHECKERS**	**SHOPRITE**

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Dairy-fruit mix	22.49/L	21.79/L	21.79/L
Guava juice, Luid fruit/Ceres	21.99/L	22.99/L	21.99/L
Guava juice, sweetened	16.99/L	43.99/L	12.99/500mL
Mango and orange juice, Liquid fruit	23.49/L	16.99/L	21.99/L
Mango juice, Ceres	21.99/L	22.99/L	16.99/L
Naartjie juice, Ceres	21.99/L	22.99/L	16.99/L
Orange juice, canned, sweetened	41.99/L	21.99/1.5L	29.99/1.5L
Orange juice, fresh	18.99/L	16.99/L	12.79/330mL
Orange juice, Liquid fruit/Ceres	21.99/L	22.99/L	21.99/L
Peach and banana juice, Liquid fruit	23.49/L	16.99/L	21.99/L
Peach juice, Ceres	21.99/L	22.99/L	21.99/L
Pineapple juice, canned, unsweetened	34.99/L	21.99/1.5L	19.99/2L
Fizzy drink, coke	21.99/2L	21.99/L	19.99/2L
OROS	38.99/2L	35.99/2L	39.99/2L

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APPENDIX B: QUESTIONNAIRES

SECTION A
Maternal and infant postpartum questionnaire
BREASTFEEDING PRACTICES

1. Did you ever breastfeed or try to breastfeed your baby, even if only for a single feed?
☐ Yes → Skip to question 3
☐ No
☐ Prefer not to answer → Skip to question 5

2. If no, why was this? Select all that apply
☐ Personal choice → Skip to question 11
☐ Personal circumstances (e.g., other demands, return to work) → Skip to question 11
☐ You were unwell → Skip to question 11
☐ Baby was too small or unwell → Skip to question 11
☐ Didn't think you had enough milk → Skip to question 11
☐ Lack of support/resources → Skip to question 11
☐ Other reason: Please specify: ______________________________ → Skip to question 11
☐ Prefer not to answer → Skip to question 13

3. How soon after birth was your baby first put to the breast? ***(SKIP IF NO TO question 1)***
_______ minutes or _________ hours after birth
☐ Never (baby was fed pumped milk)
☐ Prefer not to answer

4. Has your baby ever been fed breast milk from a bottle?
☐ Yes
☐ No
☐ Prefer not to answer

5a. At how many weeks or months after birth is <u>this</u> follow up visit occurring?
☐ 6 weeks postnatal *or* ☐ 14 weeks postnatal *or*
☐ 6 months postnatal *or* ☐ 9 months postnatal *or*
☐ 12 months postnatal *or* ☐ 24 months postnatal

5b. Thinking about the time between when your baby was born and now (this visit), how did you feed your baby <u>from birth until now?</u> (For example, if this visit is occurring at approximately 14 weeks after your baby was born, how did you feed your baby from birth until 14 weeks of age?)
☐ Breast milk only <u>directly from the breast</u> (*no* expressed breast milk and *no* formula feeding) from birth to baby's current age
☐ Breast milk only with some feeding directly from the breast and some from expressed breast milk (e.g.: expressed using your hand or a pump) before baby's current age, but *no* formula feeding up to baby's current age
☐ Breast milk and formula feeding (baby received some formula before his/her current age but still received some direct or expressed breast milk at his/her current age)
☐ Formula feeding only (baby did not receive any breast milk between birth and his/her current age)

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6. Are you currently breastfeeding your baby or giving your baby expressed breast milk?
☐ Yes
☐ No → Skip to question 8
☐ Prefer not to answer → Skip to question 13

If yes, is your baby currently receiving breast milk <u>only</u>?
☐ Yes → Skip to question 13
☐ No, my baby receives both breast milk and formula
☐ Prefer not to answer

7. Which scenario best describes your baby's feeding?
☐ My baby receives infant formula most (80-100%) of the time.
☐ My baby receives breast milk most (80-100%) of the time.
☐ My baby receives both breast milk and formula equally.
☐ Prefer not to answer

8. How old was your baby when you stopped breastfeeding?
__________ days or _________weeks
☐ Prefer not to answer

9. How old was your baby when you introduced formula?
__________ days or _________weeks
☐ Prefer not to answer

10. What was the main reason for introducing formula?
☐ Breastfeeding took too long or was too tiring
☐ Needed to return to work
☐ Convenience or to allow others to feed
☐ To try and get baby to sleep through the night
☐ Insufficient milk to satisfy the baby
☐ Baby wouldn't suck because unwell or low birth weight
☐ Baby wouldn't suck for no apparent reason
☐ Baby irritable or colicky
☐ Baby not gaining weight
☐ Painful breasts or sore nipples
☐Mastitis or breast abscess
☐ Milk dried up
☐ The right time/age to change
☐ Other reason → (Please specify: ____)
☐ Prefer not to answer

11. What type of formula do you usually feed your baby?
☐ Cow's milk-based formula
☐ Lactose-free cow's milk-based formula
☐ Soy-based formula

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□ Other → (Please specify: ____)
□ Prefer not to answer

What is the specific brand and type of formula that you usually feed your baby? Indicate all that apply
____

12. What form of formula do you usually use?
□ Liquid ready-to-use
□ Powder concentrate (add water)
□ Prefer not to answer

13. Has your baby had any liquids other than breast milk or formula since his/her birth (even if it was a temporary supplement)? Other liquids include water, glucose water, evaporated milks, goat's milk, cow's milk, tea, rooibos tea or any other drink (including muthi). Any solids, like porridge, vegetables?
□ Yes → if yes, please specify: ____
□ No
□ Prefer not to answer

14. Does your baby receive any vitamins or supplement drops?
□ Yes
□ No
□ Prefer not to answer

15. If yes, which of the following? How often are you giving the vitamins or supplements?
□ Vitamin D drops → ________ times per (day, week, month)
□ Other (Please specify: ______________) → ________ times per (day, week, month)
□ Prefer not to answer

16. Has your baby ever taken any prescribed medications?
□ Yes → If yes, please specify: ____
□ No
□ Prefer not to answer

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SECTION B

FOOD COST QUESTIONNAIRE

Part 1: Socio-demographic questions

47. What is the average income for the household per month?
□ R0-2000
□ R2000 – R4000
□ R4000 – R6000
□ R6000 – R8000
□ More than R8000

48. What is the average income of the main source of income of the household per month?
□ R0-2000
□ R2000 – R4000
□ R4000 – R6000
□ R6000 – R8000
□ More than R8000

49. Does your household receive any income from grants?
□ Yes
□ No (**If No, go to question 52)**

50. What kind of grants? (Please answer the question by ticking in the brackets, tick all grants your household receive and the number of each.
□ Child Support Grant
□ Grant-in-Aid
□ Care Dependency Grant
□ Foster Child Grant
□ Social Relief of Distress
□ Grant for older persons
□ Disability grant
□ War veterans grant
□ Pension
□ Other: ___________________________

51. How many people are receiving grants in your household? _ ________________________

52. How many people are earning an income per month in your household?
□ One
□ Two
□ More than two
□ None
□ Other: ____

53. What is your partnership status?
□ Living with a partner
□ Not living with a partner

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54. How many children (under 18 years) are residing in your household? ______________________

55. How many are your own children? ________________________

56. Do you have any dependent individuals (above 18 years) living with you?
□ Yes, have dependent individuals living with me
□ No dependent individuals living with me. **Go to part 2**

57. How many dependent individuals are living with you? ____________________

Part 2: Food purchasing practices

58. Who usually does the grocery shopping in the house?
□ Me
□ My partner
□ Children
□ Other, specify: _________________________

59. Do you buy in bulk or on a daily basis when food is needed?
□ Bulk
□ Daily
□ Other: _________________________

60. Do you only buy food when the food is on special?
□ Yes
□ No
□ Sometimes

61. To which of these shops do you go to buy food?
□ Local producer (on street)
□ Big Hypermarket
□ Local Shop (e.g. OK/Shoprite/Boxer)
□ Other: _________________________
□ Not recorded

62. Why do you mostly choose these shops?
□ Distance from home
□ Prices
□ Quality
□ Other: _________________________
□ Not recorded

63. What can you say about the freshness of products i.e. fruits and vegetables at a local producer on the streets?
□ Fresh most of the times
□ Sometimes
□ Never
□ Other: _________________________
64. What is your main mode of transport?

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□ Walking
□ Public transport
□ Own car
□ Other: ________________________

65. How often do you use public transport (e.g. taxi) to the shops to buy food?
□ Most of the times
□ Sometimes
□ Never
□ Other: ________________________

66. What is the estimate taxi fare you pay to buy food? ____________________

67. Do you give your child any milk feeds?
□ Yes
□ No
□ Sometimes

68. What kind of milk feeds do you give to your child?
□ Cow's milk only
□ Formula milk only
□ Cow's milk and formula milk
□ Other: ________________________

69. What is the name of the formula milk you give to your child?
□ Nan pelargon
□ Infacare classic
□ Lactogen
□ Nan
□ NIDO
□ Milk powder (Klim)
□ Other: __________________

70. Why do you choose this kind of formula milk?
____

71. How much are you spending on (any) milk, either for the child or for the household per month?
□ Below R100.00
□ R100.00 to R200.00
□ R200.00 to R300.00
□ Above R300.00

72. Do you buy the formula in bulk, on a daily basis when needed, when on special?
□ Bulk
□ Daily
□ When on special

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SECTION C
24-HR DIETARY RECALL

Date: ________________

File number: [ ]

What day is it today?	1 = Monday	2 = Tuesday	3 = Wednesday	4 = Thursday	5 = Friday	

Greetings!

Thank you for giving up your time to participate in this study. I hope you are enjoying it so far. Here we want to find out what your baby is eating and drinking. This information is important to know as it will tell us how much and what types of food babies in the area are eating.

There are no right or wrong answers.

Everything you tell me is confidential.

Is there anything you want to ask now? Are you willing to go on with the questions?

I want to find out about everything your baby ate or drank yesterday, including breast milk and water. Please tell me everything your baby ate from the time he/she woke up yesterday, throughout the day and during the night. I will also ask you where your baby ate the food and how much he/she ate.

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File number:

Time of	What food and drink	How was it prepared?	How much was eaten	How much left?
Waking up to about 9 o'clock (breakfast time)				
Mid-morning (09h00 – 12h00)				
Lunch time (12h00 – 14h00)				
Afternoon (14h00 - 17h00)				
Supper time (17h00 – sunset)				
After supper; during the night				

Would you describe the food that your baby ate yesterday as typical of his/her usual food intake?	1 = Yes	2 = No	
If NO, please give the reason:			

END OF QUESTIONNAIRE

Thank you for completing this questionnaire. We really appreciate your participation in our study.

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APPENDIX C: CONSENT FORM

PATIENT / PARTICIPANT'S INFORMATION LEAFLET & INFORMED CONSENT FORM FOR A NON-INTERVENTION STUDY

STUDY TITLE: Assessment of factors impacting on foetal and infant immunity, growth, and neurodevelopment in HIV- and antiretroviral-exposed uninfected children

STUDY NAME: Siyakhula study

SPONSOR: The International AIDS Society

Principal Investigator: Prof Ute Feucht

Institution: University of Pretoria MRC

DAYTIME AND AFTER-HOURS TELEPHONE NUMBER(S):
Daytime numbers: 012 373 1082
Afterhours: 083 368 4995

DATE AND TIME OF FIRST INFORMED CONSENT DISCUSSION:

				:
dd	**mmm**	**ivy**		**Time**

Dear Patient

Dear Ms. / Mrs. ....

1) INTRODUCTION

We invite you to participate in a research study. We are doing research on factors that may influence the immune system (these are the cells of the body that fight infection), growth and development of children born to HIV negative women compared to HIV positive women. I am going to give you information about the study and invite you to be part of this research. If there is anything that you do not understand please ask me to explain. You should not agree to take part unless you are completely happy about all the procedures involved.

2) THE NATURE AND PURPOSE OF THIS STUDY

The aim of the research is to understand how mother's HIV infection influences the growth of the foetus (unborn baby) during pregnancy compared to HIV negative women. We also want to follow up your baby after birth to learn about the immune function, growth and brain development of babies from both HIV negative and HIV positive mothers.

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3) EXPLANATION OF PROCEDURES TO BE FOLLOWED

We are inviting all women from the Southwest Tshwane, with a pregnancy before 22 weeks, to participate in the research. We are looking for HIV negative and HIV positive women on treatment who are able to follow up at the clinic with their babies for 2 years after delivery. We will pay for your transportation to the clinic for the study.

If you agree to participate in the research, we will ask you to come for 3 visits for a sonar to Kalafong Hospital during your pregnancy. You will deliver your baby at Kalafong or Pretoria West Hospital. After delivery, we will ask to see you and your baby for 8 visits at Kalafong Hospital until the child is 2 years old. The following procedures will be done during pregnancy, delivery and after delivery.

3.1 The procedures for the mother

3.1.1 During pregnancy

- We routinely do one ultrasound (sonar) to see how far pregnant you are. More sonars are done if there are problems with the pregnancy. In this research, you will have a total of 3 sonars to look at any abnormalities and to see how the baby is growing.
- We will ask you questions about your health and social circumstances.
- The routine antenatal care clinical examinations and tests will be done as always.
- At each visit when you have a sonar done and around time of delivery, another test will be done with a specialised machine, which looks like a big scale. This test is done to see how your body changes and it measures how much fat and muscle you have. This test will also be done after your baby is born, when you are able to stand upright when you come for your 6 weeks visit. This measurement is not painful at all and it is not harmful to you or the baby.
- A small amount of blood, 30 millilitres (about 2 tablespoons), will be collected from your arm with a syringe, at 28 and 36 weeks. The blood will be sent for tests to look for markers of inflammation and other related biological factors. If you are HIV infected, blood will also be sent for antiretroviral drug levels – this is to see how much medicine is in your blood.
- We will also take vaginal swabs at 28 and 36 weeks. This sample will be tested to look for markers of inflammation and infections and other biological markers important for your health
- An oral glucose tolerance test (a test to look for abnormal blood sugar levels) is usually done in patients who have a high risk of diabetes. In this study, we will do this test in all women because, if the mother is diabetic, this can affect the growth of the unborn baby.

3.1.2 At delivery

- At delivery or just after birth, we will collect another 30 millilitres (about 2 tablespoons), of blood to look for markers of inflammation and other biological factors. In women who are HIV-infected, we will also test the amount of virus in your blood.
- After your baby is born, we will use a small needle to take blood from the umbilical cord to test for inflammation and other related biological factors important for the development of the baby, such as infection markers and growth factors.

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- We will also take a few small pieces of the placenta after delivery and we will test factors that are important for the development of the baby.
- Before you leave the hospital, we will ask you to express some breast milk (about one tablespoon) so that we can measure substances in the breast milk that are important for the new-born.
- We will also ask you to give a stool sample if at all possible.

3.1.3 The next two years

- We will ask you to come to Kalafong Hospital with your baby for 8 visits when the baby is 6, 10 and 14 weeks, and 6, 9, 12, 18 and 24 months old. These visits are part of the routine follow-up care for you and your baby and will replace your usual clinic visits.
- At these visits, we will ask you to answer some questions about you and your baby's health, diet and how you feed your baby.
- We will take 30 millilitres (about 2 tablespoons) of blood to look for markers of inflammation and infections and other related biological markers important for your health.
- At each visit, we will also ask you to express some breastmilk (about 6 tablespoons) so that we can measure substances in the breast milk that are important for the development of your baby.
- We will ask for a stool sample at 6 weeks and again at 3, 6 and 12 months. We will provide you with a container so you can do this at home, if you so prefer.

3.2 The procedures for the child

3.2.1 Newborn

- The routine measurements of the new-born, such as length, weight and the size of the head, will be taken.
- In addition, we will collect stool from the new-born to look at the organisms in the stool.
- For babies born to HIV infected mothers, 5 millilitres (one teaspoon) of blood will be taken on the baby for HIV birth PCR test as part of routine new-born care.

3.2.2 Child visits

- The child visits will be when the baby is 6, 10 and 14 weeks, and 6, 9, 12, 18 and 24 months old.
- At these visits we will weigh and measure your baby's length and head size and to look at his or her Road to Health chart.
- We will do an assessment of your child's brain development at these time points by looking if he or she can do the usual things expected of a child at that age.
- At these visits, we will take 10 millilitres (about 2 teaspoons) of blood from your baby to check for low iron levels (anaemia) and to look at biological factors important for the growth and health of the baby.
- We will collect stool from your child at 6 weeks and 3, 6 and 12 months.
- If there are any problems with the child's development or anaemia, your child will be referred for further care.

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- We will also offer the childhood immunisations at all time points as required by the national immunisation programme and this will replace your regular clinic visits.

3.3 Testing of samples

Most of the tests will be done at the Department of Immunology at the University of Pretoria. We will also send a small amount of blood, vaginal swab, breastmilk, placenta and stool overseas for testing at the Department of Health Sciences at Carleton University in Canada. We also ask your permission to store all the left-over samples that we have collected for future testing. We will first get approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria and the Research Ethics Board at Carleton University before doing any more tests on these samples.

4) RISK AND DISCOMFORT INVOLVED.

The main inconvenience for you will be your doctor visits will be longer than usual. There is only minimal risk or possible discomfort involved with providing blood, breast milk or stool samples, or having the vaginal swab, or measuring your child's growth and development. Taking blood can sometimes be painful and could cause bruising afterwards.

5) POSSIBLE BENEFITS OF THIS STUDY.

The benefits during pregnancy; you will be seen by a specialist and you will have detailed sonars by a skilled specialist in this field. If there are any complications, you will receive treatment immediately.

The benefits for your baby are that a specialist will do the routine visits. Your child will receive additional screening for growth and brain development. We will be able to diagnose anaemia and any problems with development early and your child can get treatment. Your child will also get all required immunisations, which means that your child will not have to go to the clinic as well.

6) VOLUNTARY PARTICIPATION

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. Whether you choose to participate or not, all the necessary services at this clinic or hospital will continue and nothing will change. If you choose not to participate in this research project you will be offered the treatment that is routinely offered in this clinic or hospital. You are allowed to withdraw from the study at any time. Any information or samples we collect from you as part of the study before you withdraw will remain part of the study. There will be no further information or samples collected from you once you withdraw from the study.

7) I understand that if I and my baby do not want to participate in this study, I will still receive standard treatment for my illness.

8) I may at any time withdraw from this study.

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9) REIMBURSEMENTS

There are no direct financial benefits to you, but we will give you money to pay for your transport to the hospital during pregnancy and for the follow-up visits. The amount will be based on the distance you stay from the clinic.

10) HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 3563084 / 012 3563085 and written approval has been granted by that committee. This protocol was also submitted to the Carleton University Research Ethics Board, and written approval has been granted. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2013), which deals with the recommendations guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.

11) INFORMATION If you have any questions concerning this study, you should contact:

1. Dr Felicia Molokoane: 083 368 4995
2. Prof Mphele Mulaudzi: 083 258 8705
3. Prof Ute Feucht: 072 428 0465

12) CONFIDENTIALITY

The information that we collect from this research project will be kept confidential. Participants will be identified for study purposes with a unique study number. Your personal identifying information will not be connected to the information collected for this research study. Information collected about you and your baby during the research will be stored safely and will only be available to the approved researchers.

13) CONSENT TO PARTICIPATE IN THIS STUDY

I have read or had read to me in a language that I understand the above information before signing this consent form. The content and meaning of this information have been explained to me. I have been given the opportunity to ask questions and am satisfied that they have been answered satisfactorily. I understand that if I do not participate it will not alter my management in any way. I hereby volunteer to take part in this study.

I have received a signed copy of this informed consent agreement.

....
Patient name Date

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....
Patient signature   Date

....
Investigator's name   Date

....
Investigator's signature   Date

....
Witness name and signature   Date

VERBAL PATIENT INFORMED CONSENT (applicable when patients cannot read or write)

I, the undersigned, Dr ……………………………………..…, have read and have explained fully to the patient, named ………………. and/or his/her relative, the patient information leaflet, which has indicated the nature and purpose of the study in which I have asked the patient to participate. The explanation I have given has mentioned both the possible risks and benefits of the study and the alternative treatments available for his/her illness. The patient indicated that he/she understands that he/she will be free to withdraw from the study at any time for any reason and without jeopardizing his/her treatment.

I hereby certify that the patient has agreed to participate in this study.

Patient's Name ________________
(Please print)

Patient's Signature ____________________ Date ______________

Investigator's Name ________________
(Please print)

Investigator's Signature ________________ Date ___________

Witness's Name __________ Witness's Signature _______ Date ___________
(Please print)

(Witness - sign that he/she has witnessed the process of informed consent)

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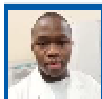
APPENDIX D: CONFERENCE POSTER PRESENTATION



Cost of diet in relation to nutrient intake of 6- and 12-months old infants residing in an HIV-exposed versus unexposed environment

Department of Consumer and Food Sciences
Faculty of Natural and Agricultural Sciences

Mothusi Nyofane, Marinel Hoffman, *Ute Feucht
Email: mothusinyofane@gmail.com

Department of Consumer and Food Sciences and Institute for Food, Nutrition and Well-being, University of Pretoria, Pretoria, South Africa
*Department of Paediatrics, University of Pretoria | *Research Centre for Maternal, Fetal, Newborn and Child Health Care Strategies, University of Pretoria | *Research Unit for Maternal and Infant Health Care Strategies, South African Medical Research Centre

Background

- South Africa has an estimation of 7.9 million individuals living with HIV, with a high prevalence (26.3%) among women of childbearing age.[1]
- The success of prevention of mother-to-child transmission of HIV (PMTCT) programmes and antiretrovirals (ARVs) have increased the number of HIV-exposed-uninfected (HEU) infants,[2] who are at risk of poor nutritional status with resultant complications related to malnutrition.[3]
- Due to concerns raised on the cost and type of complementary feeding for infants, there is a need to investigate the cost of feeding an HEU infant.

Aim

To compare the cost of diet in relation to nutrient intake and feeding practices of 6- and 12-months old HEU versus HIV-unexposed-uninfected (HUU) infants.

Objectives

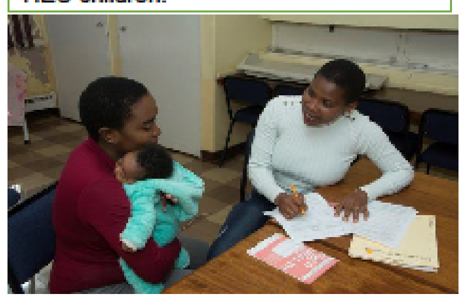
- Determine socio-economic status of caregivers
- Determine food items most often consumed by infants and collect food prices of those foods
- Calculate the cost of each food item, and compare foods consumed and their prices, by HEU versus HUU infants.
- Determine infant's nutrient intake using South Africa Medical Research Council Food Finder program™

Study progress

- Ethics approvals in place
- Data collection tools implemented

Potential impact

The study will generate useful information that will benefit the development of nutritional interventions for early life and the complementary feeding policy, with a special focus on HEU children.



Study design

- Substudy to the Siyakhula study, which assesses factors impacting on fetal and infant immunity and growth in HIV- and ARV-exposed uninfected children
- South-West Tshwane, Gauteng Province, South Africa
- Cross sectional descriptive study
- 100 women (50 HIV+; 50 HIV-)
- Variables
  - Independent variables: HEU and HUU
  - Dependent variables: Nutrient intake, cost of diet
- 24-hour dietary recall and Food cost questionnaire
- Analysis of food intake by MRC Food Finder program™
- Manual conversions and cost of diet calculations
- SPSS statistical analysis: Analysis of Variance (ANOVA) Test

References

1. Human Sciences Resource Council (HSRC) (2018) HIV Impact Assessment Summary.
2. Rossouw et al., (2016) *SAJHIVM.* 17 (1), a398
3. Brink et al., (2014). *S Afr J CH.* 8(3):112-116

Acknowledgements

CIPHER PAEDIATRIC HIV MATTERS
saMRC advancing life
GAUTENG PROVINCE HEALTH REPUBLIC OF SOUTH AFRICA

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APPENDIX E: APPROVAL LETTERS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences
Ethics Committee

E-mail: ethics.nas@up.ac.za

ETHICS SUBMISSION: LETTER OF APPROVAL

Mr M Nyofane
Department of Consumer and Food Sciences
Faculty of Natural and Agricultural Science
University of Pretoria

Reference number: NAS164/2019
Project title: Comparison of cost of diet in relation to nutrient intake and feeding practices of 6-month old infants residing in an HIV exposed versus-unexposed environment

Dear Mr M Nyofane,

We are pleased to inform you that your submission conforms to the requirements of the Faculty of Natural and Agricultural Sciences Research Ethics committee.

Please note the following about your ethics approval:

- Please use your reference number (NAS164/2019) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
- Please note that ethical approval is granted for the duration of the research (e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
- The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

From the materials and methods it seem that the research population is the mothers of 6 month old children rather than the 6 month old children. Please revise accordingly. Please ensure that ethics approval of associated project and any other relevant documentation that may be required for the purpose of this study, are attached.

Post approval submissions including application for ethics extension and amendments to the approved application should be submitted online via the Ethics work centre.

We wish you the best with your research.

Yours sincerely,

Chairperson: NAS Ethics Committee

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Faculty of Health Sciences

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 03/14/2020.

29 August 2019

Approval Certificate
New Application

Ethics Reference No.: NAS164/2019
Title: Comparison of cost of diet in relation to nutrient intake and feeding practices of 6-month old infants residing in an HIV exposed versus-unexposed environment

Dear Dr UD Feucht

The **New Application** as supported by documents received between 2019-08-02 and 2019-08-28 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 2019-08-28.

Please note the following about your ethics approval:

- Ethics Approval is valid for 1 year and needs to be renewed annually by 2020-08-29.
- Please remember to use your protocol number (NAS164/2019) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

Researcher to note: If dangerous practices are identified during the research process the participants must be referred for feeding counselling if the researcher is not able to do counselling.

We wish you the best with your research.

Yours sincerely

Dr R Sommers
MBChB MMed (Int) MPharmMed PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

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Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

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Faculty of Natural and Agricultural Sciences
Ethics Committee

E-mail: ethics.nas@up.ac.za

13 July 2020

ETHICS SUBMISSION: EXTENSION LETTER

Mr M Nyofane
Department of Consumer and Food Sciences
Faculty of Natural and Agricultural Science
University of Pretoria

Reference number: NAS164/2019
Project title: Cost of feeding practices and nutrients intake of six-month-old HIV exposed uninfected versus HIV uninfected unexposed infants in Gauteng province, South Africa

Dear Mr M Nyofane,

We are pleased to inform your application for ethics extension conforms to the requirements of the Faculty of Natural and Agricultural Sciences Research Ethics committee.

Please note the following about your ethics approval:

- Please use your reference number (NAS164/2019) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.
- Please note that ethical approval is granted for the duration of the research (e.g. Honours studies: 1 year, Masters studies: two years, and PhD studies: three years) and should be extended when the approval period lapses.
- The digital archiving of data is a requirement of the University of Pretoria. The data should be accessible in the event of an enquiry or further analysis of the data.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

From the materials and methods it seem that the research population is the mothers of 6 month old children rather than the 6 month old children. Please revise accordingly. Please ensure that ethics approval of associated project and any other relevant documentation that may be required for the purpose of this study, are attached.

Post approval submissions including application for ethics extension and amendments to the approved application should be submitted online via the ethics work centre.

We wish you the best with your research.

Yours sincerely,

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Faculty of Health Sciences

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 03/14/2020.

17 May 2019

Approval Certificate
Amendment

Ethics Reference No.: 294-2017
Title: Assessment of factors impacting on foetal and infant immunity, growth, and neurodevelopment in HIV- and antiretroviral-exposed uninfected children (the Siyakhula study)

Dear Dr UD Feucht

The **Amendment** as supported by documents received between 2019-05-02 and 2019-05-17 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 2019-05-15.

Please note the following about your ethics approval:

- Please remember to use your protocol number (294-2017) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Dr R Sommers
MBChB MMed (Int) MPharmMed PhD
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health).

Research Ethics Committee
Room 4-60, Level 4, Tswelopele Building
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Arcadia 0007, South Africa
Tel +27 (0)12 356 3084
Email deepeka.behari@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Disaense tša Maphelo

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GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Enquiries: Dr. Lufuno Razwiedani
Tel: +27 12 451 9036
E-mail: lufuno.razwiedani@gauteng.gov.za

TSHWANE RESEARCH COMMITTEE: CLEARANCE CERTIFICATE

MEETING: 06/2017
PROJECT NUMBER: 93/2017
NHRD REFERENCE NUMBER: GP_201710_002

TOPIC: Assessment of factors impacting on foetal and infant immunity, growth, and neurodevelopment in HIV- and antiretroviral-exposed uninfected children

Name of the Researcher:

Felicia Molokoane
Ameena Goga
Mphele Mulaudzi
Robert Pattinson
Theuns Avenant
Jennifer Makin
Andrea Prinsloo
Louise du Toit
Helen Steel
Marlene Gilfillan
Ute Feucht
Theresa Rossouw

Facility: Kalafong Tertiary Hospital
Pretoria West Hospital

Name of the Department: University of Pretoria

NB: THIS OFFICE REQUEST A FULL REPORT ON THE OUTCOME OF THE RESEARCH DONE AND

NOTE THAT RESUBMISSION OF THE PROTOCOL BY RESEARCHER(S) IS REQUIRED IF THERE IS DEPARTURE FROM THE PROTOCOL PROCEDURES AS APPROVED BY THE COMMITTEE.

DECISION OF THE COMMITTEE: APPROVED

....
Dr. R. Oyedipe
Acting Chairperson: Tshwane Research Committee
Date: 09/11/2017

....
Ms. M. Lerutla
Acting Chief Director: Tshwane District Health
Date: 13/11/17

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Permission to conduct research and access records / files / database at Kalafong Hospital

To: Chief Executive Officer/Information Officer
Kalafong Hospital
Dr Letebele

From: The Investigator
Prof U Feucht

Re: Permission to do research at Kalafong Hospital

Proff/Drs Pattinson, Avenant, Molokoane, Mulaudzi and I are researchers working at the MRC Unit and Department of Obstetrics and Gynaecology and the Department of Paediatrics at Kalafong Hospital. I am requesting permission on behalf of all of us to conduct a study on the Kalafong Hospital grounds that involves patient follow-up and access to patient records.

The request is lodged with you in terms of the requirements of the Promotion of Access to Information Act. No. 2 of 2000.

The title of the study is: Assessment of factors impacting on foetal and infant immunity, growth, and neurodevelopment in HIV- and antiretroviral-exposed uninfected children.

The researchers request access to the following information: Clinical files, record books and databases.

We intend to publish the findings of the study in a professional journal and/ or at professional meeting like symposia, congresses, or other meetings of such a nature.

We intend to protect the personal identity of the patients by assigning each patient a random code number.

We undertake not to proceed with the study until we have received approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely

Permission to do the research study at this hospital and to access the information as requested, is hereby approved.

Chief Executive Officer

Kalafong Hospital

Dr K. E. Letebele - Kartell

Date: 04/10/2017

Signature of the CEO

GAUTENG PROVINCIAL GOVERNMENT
KALAFONG HOSPITAL / HOSPITAAL
04 OCT 2017
PRIVATE BAG / PRIVAATSAK X396 PRETORIA 0001
SUPERINTENDENT'S OFFICE

Hospital Official Stamp

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HEALTH
REPUBLIC OF SOUTH AFRICA

DECLARATION OF INTENT FROM THE PRIMARY HEALTH CARE MANAGER, TSHWANE

18 September 2017

Prof/Drs Pattinson, Avenant, Molokoane, Mulaudzi and I are researchers working at the MRC Unit and Department of Obstetrics and Gynaecology and the Department of Paediatrics at Kalafong Hospital. I am requesting permission on behalf of all of us to recruit patients at Primary Health Care facilities in the Tshwane District Health services. The title of the study is: **Assessment of factors impacting on foetal and infant immunity, growth, and neurodevelopment in HIV- and antiretroviral-exposed uninfected children.**

The researchers request the following: Access to potential study participants for recruitment.

The study follow-up will be conducted at Kalafong Hospital. We intend to protect the personal identity of the patients by assigning each patient a random code number. We undertake not to proceed with the study until we have received approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely

Prof UD Feucht

I give preliminary permission for the research project: **Assessment of factors impacting on foetal and infant immunity, growth, and neurodevelopment in HIV- and antiretroviral-exposed uninfected children.**

The final approval will be from the Tshwane Research Ethics Committee and that this is only to indicate that the Tshwane Provincial office is willing to assist.

Other comments or conditions prescribed: For issues affecting Kalafong hospital, please contact the office below:

Enquiries: Innocentia Mcena
Directorate: Office of CEO – Kalafong Provincial Tertiary Hospital
Tel: +27 (0)12 3186501[Number]
Fax: +27 (0)12 318 6791

Signature & Date 18 09 2017
Primary Health Care, Tshwane

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