Dietary intake of infants followed from age 6 to 18 months from a low socio-economic peri-urban community

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Mamma Handri and Pappa Anton. Thanks for raising me in the way that you have, for all your support and the time and love that you put into my life. I know that you smile down from heaven and I hope that you are proud. I honor you.

Drikus – my little baby boy. You came in the middle of all this but I wouldn't have had it any other way. Thanks for still loving your mommy even though you had to share me when I worked on this. You taught me unconditional love.

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> *"For from Him and through Him and for Him are all things. To Him be the glory forever! Amen."*

Romans 11.36 (NIV)

ABSTRACT

Background

During the complementary feeding period, children require foods with high nutrient density as they consume small amounts of food but have high growth and developmental needs (Dewey, 2013:2050) and to avoid growth impairment it is important to provide an adequate complementary diet (Victora *et al.,* 2010:e480). Often children in developing countries do not consume a nutrient dense or diverse diet and the complementary diets of these children have been shown to be mainly deficient in iron, zinc and calcium (Dewey & Brown, 2003). Limited data is available on the adequacy of the complementary diet of infants and young children in South Africa and data is needed to measure progress and impact of existing nutritional interventions (IFPRI, 2014:xvi). Proposed global strategies to improve the complementary diet include promotion of a diverse complementary diet, micronutrient supplementation, staple food fortification and optimal consumption of local micronutrient rich foods (Bhutta *et al.,* 2013:10; Dewey & Adu-Afarwuah, 2008:32). In South Africa the National Food Fortification Programme (NFFP) has been implemented as a means to improve dietary intake of certain identified key nutrients in the general population (South Africa, 2003) but its contribution to infant nutrition may be limited due to small amounts of these foods consumed by them (Faber, 2005:373). It has also been suggested that a complementary diet consisting of family foods only, may not be able to meet the increased nutrient needs and that commercially fortified infant products may be required to bridge the gap (Vossenaar & Solomons, 2012:865). Limited research investigating the role of commercial infant products and the NFFP in the South African complementary diet is available. The main aim of this study was to assess trends in dietary intake, dietary diversity, nutrient intake and nutrient density of infants followed from ages six to 18 months in a peri-urban community of the North West province.

Objectives

Objectives were to observe trends in type of foods consumed at two to three monthly intervals from ages six to 18 months; secondly to determine dietary intake in terms of energy, macronutrients and micronutrients, nutrient density and dietary diversity in infants aged six, 12 and 18 months respectively, and finally to determine the contribution of commercial infant foods (infant formula, infant cereals, baby juice and jarred baby foods) and fortified maize meal and bread (NFFP foods) at six, 12 and 18 months to dietary intake in terms of energy, macronutrients and micronutrients.

Methods

This was a cohort observational study affiliated with a randomised controlled trial (Tswaka) that investigated the effect of small-quantity lipid based nutrient supplements (SQ-LNS) on child growth. Dietary data was collected by means of an unquantified food frequency questionnaire (FFQ) from six to 18 months at two to three monthly intervals to show dietary trends over time and a single 24 hour recall at ages six, 12 and 18 months to determine nutrient intake, nutrient density and dietary diversity. The 24 hour recall data was also used to calculate the contribution of commercial infant products and fortified maize meal and bread to total intake and to compare nutrient intake and nutrient density of consumers versus non-consumers of these products. In total 750 infants were enrolled.

Main findings

Dietary trends are based and reported on for a frequency of consumption of at least once during the previous week. At age six months, 71.9% of infants were still being breastfed, but by age 18 months only 35% were still being breastfed. Commercial infant cereal and jarred baby foods were respectively consumed by 80.4% and 55.3% of infants at age six months but the consumption thereof decreased to 13.3% and 9.3% towards 18 months. A third of infants consumed maize meal porridge at age six months, however by 18 months almost all infants (91.1%) were introduced to it. Chicken was the flesh food consumed by the largest number of children at all three ages (21.9% at six months, 74.9% at 12 months and 85.5% at 18 months), and red meat, liver and fish were not widely introduced at any age. Carbonated drinks, sweets and chips were already consumed at least once during the previous week by 12.8%, 31.2% and 20% of infants at six months and by 56.9%, 73.4% and 83.9% of children age 18 months.

A low total intake of iron and zinc was seen for 61.5% and 46.6% respectively of infants aged six months. At age 12 and 18 months respectively, 75.8% and 75.1% of children had low total calcium intakes. Low nutrient densities of iron and zinc at six months, and iron and calcium at 12 and 18 months of the complementary diet were found. More than 70% of children at all three ages did not consume four or more out of seven food groups and therefore did not have minimum dietary diversity.

For the consumers of commercial infant products – at age six months, the infants' total intake of commercial infant products contributed > 90% of iron intake, ≥ 70% of thiamine and niacin intakes and ≥ 50% of zinc, riboflavin, vitamin B6, folate and vitamin C intakes. At age 12 months it still contributed to > 50% of the infants' total iron and vitamin C intakes. Consumers of commercial infant products on the day of recall had a significantly higher intake of all nutrients (except fat) at age six months, and of calcium, iron, zinc, vitamin A, thiamine, riboflavin, niacin,

vitamin B12 and vitamin C at 12 months compared to non-consumers on the day of recall. Commercial infant products were the major contributor of protein, carbohydrate and all key micronutrients (except vitamin B12) and of iron and vitamin C at 12 months on the day of recall when looking at per capita intake.

At age six months the contribution of fortified maize meal and bread to total nutrient intake were minimal; at age 12 months, of total intake, these foods contributed more than 50% of thiamine, vitamin B6 and folate; and at age 18 months, of total intake, fortified maize meal and bread contributed > 40% iron and zinc, > 50% thiamine and vitamin B6 and > 70% folate intakes for consumers thereof. Consumers of these products at age 12 months had significantly higher intakes of zinc, vitamin B6, folate, thiamine and niacin compared to non-consumers on the day of recall. Non-consumers of fortified maize meal and bread had a significantly higher nutrient density of calcium, iron, vitamin A, riboflavin and niacin at age 12 months on the day of recall. Fortified maize meal and bread were the main contributors of vitamin B6, folate and thiamine at ages 12 and 18 months on the day of recall when looking at per capita intake.

Conclusion

In conclusion, dietary trends observed in this study population illustrated poor continued breastfeeding rates, large numbers of infants consuming commercial infant products at six months and decreasing numbers at 18 months with an opposite trend for maize meal consumption. Few children consumed flesh foods other than chicken at all three ages. Compared to recommendations, the consumption of salty snacks, sweets and sugary beverages were quite high at all ages. Low intake and nutrient density of key nutrients – especially iron, zinc and calcium were also seen. Low dietary diversity was found for the majority of children across all three age groups. Commercial infant products were consumed by the majority of six month old infants and it made significant contributions to key micronutrients at this age. With an increase in age, fewer children consumed commercial infant products, however it still contributed to significant amounts of key nutrients. Fortified maize meal and bread did not make significant contributions to key micronutrients at age six months, however with an increase in age towards 18 months it started to play a larger role in terms of nutrient contribution. Interventions to improve dietary quality of complementary feeding should focus on combining strategies, such as fortification of staple foods, and consumption of commercial infant products with counselling strategies, such as diversification of the diet.

Key terms: Complementary diet, dietary trends, commercial infant products, fortification program, nutrient density, dietary diversity, infants, young children, South Africa

OPSOMMING

Agtergrond

Gedurende die komplementêre voedingsperiode benodig kinders kos met 'n hoë nutriëntdigtheid, aangesien hulle klein hoeveelhede kos inneem, maar hoë groei- en ontwikkelingsbehoeftes het (Dewey, 2013:2050). Om 'n gebrek aan groei te voorkom, is dit belangrik om 'n voldoende komplementêre dieet daar te stel (Victora et al., 2010:e480). Gewoonlik volg kinders in ontwikkelende lande nie 'n nutriëntdigte of diverse dieet nie en die komplementêre diëte van hierdie kinders is bewys om 'n tekort te hê aan yster, sink en kalsium (Dewey & Brown, 2003). Beperkte data is beskikbaar rakende die genoegsaamheid van die komplementêre dieet van babas en jong kinders in Suid-Afrika. Data word benodig om die vordering en impak van bestaande voedingsintervensies te bepaal (IFPRI, 2014:xvi). Voorgestelde globale strategieë om die komplementêre dieet te verbeter sluit die bevordering van 'n diverse komplementêre dieet, mikronutriënt aanvulling, stapelvoedsel-fortifisering en optimale inname van plaaslike kosse ryk aan mikronutriënte (Bhutta et al., 2013:10; Dewey & Adu-Afarwuah, 2008:32). In Suid-Afrika is die Nasionale Voedselfortifiseringsprogram (NFFP) geïmplementeer as 'n hulpmiddel om voedselinname van sekere geïdentifiseerde sleutelmikronutriënte te verbeter in die algemene populasie (South Africa, 2003), maar hulle bydrae tot babavoeding kan beperk wees as gevolg van die klein hoeveelhede van hierdie kos wat deur babas ingeneem word (Faber, 2005). Daar word beweer dat 'n komplementêre dieet wat bestaan uit slegs familiekos, moontlik nie aan die verhoogde nutriëntbenodighede voldoen nie, en dat kommersieel-gefortifiseerde babaprodukte dalk nodig gaan wees om die gaping te oorbrug (Vossenaar & Solomons, 2012:865). Daar is beperkte navorsing beskikbaar wat na die rol van kommersiële babaprodukte en die NFFP in die Suid-Afrikaanse komplementêre dieet kyk. Die hoofdoel van hierdie studie is om die neigings in dieetinname, dieetverskeidenheid, nutriëntinname en nutriëntdigtheid van babas van ses tot 18 maande in 'n peri-stedelike gemeenskap van die Noordwes provinsie te assesseer.

Doelwitte

Die doelwitte was om die neigings te bestudeer in die tipe kos ingeneem in twee tot drie maandelikse intervalle vanaf die ouderdomme ses tot 18 maande; tweedens was dit om die dieetinname in terme van energie, makronutriënte en mikronutriënte, nutriëntdigtheid en dieetverskeidenheid te bepaal in babas van onderskeidelik ses, 12 en 18 maande; en laastens was dit om die bydrae van kommersiële babakos (babaformule, babagraankos, babasap en gebottelde babakos) en die Nasionale Voedselfortifiseringsprogram (NFFP) tot dieetinname in terme van energie, makro- en mikronutriënte te bepaal in babas van ses, 12 en 18 maande oud.

Metodes

Hierdie studie was 'n groepswaarnemingstudie geaffilieer met 'n ewekansige beheerde proefneming, (Tswaka) wat die effek van klein hoeveelhede lipiedgebaseerde aanvullings (SQ-LNS) op die groei van kinders ondersoek. Gewoontelike-dieetdata was versamel deur middel van 'n ongekwantifiseerde voedselfrekwensievraelys (FFQ) vanaf ses tot 18 maande in twee tot drie maandelikse intervalle om dieetneigings oor tyd aan te dui, en 'n enkele 24 uur herroep is gedoen op ses, 12 en 18 maande om die nutriëntinname, nutriëntdigtheid en dieetverskeidenheid te bepaal. Die data van die 24 uur herroep was ook gebruik om die bydrae van kommersiële babaprodukte en gefortifiseerde mieliemeel en brood tot totale inname te kry en om die nutriëntinname en nutriëntdigtheid van gebruikers teenoor niegebruikers van hierdie produkte te vergelyk. 'n Totaal van 750 babas het deelgeneem aan die studie.

Hoof bevindinge

Dieetneigings word gebasseer op en gerapporteer volgens 'n frekwensie van inname van ten minste een keer gedurende die vorige week. Teen ses maande was 71.9% van die babas steeds geborsvoed, maar teen 18 maande was slegs 35% steeds geborsvoed. Kommersiële babagraankos en gebottelde babakos was onderskeidelik deur 80.4% en 55.3% van babas van die ouderdom van ses maande ingeneem, maar die inname daarvan het verminder na 13.3% en 9.3% teen 18 maande. 'n Derde van die babas het mieliepap ingeneem teen ses maande, maar teen 18 maande was amper alle babas (91.1%) daaraan blootgestel. Hoender was die vleis voedselgroep wat deur die grootste hoeveelheid kinders op al drie ouderdomme ingeneem is (21.9% teen ses maande, 74.9% teen 12 maande en 85.5% teen 18 maande), en rooivleis, lewer en vis was nog nie wyd bekendgestel teen enige van die ouderdomme nie. Gaskoeldrank, lekkers en skyfies was alreeds bekendgestel aan 12.8%, 31.2% en 20% van babas op ses maande en teen 18 maande het 56.9%, 73.4% en 83.9% van kinders dit alreeds ten minste een keer per week ingeneem.

'n Lae totale inname van yster (61.5%) en sink (46.6%) word gesien in babas van ses maande. Kinders wat 12 en 18 maande oud is het onderskeidelik 75.8% 75.1% lae totale kalsium innames gehad. Daar is lae nutriëntdigthede van yster en sink gevind in die komplementêre dieet van ses maande oue babas, en lae nutriëntdigthede van yster en kalsium is gevind in die komplementêre dieet van kinders wat 12 en 18 maande oud is. Meer as 70% van kinders in al drie ouderdomsgroepe het nie vier of meer van die sewe voedselgroepe ingeneem nie en dus voldoen hulle nie aan minimum dieetverskeidenheid nie.

Vir die gebruikers van die kommersiële babaprodukte - teen ses maande het die babas se totale inname van kommersiële babaprodukte bygedra tot > 90% van ysterinname, ≥ 70% van tiamien (Vit B_1) en niasien inname en ≥ 50% van sink, riboflavien, vitamien B_6, folaat en vitamien C inname. Teen 12 maande het dit steeds bygedra tot > 50% van die babas se totale yster en vitamien C inname. Gebruikers van kommersiële babaprodukte het 'n noemenswaardige hoër inname van alle nutriënte gehad (behalwe vet) teen ses maande, en teen 12 maande van kalsium, yster, sink, vitamien A, tiamien, riboflavien, niasien, vitamien B_{12} en vitamien C in vergelyking met nie-verbruikers, op die dag van herroeping. Kommersiële babaprodukte het op die dag van herroeping in kinders van 12 maande die meeste bygedra tot proteïene, koolhidrate, alle sleutelmikronutriënte (behalwe vitamien B_{12}), yster en vitamien C, wanneer daar gekyk word na per kop inname.

Teen die ouderdom van ses maande was die bydrae van gefortifiseerde mieliemeel en brood tot totale nutriëntinname minimaal; teen 12 maande het hierdie kos bygedra tot meer as 50% van tiamien, vitamien B_6 en folaat se totale inname; en teen 18 maande het gefortifiseerde mieliemeel en brood bygedra tot > 40% yster en sink, > 50% tiamien, vitamien B_6 en > 70% folaat inname van totale inname van verbruikers. Verbruikers van hierdie produkte het teen 12 maande noemenswaardige hoër innames gehad van sink, vitamien B_6, folaat, tiamien en niasien in vergelyking met nie-verbruikers op die dag van herroeping. Nie-verbruikers van NFFP-kosse het 'n noemenswaardige hoër nutriëntdigtheid van kalsium, yster, vitamien A, riboflavien en niasien gehad teen 12 maande op die dag van herroeping. Wanneer daar gekyk word na per kop inname, het gerfortifiseerde mieliemeel en brood die grootste bydrae gelewer tot vitamin B_6, folaat en tiamien teen die ouderdomme van 12 en 18 maande op die dag van herroeping.

Gevolgtrekking

Om op te som, het dieetneigings wat in hierdie studie waargeneem is, swak volgehoue borsvoeding na ses maande geïllustreer, asook groot hoeveelhede babas wat kommersiële babaprodukte op ses maande gebruik het, en 'n afname in gebruikers daarvan teen 18 maande, met 'n teenoorgestelde neiging vir die inname van mieliemeel. Min kinders het ander vleissoorte ingeneem as hoender op al 3 ouderdomme. In vergelyking met voorstelle, was die inname van sout versnapperinge, lekkers en suikerryke drankies redelik hoog vir alle ouderdomme. Lae inname en nutriëntdigtheid van sleutelnutriënte - veral yster, sink en kalsium - was ook opgemerk. Lae dieetverskeidenheid was gevind vir die meerderheid van kinders regoor al drie ouderdomsgroepe. Kommersiële babaprodukte was ingeneem deur die meerderheid van ses maande oue babas en dit het noemenswaardige bydraes gelewer tot sleutelmikronutriënte op hierdie ouderdom. Met 'n toename in ouderdom het minder kinders hierdie kosse ingeneem, maar dit het steeds bygedra tot noemenswaardige hoeveelhede sleutelnutriënte. Gefortifiseerde

mieliemeel en brood het nie 'n noemenswaardige bydrae gelewer tot sleutelmikronutriënte teen ses maande nie, maar met 'n toename in ouderdom na 18 maande, het dit 'n grootter rol begin speel in terme van nutriëntinname. Intervensies moet daarop fokus om strategië te kombineer, soos fortifisering van stapelkos, en inname van kommersiële babaprodukte met beradingstrategië, soos die verskeidenheid van die dieet.

Sleutelterme: Komplementêre dieet, dieetneigings, kommersiële babaprodukte, fortifiseringsprogram, nutriëntdigtheid, dieetverskeidenheid, babas, jong kinders, Suid-Afrika

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AI:	Adequate Intake
CI:	Confidence Interval
CEN:	Centre of Excellence for Nutrition
DDS:	Dietary diversity score
DOH:	Department of Health
EAR:	Estimated Average Requirement
EER:	Estimated Energy Requirements
ESPGHAN:	The European Society for Paediatric Gastroenterology Hepatology and Nutrition
FAO:	Food and Agricultural Organization of the United Nations
FFQ:	Food Frequency Questionnaire
FVS:	Food Variety Score
g:	gram
Hb:	Haemoglobin
HIV:	Human Immunodeficiency Virus
HREC:	Health Research Ethics Committee
IFPRI:	International Food Policy Research Institute
IOM:	Institute of Medicine
IQR:	Interquartile Range
IYCFP:	Infant and Young Child Feeding Policy
kcal:	kilocalorie
KZN:	KwaZulu-Natal

MAR: Mean Adequacy Ratio

MBFI: Mother Baby Friendly Initiative

mg: milligram

ml: millilitre

MMDA: Mean Micronutrient Density Adequacy

NAR: Nutrient Adequacy Ratio

NFCS: National Food Consumption Survey

NFFP: National Food Fortification Programme

NWU: North-West University

QFFQ: Quantified Food Frequency Questionnaire

RDA: Recommended Dietary Allowance

RE: Retinol Equivalents

RAE: Retinol Activity Equivalents

RNI: Recommended Nutrient Intake

RtHB: Road to Health Booklet

SADHS: South African Demographic and Health Survey

SAM: Severe Acute Malnutrition

SAMRC: South African Medical Research Council

SANHANES: South African National Health and Nutrition Survey

SAVACG: South African Vitamin A Consultancy Group

SD: Standard Deviation

TE: Total Energy

UN: United Nations

UNICEF: United Nations Children's Fund

USA: United States of America

WHO: World Health Organisation

µg: microgram

CHAPTER 1: INTRODUCTION

1.1 Background

Malnutrition in children under five years of age is a global problem. A report from the United Nations Children's Fund (UNICEF) shows that globally 50 million children under five years of age are wasted, one in four children is stunted and the prevalence of overweight is increasing (UNICEF, 2015). The 2016 South African Demographic and Health Survey (SADHS) shows that 27% of children in South Africa are currently stunted (NDoH, Stats SA, SAMRC & ICF, 2017:27). Overweight is also seen as a major nutritional problem in South Africa – 13% of children under five years are overweight (NDoH, Stats SA, SAMRC & ICF, 2017:27).

Malnutrition is one of the most important risk factors for disease as it reduces immunity (IFPRI, 2014:xiii) and leads to severe illnesses such as diarrhoea (intestinal infectious diseases) and pneumonia, which were respectively the leading and third leading causes of death in children under five years in 2014 in South Africa (Statistics South Africa, 2015:36). Malnutrition can have a detrimental effect on the intellectual development of a child, which results in lower education, and lower productivity and income later in life; this may result in the individual becoming a social burden, which ultimately impacts the economy of a country (IFPRI, 2014:xiii; Prado & Dewey, 2014:274).

The International Food Policy Research Institute (IFPRI) identified infant morbidity and mortality as one of the 'faces' of poor nutrition and it is caused by, amongst others, poor infant feeding practices, two of which are nutritionally inadequate foods and unsafe foods (IFPRI, 2014:2). High levels of stunting as well as the increasing occurrence of South African children being overweight and obese are the consequence of, amongst others, poor breastfeeding and complementary feeding practices as well as inadequate nutritional quality of the complementary diet (Du Plessis *et al.,* 2013:S129; Mamabolo *et al.,* 2006:112).

A study done in KwaZulu-Natal showed the poor quality of the complementary diet of infants aged six to 12 months with less than half of the desired nutrient density for calcium, iron and zinc met (Faber, 2005:375). A more recent study by Faber *et al.* (2016:528) showed that the complementary diet of urban and rural children, aged six to 24 months, in KwaZulu-Natal was lacking in dietary diversity and also in nutrient density, with less than 25% of children consuming more than four out of the seven recommended food groups. The nutrient densities of the complementary diet for several micronutrients such as zinc, calcium, iron, niacin, and riboflavin were also less than the recommended densities.

There are a limited number of studies such as these that report on the minimum adequate diet of infants and young children in South Africa and it is important to gather as much data as possible, on a continuous basis, on nutrition indicators. The Global Nutrition Report of 2014 states that: "It is hard to meet nutrition goals if you do not have data on nutrition" (IFPRI, 2014:xvi). Current nutritional data is needed to measure accountability of a country to nutritional interventions that it has developed or committed to (IFPRI, 2014:xvi). Even though the study presented in this mini-dissertation only describes the dietary intakes of six month old infants followed up to the age of 18 months from a small area in the North West province of South Africa, it will contribute to the pool of data on infant and young child feeding practices in South Africa.

It is also worthwhile to determine the contribution of commercial infant products to the nutritional quality of the diets of infants. The 2012 South African National Health and Nutrition Examination Survey (SANHANES) showed that the most common first food introduced was commercial infant cereals (51.2% of children), followed by homemade porridge (29%), pureed vegetables or fruits (4.4%) with the remaining 15.4% consisting of clinic-issued porridge, jarred baby foods, custard and other foods (less than 4% each) (Shisana *et al.*, 2013:24). Thus, a large percentage of South African infants seem to have commercial infant products such as infant cereals introduced as first food. The authors of the SANHANES report consider this to be a potential problem in terms of cost and proposed that homemade porridge would be much more affordable as it is a staple food for most families (Shisana *et al.,* 2013:27). Faber (2005:379) suggests that despite the fortification of the South African staple, maize meal, its impact on infant nutrition might be low as infants consume relatively small amounts thereof.

In 2003 it became mandatory in South Africa that maize meal and wheat flour (bread), which are staple foods in South Africa, must be fortified with vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron and zinc (South Africa, 2003:6). This fortification program is known as the National Food Fortification Programme (NFFP) or the 'Fortified for Better Health' programme. It was implemented following research done by the South African Vitamin A Consultative Group (SAVACG) in 1994 which found that 33% of South African children aged six to 23 months were vitamin A deficient, one out of 10 of these children were iron deficient and 25% of the children were stunted (SAVACG, 1996:355). The SAVACG group recommended fortification as one of the strategies to improve micronutrient intake and status in children (SAVACG, 1996:356). Following the SAVACG report, the National Food Consumption Survey (NFCS) was conducted with one of its aims to identify suitable food items or 'vehicles' for fortification (Labadarios *et al.,* 2000). Maize and brown bread were identified as two of the most commonly consumed foods and it was therefore chosen as the

vehicles for fortification (Labadarios *et al.,* 2000). Through secondary data analysis of existing food intake data, Steyn and Labadarios (2008:26) showed that substituting the unfortified staple foods with the fortified equivalents significantly increases the intake of the aforementioned vitamins and minerals in children aged *one to nine* years in South Africa. However from this study (Steyn and Labadarios, 2008: 26) the impact of fortification would have on the complementary diet of infants younger than one year is not known. Whereas iron content on fortified maize meal ranges from 2.6mg to 3.2 mg/100 dry product; iron content in infant cereal is substantially higher, ranging from 7.5mg to 33.3 mg/100 dry product (Wolmarans *et al.,* 2010:1-12, 1-13, 14-2).

A study conducted in Guatemalan infants, aged 6-24 months, aimed to determine whether the infants' nutritional needs will be met without commercially fortified infant food products known as 'baby foods', for example infant cereals or jarred foods. The results suggested that it would be a challenge to meet the infants' needs without these products as even in the best case scenario; family foods in this developing country do not have sufficient nutrient density to meet the infants' nutritional needs (Vossenaar & Solomons, 2012:865). Children under the age of two years require a high nutrient intake, because of rapid growth and development and because they also consume relatively small amounts of foods. It is important that the foods consumed at this age should have a high nutrient density (Dewey, 2013:2050).

Thus, in addition to total dietary intake, the contribution of the foods that are fortified according to the NFFP (maize meal and bread) as well as the contribution of commercial infant products were investigated in the context of total intake to determine what the role of these products in the complementary diet is. Dietary information was collected to assess the infants' nutritional intake and to calculate dietary diversity and nutrient density of the complementary diet at different time points and ultimately to contribute to the pool of data on the diet of the age group six to 18 months in South Africa.

1.2   Aims and Objectives

The aim of the study was to assess trends in dietary intake, dietary diversity, nutrient intake and nutrient density of infants followed from ages six to 18 months in a peri-urban community of the North West province, South Africa.

The specific objectives were to:

1.   Observe trends in types of foods consumed at two to three monthly intervals from ages six to 18 months

2. Determine dietary intake in terms of energy, macronutrients and micronutrients, nutrient density and dietary diversity in infants at ages six, 12 and 18 months

3. Determine the contribution of commercial infant foods (formula milk, infant cereals, baby juice and jarred baby foods) and the National Food Fortification Programme (NFFP) (fortified maize meal and bread) at six, 12 and 18 months to dietary intake in terms of energy, macronutrients and micronutrients

1.3 Research team

Table 1.1 summarizes the research team with each member's specific role and contribution towards this MSc mini-dissertation

Table 1-1:   Research team members, roles and contributions

Team member	Affiliation	Expertise	Role and contribution
Prof. Lize Havemann-Nel (PhD Exercise science, B Dietetics)	Centre of Excellence for Nutrition (CEN), North-West University (NWU), Potchefstroom Campus	Registered Dietitian with an interest in infant and young child nutrition	Supervisor of the MSc student. Responsible for ethics application. Guidance regarding writing the protocol, writing of literature review and article (manuscript)
Prof Mieke Faber (PhD)	South African Medical Research Council (SAMRC)	Expert on dietary intake assessment, co-principle investigator of the Tswaka study	Co-Supervisor of the MSc student, guidance regarding writing of protocol, literature review, analysis, interpretation and writing up of results and article
Dr Marinel Rothman (PhD)	Centre of Excellence for Nutrition (CEN), North-West University (NWU), Potchefstroom Campus	PhD (nutrition); project co-ordinator of the Tswaka study	Co-Supervisor, Guidance in writing of protocol, analysis and processing of results
Eloïse Swanepoel (BSc. Dietetics)	MSc student at Centre of Excellence for Nutrition (CEN), North-West University (NWU), Potchefstroom Campus	Registered Dietician	Part time MSc student. Writing of protocol, assisting with ethics application, writing of literature review, analysis, interpretation and writing up of data. Writing of manuscript
Ria Laubscher	South African Medical Research Council (SAMRC)	Biostatistician; expertise in dietary data analysis	Nutrient analysis of dietary data

1.4 Structure of dissertation

The mini-dissertation is for the partial fulfilment of the MSc degree in Dietetics, it is written in article format and is presented in four chapters. Chapter one is the rationale for the study and the aim and objectives are also presented. An overview of the research team is also given, along with the structure of the mini-dissertation. Chapter two presents the literature review where an overview of the role of nutrition in the first 1000 days of a child's life is discussed along with the issue of malnutrition in this age range. Thereafter feeding recommendations for infants and young children in South Africa are discussed together with nutrient requirements, desired nutrient density and dietary diversity of the complementary diet. An overview is further given of complementary feeding practices of infants and young children, six months and older both globally and in South Africa. Lastly the role of commercial infant products and foods fortified according to the National Food Fortification Programme is outlined. Chapter three is the research article titled: "Dietary intake and contribution of commercial infant products and fortified staple foods in a cohort of six to 18 month old children from a low socio-economic community in South Africa", and is written according to the specifications of the journal Maternal and Child Nutrition and the reference style of the American Psychological Association (APA). Chapter four is a summary and conclusion of relevant, important findings of the research study, it also discusses the strengths and limitations of the study and recommendations are made for future research as well as implications for policy making according to the findings. The bibliography at the end of the mini-dissertation is for the references cited in chapters one and two which are made according to the North-West University Harvard style.

CHAPTER 2:   LITERATURE REVIEW

2.1   Introduction

Malnutrition in children under five years of age is a global problem. A report from the United Nations Children's Fund (UNICEF) shows that globally 50 million children under five years of age are wasted, one in four children is stunted and the prevalence of children being overweight is increasing (UNICEF, 2015). The 2016 South African Demographic and Health Survey (SADHS) shows that 27% of children in South Africa under five years of age are currently stunted (NDoH, Stats SA, SAMRC & ICF, 2017:27). Being overweight is also seen as a major nutritional problem in South Africa – 13% of children under five years are overweight (NDoH, Stats SA, SAMRC & ICF, 2017:27). Malnutrition is also one of the most important risk factors for disease as it reduces immunity (IFPRI, 2014:xiii) and leads to severe illnesses such as diarrhoea (intestinal infectious diseases) and pneumonia, which were respectively the leading and third leading causes of death in children under five years in 2014 in South Africa (Statistics South Africa, 2015:36). Malnutrition can have a detrimental effect on the intellectual development of a child, which results in lower education, and lower productivity and income later in life. This may subsequently result in the individual becoming a social burden, which ultimately impacts the economy of a country (Black *et al.,* 2013:1; IFPRI, 2014:xiii; Prado & Dewey, 2014:274).

The International Food Policy Research Institute (IFPRI) identified infant morbidity and mortality as one of the 'faces' of poor nutrition and it is caused by, amongst others, poor infant feeding practices, including nutritionally inadequate and unsafe foods (IFPRI, 2014:2). The high prevalence of stunting as well as the increasing occurrence of South African children being overweight and obese might be the consequence of, amongst others, poor breastfeeding and complementary feeding practices as well as the inadequate nutritional quality of the complementary diet (Mamabolo *et al.,* 2006:112).

This literature review will examine the role of optimal nutrition in the first 1000 days from conception to two years of age. This includes the role of breastfeeding in the first six months as well as continued breastfeeding together with complementary feeding from six months of age. The energy and nutrient requirements of the complementary period are also highlighted. The current recommendations and complementary feeding practices globally and in South Africa will be reviewed. In addition, strategies to address malnutrition, specifically in terms of the complementary diet will be reviewed, including the role and contribution of fortified foods and commercial infant products to the complementary diet of infants older than six months.

2.2 The first 1000 days

The importance of optimal nutrition during the first 1000 days of a child's life, starting from conception to a child's second birthday is well recognized (Black *et al.,* 2013:1; Bryce *et al.,* 2008:510). This period is the essential time when critical brain development (Prado & Dewey, 2014), growth and the building of a healthy immune system occurs (Victora *et al.*, 2016:486), and good nutrition during the first 1000 days provides the building blocks for all of these benefits.

2.2.1 The role of nutrition from conception to birth

Maternal nutrition during pregnancy is directly linked to an infant's weight at birth and it is known that low birth weight of infants (below 2500g) increases the risk for morbidity and mortality (Verma & Shrivastava, 2016:943). A recent study done in 1,034 Indian women showed again that energy intake during pregnancy can have a significant influence on an infant's birth weight – a lower caloric intake by the mother was associated with a low or very low birth weight and a higher or optimal caloric intake was associated with a birth weight above 3000 g (Verma & Shrivastava, 2016). A review that investigated the genetic link between maternal nutrition and the nutritional status of the offspring found that the offspring of malnourished (underfed) as well as overweight (excess dietary intake) mothers during pregnancy and lactation and who were also exposed to an obesogenic environment during childhood were more prone to develop obesity (Parlee and MacDougald, 2013). Therefore, not only the nutritional environment that a child is exposed to after birth, but also the diet or nutritional status of the mother is an important determinant of the nutritional status of her child.

2.2.2 The role of nutrition from birth to six months

Clear recommendations exist with regards to nutrition of infants and young children. Exclusive breastfeeding for the first six months of a child's life is recommended (WHO, 2003:11). Breast milk contains sufficient nutrients to support an infant's growth for the first six months of life (Butte *et al.,* 2002). A recent Cochrane review showed no benefits of giving additional fluids (to healthy newborn infants) or food before six months in comparison to exclusive breastfeeding for the first six months (Becker & Remmington*,* 2014; 2). The benefits of breastfeeding during the first six months of life for the infant is well known and was reported again recently in a Lancet publication that analysed the results of 28 systematic reviews and meta-analyses (Victora *et al.,* 2016). Benefits of breastfeeding for babies younger than six months (categories compared were mostly any breastfeeding [exclusive, predominant or partial] versus no breastfeeding) that were highlighted include; decreased

morbidity and mortality from infectious diseases such as diarrhoea and respiratory tract infections (Victora *et al.,* 2016; 480). The benefits of breastfeeding may also be extended to adulthood as a growing body of research suggests that it may protect against becoming overweight and developing diabetes in later years (Victora *et al.,* 2016; 476) and possibly increase intelligence compared to those not receiving breast milk (Victora *et al.,* 2016:483). A study done in 15,141 Hawaiian children, for example, showed that children who were breastfed for at least six months had a lower risk of being obese at age two compared to those children who never received breast milk (Anderson *et al.,* 2014).

2.2.3   The role of nutrition from six months to two years

2.2.3.1   The role of continued breastfeeding

Continued breastfeeding from the age of six to 24 months and beyond with appropriate complementary feeding from age six months is recommended (WHO, 2003:11). A recent systematic review and meta-analysis showed that infants and young children who were not breastfed beyond six months had up to two times the risk for mortality compared to those who were breastfed in that period (Sankar *et al.,* 2015; 8). Breastfeeding duration might also influence an infant or child's diet. A longer duration of breastfeeding (children who were never breastfed versus. children breastfed less than six months and versus. children breastfed longer than six months) in an American population was associated with better adherence to dietary recommendations.   Those children who were breastfed for a longer duration had timely introduction of solids (from six months of age), increased fruit and vegetable consumption and decreased intake of fatty and sugary foods in their preschool years (two to five years of age) (Musaad *et al.*, 2015:96).

2.2.3.2   The role of complementary foods

While breast milk continues to be an important source of nutrition in this period, it is important that a complementary diet of good quality be introduced at six months of age as breast milk alone does not provide sufficient nutrition to meet the infant's needs anymore (WHO, 2003). In this period infants have high nutrient needs because of their rapid growth and development. Additionally, they consume small amounts of food, thus the complementary food that is consumed must have a high nutrient density (WHO, 2003:12). Adequate intake of recommended foods such as animal derived foods may protect against adverse growth outcomes such as stunting, inadequate weight gain or inadequate head growth (Du Plessis *et al.,* 2013:S133, Krebs *et al.,* 2006:207). The complementary diet also needs to provide certain key nutrients that are not sufficiently supplied by breast milk at this age, for example iron. Insufficient intake of key nutrients such as iron and zinc may lead to impaired cognitive

development (Georgieff, 2007:614S; Prado & Dewey, 2014:267) and decreased haemoglobin levels (anaemia) (WHO, 2015). Providing an optimal complementary diet containing the recommended nutrients promotes adequate growth and development of various body systems (ESPGHAN Committee on Nutrition, 2008).

Dewey (2013:2050) emphasize that adequate nutrition during the complementary period is a global health priority as research have shown that growth impairment occurs mainly before two years of age (Victora *et al.* 2010:e480). It is especially important in underprivileged populations where the incidence of infections also contribute to increased nutritional needs (Dewey & Mayers, 2011:129). Children are especially susceptible to micronutrient deficiencies because of the high requirement for nutrients for growth and because they are vulnerable to infections causing diarrhoea and respiratory infections, leading to poor nutrient absorption and also decrease in appetite (Ochoa *et al.,* 2004:229).

2.3 Nutritional requirements of infants aged six to 23 months

2.3.1 Energy and nutrient requirements of the complementary feeding period (six months to two years)

Nutrient needs are determined in various ways – through direct measurement of energy expenditure, using intake of populations with normal growth curves, observed intakes of healthy infants and children or extrapolation from other age groups (Dewey & Brown, 2003:6). Total nutrient requirements of infants aged six to 12 months are based on the sum of the average amount of the nutrients provided by 600 ml breast milk and the average amount of nutrients provided by usual intakes of complementary foods that are consumed by healthy infants at these ages (Otten *et al.,* 2006:14). Total nutrient requirements of infants 12 months to three years are derived from extrapolated data from infants or adults due to the limited available research in this age group (Otten *et al.,* 2006:14). The total nutrient requirements for energy and key nutrients for infants and young children age six to 23 months are shown in Table 2.1.

Table 2-1: Dietary reference intakes - daily key nutrient requirements for infants and young children age six to 23 months

	6-12 months	12 -36 months
Energy (kJ/d)[a]	6-8 months: 2864 9-11 months:3486	12-23 months: 4586
Protein (g)	1.0g/kg/d[b]	0.87g/kg/d[b]
Fat (g)	30[c]	-[d]
Carbohydrates (g)	95[c]	100[b]
Vitamin A (µg RE)	500[c]	210[b]
Folate (µg)	80[c]	120[b]
Niacin (mg)	4[c]	5[b]
Riboflavin (mg)	0.4[c]	0.4[b]
Thiamine (mg)	0.3[c]	0.4[b]
Vitamin B6 (mg)	0.3[c]	0.4[b]
Vitamin B12 (µg)	0.5[c]	0.7[b]
Vitamin C (mg)	50[c]	13[b]
Calcium (mg)	260[c]	500[b]
Iron (mg)	6.9[b]	3.0[b]
Zinc (mg)	2.5[b]	2.5[b]

TE: Total energy, g: gram, mg: milligram, µg: microgram, µg RE: microgram Retinol Equivalents, kcal: kilocalories
Values from Institute of Medicine, 1998; 2000; 2001; 2005; 2011 unless indicated otherwise
[a] Values from WHO, 1998
[b] EAR of the US DRI published by the Institute of Medicine (IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2005; IOM, 2011)
[c] AI of the US DRI published by the Institute of Medicine (IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2005; IOM, 2011)
[d] Not determined – insufficient evidence/data to set reference values

Estimated energy and nutrient needs from the complementary diet are calculated based on the difference between recommended nutrient intakes (RNIs) or the relevant reference value and the amount of nutrients which are estimated to be provided by breast milk (Dewey & Brown, 2003:12). When working with these estimated energy and nutrient requirements, it should be kept in mind that these values are derived from estimated intakes of breast milk of which the nutrient content may vary depending on the maternal nutritional status (Allen, 1994; Black *et al.,* 2008:5). Depending on the reference value used, the estimated amount needed from the complementary diet will differ.

2.3.2 Nutrient density

Nutrient density is defined as the amount of nutrients per 100 kcal of feeds (including food and drinks) (Dewey, 2013:2050). Average desired nutrient densities of key nutrients of the complementary diet are shown in Table 2. The nutrient density of the complementary diet has to be sufficient as infants and young children eat typically small amounts of food but they

have high nutrient needs for growth (Dewey, 2013:2050). Critical nutrient density is the amount of nutrients per 100 kcal that need to be provided by complementary feeds to meet the total dietary requirements, after accounting for the nutrients provided by breast milk (Vossenaar & Solomons, 2012:860). As with determining the estimated energy and nutrients required from the complementary diet, some limitations apply to determine the necessary nutrient density of the complementary diet. Breast milk intakes are estimated and breast milk content varies depending on maternal nutritional status (Allen, 1994; Black *et al.,* 2008:6). Furthermore, the nutrient density value will also be different depending on the reference value that is used to calculate it (Dewey and Brown, 2003:15).

Table 2-2: **Average desired daily nutrient densities of complementary food diets for breastfed infants aged six to 23 months**

	6-8 months	**9-11 months**	**12-23 months**
Protein (g/100 kcal)	1.0	1	0.9
Vitamin A (µg RE/100 kcal)	81	63	5
Calcium (mg/100 kcal)	40	32	63
Iron (mg/100 kcal)	5.3	3.5	1.2
Zinc (mg/100 kcal)	1.1	0.7	0.4
Riboflavin (mg/100 kcal)	0.08	0.06	0.06
Thiamine (mg/100 kcal)	0.08	0.06	0.07
Niacin (mg/100 kcal)	1.5	1	0.9
Folate (µg/100 kcal)	11	9	19
Vitamin B6 (mg/100 kcal)	0.12	0.08	0.08
Vitamin C (mg/100 kcal)	11	8	0

TE: Total energy, g: gram, mg: milligram, µg: microgram, kcal: kilocalories

[a] Dewey and Brown (2003)

Because the amount of complementary food consumed is expected to be the least at six months, the required nutrient density is the highest at six months and often the period between six and 12 months poses the greatest challenge in meeting the micronutrient needs of these infants (Dewey, 2013:2050). One of the reasons for this is that infants are often fed diluted porridges that are nutrient poor (Dewey, 2013:2051) and these grain based diets contain phytate, limiting the bioavailability of some nutrients for example iron, zinc, phosphorous and potassium (Dewey, 2013:2051).

The nutrient density of the diet can be increased by adding animal source foods as it contributes toward the intake of protein, iron, zinc and calcium; however, it is not always an affordable option in most developing countries (Dewey and Brown, 2003:19). Considering

this, a lot of research has focused on strategies to meet nutrient needs in a cost effective way. Strategies that have been proposed are to optimally use locally available foods, the provision of micronutrient supplements and the use of fortified commercial complementary foods (Dewey and Brown, 2003:20). The optimal use of locally available foods includes educating caregivers on preparation methods and consumption practices that would increase bioavailability of micronutrients. Fermentation, soaking and germination as well as the use of ascorbic acid and reduction of polyphenols when consuming non-haem iron sources increases its bioavailability (Dewey and Brown, 2003:19; Gibson *et al.,* 1998:769). The use and role of commercial complementary foods will be discussed later in section 2.5 and 2.6. in this literature review.

Another way of improving micronutrient adequacy is to have adequate dietary diversity (Steyn *et al.,* 2005:644) and is discussed in the next section.

2.3.3   Dietary diversity

Dietary diversity is an important determinant of the quality of the diet and is defined as the number of foods or food groups consumed over a given period of time (Ruel, 2003:3912S). A variety of food is needed to meet essential nutrient requirements (Arimond & Ruel 2004:2579). Dietary diversity as indicator of dietary quality is often used in developing countries, possibly because of its simple application (Ruel, 2003:3912S). Dietary diversity and socio-economic status are closely linked, with poor socio-economic populations tending to have poor dietary diversity (Arimond & Ruel, 2004:2579, Labadarios *et al.,* 2011:8).

Associations between dietary diversity and child growth have been suggested. A study using data from 11 countries' demographic and health surveys showed a significant association between dietary diversity and height-for-age z-scores in infants and young children, six to 23 months of age in all but one of the countries (Arimond & Ruel, 2004:2584).

There are various ways to measure or classify dietary diversity, but the lack of consensus on which one to use makes it difficult to compare studies (Ruel, 2003:3911S). Most dietary diversity tools use a count of foods (food variety scores – FVS) or food groups (dietary diversity scores – DDS) consumed (Ruel, 2003:3912S). Examples of these are the methods proposed by the Food and Agricultural Organization (FAO) of the United Nations (UN) (Kennedy *et al.,* 2010) and the World Health Organization (WHO) (2008).

The FAO DDS measures household and/or individual dietary diversity by using a list of 12 or nine food groups respectively (Kennedy *et al.*, 2010:26). This DDS method has been validated in South Africa using national data of children aged one to nine years old with a

cut-off of a DDS of 4 to indicate a mean adequacy ratio (MAR) less than 50% (Steyn *et al.,* 2006:650).

The DDS method recommended by WHO (2008) consists of seven food groups; 1) grains, roots and tubers, 2) legumes and nuts, 3) dairy products (milk, yogurt, and cheese), 4) flesh foods (meat, fish, poultry and liver/organ meats), 5) eggs, 6) vitamin-A rich fruits and vegetables, and 7) other fruits and vegetables. The indicator sets minimum dietary diversity as the proportion of six to 23 month old children who consume foods from ≥ four (out of seven) food groups. The reasoning behind the cut-off for four out of seven food groups is that there is an association with a better quality diet whether a child is breastfed or not (WHO, 2008:7, Moursi *et al.,* 2008:2450). The analysis that investigated the application/validity of this DDS included data sets of 10 countries and examined the relationship between the indicators – a seven group indicator and a mean micronutrient density adequacy (MMDA) (Working group on infant and young child feeding indicators, 2007:4). This MMDA excluded iron as the authors acknowledged that iron is a limiting micronutrient in almost all diets due to the difficulty to meet the needs thereof without iron-fortified products (Working group on infant and young child feeding indicators, 2007:3). Micronutrients included in the MMDA are vitamin A, thiamine, riboflavin, vitamin B6, folate, vitamin C, calcium and zinc, for breastfed infants aged six to 11 months, and vitamin B12 for breastfed children, aged 12 to 23 months, and all non-breastfed children (Working group on infant and young child feeding indicators, 2007:5). The aim of this analysis was to determine how well the seven group DDS indicator will predict the MMDA of ≥ 75% (Working group on infant and young child feeding indicators, 2007:5). Thus, with the consumption of four or more out of seven of the food groups, it is assumed that a MMDA of ≥ 75% will be reached for the aforementioned micronutrients and can therefore be seen as an 'adequate' diet. It is assumed that with the consumption of at least four of the seven food groups at least a fruit, a vegetable, an animal source product and a staple food from the grain, root or tuber group are consumed (WHO, 2008:7).

2.4   Guidelines on infant and young child feeding

The WHO published complementary feeding guidelines for the breastfed (WHO, 2003) and non-breastfed child (WHO, 2004). These guidelines are summarized in Table 3. Exclusive breastfeeding is promoted as the optimal and preferred feeding method up to six months of age with continued breastfeeding thereafter up to two years of age and beyond. Most complementary feeding recommendations for breastfed and non-breastfed children are similar.

Table 2-3: **Complementary feeding guidelines for the breastfed and non-breastfed child**

Breastfed children[a]	Non-breastfed children[b]
Breastfeed exclusively from birth to age six months and introduce complementary foods at six months of age with continued breastfeeding.	Energy needs should be met – 600 kcal/d at six to eight months, 700 kcal at nine to 11 months and 900 kcal at 12 to 23 months.
Breastfeeding should be continued frequently and on demand for up to two years of age or beyond.	
Responsive feeding: Infants should be directly fed and older children be assisted, paying attention to signs of hunger and satiety. Encourage, but don't force a child to eat, be patient and feed them slowly. Different food combinations, textures and tastes should be considered when a child refuses many foods. Distractions should be limited especially when child loses interest easily. Feeding the child is a learning period and expression of love – eye contact and communication is important during feeding times.	
Safe preparation and storage of complementary foods: Good hygiene and appropriate food handling should be practiced – hand washing practices, safe food storage and service, use of clean preparation and feeding utensils, and avoid use of bottles as it is difficult to clean properly.	
Amount of complementary food needed: Small amounts of food should be given at age 6 months with an increase in quantity with age in addition to continued breastfeeding	
Food consistency: Consistency can be changed from pureed, mashed, semi-solid foods at six months to finger foods at eight months and 'family foods' at age 12 months. Foods should be nutrient dense. Avoid consistencies that can pose a choking hazard such as raw carrots or grapes.	
Meal frequency and energy density: The number of meals per day should increase with age (from two to three times a day at six to eight months, to three to four times a day at nine to 24 months of age, as well as nutritious snacks in between).	
Nutrient content of complementary foods: A variety of foods should be consumed in order to meet nutrient needs. Daily consumption of animal source foods should be encouraged together with vitamin A rich fruit and vegetables and foods with adequate fat content. Low nutrient foods should be avoided i.e. tea, coffee and sugary beverages.	

[a] WHO (2003), [b] WHO (2004)

2.4.1 Current recommendations for infant and young child feeding in South Africa

South African recommendations and guidelines regarding infant and young child feeding are related to and based on international guidelines (WHO, 2003; 2004). The Infant and Young Child Feeding Policy (IYCFP), the South African Paediatric Food Based Dietary Guidelines and the Road to Health Booklet (RtHB) are some of the main sources of these guidelines

and recommendations. Table 4 summarizes the information given by these sources with regards to the complementary diets.

The South African National Department of Health (DOH) published an IYCFP that provides guidelines to healthcare professionals and mothers (DOH, 2013). The main components of the IYCFP are the following: 1) Early initiation of breastfeeding in health facilities, 2) Exclusive breastfeeding for the first six months, 3) Continued breastfeeding for two years and beyond, 4) Feeding the infant in the context of HIV (Human Immunodeficiency Virus), 5) Consumption of commercial infant formula, 6) Complementary foods from the age of six months, 7) Feeding the infant and young child in difficult circumstances, and 8) Responsibilities of health care personnel implementing maternal, women, neonatal and child health at national, provincial, district and facility level (DOH, 2013:11). Information and guidance given around breastfeeding and the Mother Baby Friendly Initiative (MBFI) is promoted and used to increase awareness in health care facilities (DOH, 2013:12). Exclusive breastfeeding for the first six months of life as well as continued breastfeeding with adequate complementary feeding after six months is recommended. These guidelines are based on the WHO/UNICEF 2003 and 2010 Global Strategy for Infant and Young Child Feeding. Specific guidelines also exist for HIV positive women (DOH, 2015:9). For the purpose of this literature review, the recommendations with regards to complementary feeding given in the IYCFP are highlighted in Table 4.

The South African Paediatric Food Based Dietary Guidelines that addresses various aspects of infant and young child feeding have also recently been published. The aspects of infant and young child feeding that the Paediatric Food Based Dietary Guidelines series of articles address are the following: 1) Exclusive breastfeeding for the first six months of life (Du Plessis & Perreira, 2013), 2) Complementary feeding from six months onwards (Du Plessis *et al.,* 2013), 3) Responsive feeding – eating behaviour (Harbron *et al.,* 2013), 4) Oral health and nutrition of children under five years of age (Naidoo, 2013), and 5) Food hygiene and sanitation (Bourne *et al.,* 2013). Du Plessis *et al.* (2013:S138) proposes six messages that are in line with public health programmes which aims to address poor complementary feeding practices, to encourage consumption of locally available foods and to decrease micronutrient gaps with the use of supplementation or enrichment. These messages are known as the Paediatric Food Based Dietary Guidelines:

1. "From six months of age, start giving your baby small amounts of complementary foods, while continuing to breastfeed for up to two years and beyond.

2. Gradually increase the amount of food, number of feeds and food variety a s your child gets older.

3. From six months of age, give your baby meat, chicken, fish, liver and eggs every day, or as often as possible.

4. Start spoon feeding thick foods, and gradually increase to the consistency of family food.

5. Give your child dark-green leafy vegetables and orange-coloured vegetables or fruit every day.

6. Avoid giving tea, coffee, sugary drinks, and snacks that are high in sugar, fat or salt. ”

The Road to Health Booklet (DOH, 2012) is a functional document that is given to all mothers who give birth in a healthcare facility (either private or government) in South-Africa and also contains advice on feeding infants and young children. Information relating to the complementary diet that it provides is summarized in Table 2.4.

Table 2-4:   **South African recommendations and guidelines with regards to complementary feeding**

Aspect of complementary feeding	Recommendation
Timely introduction	Introduction from six months is promoted, and early and late introduction of complementary foods are discouraged. The age of six months is identified as the time when exclusive breast milk feeds no longer meet the needs of the infant (DOH, 2013; Du Plessis, 2013)
Appropriate foods	Nutrient dense foods are focused on – especially iron and vitamin A rich foods. Attention is given to inhibitors of iron absorption such as tea and coffee – these are discouraged. Sugar rich foods and drinks are also discouraged and linked with dental caries (DOH, 2013; Du Plessis, 2013).
	The RtHB gives the following specific guidelines:
	For infants six to 12 months: Introduce foods such as soft porridge, vegetables and then fruit – two to three teaspoons at first. Give protein rich food such as mashed beans and locally available animal source foods as a source of iron daily for example egg yolk, minced meat, fish, chicken/chicken livers and Mopani worms. Provide breast milk (preferably) or if not breastfed, formula milk or full cream cow's milk (from nine months of age)
	For children 12 to 59 months: Give children a variety of foods. Make starchy food the basis of every meal, fruit and vegetables are needed everyday. Animal foods and legumes should be consumed everyday – i.e. chicken, fish, eggs, beans, soya or peanut butter. Iron rich (organ meat, dark green leafy vegetables, egg yolk, dry beans or fortified cereals), vitamin A rich (liver, dark green leafy vegetables, mango, paw-paw, yellow sweet potato and full cream milk) and vitamin C rich (citrus fruit, guavas, tomatoes) foods should be given (DOH, 2012).
Meal frequency and quantities	It is acknowledged that children require nutrient dense, small and frequent meals because of their high nutrient needs and limited gastric capacity. It is suggested that the number of meals should be increased with age (DOH, 2013)
Food consistency	It is suggested that puree foods should be initiated and that the consistency should gradually become coarser – resembling family foods as the child's ability to chew improves (DOH, 2013; Du Plessis, 2013). A warning is given against foods that will cause choking, such as nuts (DOH, 2013)
Safety	Hygiene and food safety is addressed (DOH, 2013)
Responsive or active feeding	The caregiver is advised to actively supervise and encourage feeding (DOH, 2013)
Other	Discouraging pre-mastication practices, counselling on long term adverse impact of early introduction of complementary feeds, discouragement of adding soft porridge to bottles, hygienic daily activities with regards to feeding and playing and advising oral care when at risk for dental caries (DOH, 2013)

DOH: Department of Health, RtHB: Road to Health Booklet

2.5   Complementary feeding practices of infants and young children six to 23 months

The complementary diet is defined as transitioning from a milk-based diet to a diet including solid foods and other beverages (Fein *et al.,* 2008:S91).

In this section an overview will be given of international complementary feeding practices of infants and young children.

2.5.1   Global complementary feeding practices of infants and young children

2.5.1.1   Introduction of complementary foods

Early introduction of complementary foods (i.e. before four to six months of age if compared to WHO recommendations) is common in the majority of studied populations. In developing countries such as Cameroon, West Africa (Mananga *et al.,* 2014:4) and in the Peruvian Amazon (Lee *et al.,* 2014:153) more than half of infants have been introduced to complementary feeding before six months. Similarly, in developed countries such as Germany (Fotorek *et al.,* 2014:363), Britain (Armstrong *et al.,* 2014:203) and the United States of America (USA) (Clayton *et al.,* 2013:1108) early introduction is also common with approximately a third to half of infants in those study populations having been introduced to solids before or at the age of four months. Reasons for early introduction are related to mothers' perceptions of the babies' readiness, increased hunger or inadequacy of milk feeds (Clayton *et al.,* 2013:1111).

Some form of grain based cereal or porridge is commonly a first food to be introduced in most populations. It can either be maize based as in the Peruvian Amazon (Lee *et al.,* 2014:152) and African countries such as Zambia (Katepa-Bwalya *et al.*, 2015:4), or rice based as in Nepal (Chapagain, 2013: 446). Grains, roots and tubers are usually the most frequently consumed food group at age six months and beyond (older) (Gessese *et al.,* 2013: 236; Mekbib *et al.,* 2014:38; Joshi *et al.,* 2012:48; Kabir *et al.,* 2012:16; Lee *et al.,* 2014:153; Mananga *et al.,* 2014:4 & Patel *et al.,* 2012:33).

2.5.1.2   Nutrient intake, nutrient density and dietary diversity of the complementary diet

Earlier and recent reviews of studies in developing countries consistently report dietary inadequacy of the complementary diet for iron, zinc and calcium and to varying degrees for the majority of B vitamins, however nutrient density of protein is usually mostly adequate (Dewey and Brown, 2003:16; Osendarp *et al.,* 2016:2). These reviews include studies investigating the complementary diets of infants and young children, six to 23 months of age in various developing countries such as Bangladesh (Kimmons *et al.,* 2005), Cambodia (Anderson *et al.,* 2008), Ethiopia, (Baye *et al.,* 2013; Gibson *et al.,* 2009), Ghana (Lartey *et al.,* 1999), Guatemala

(Campos *et al.,* 2010; Hernandez *et al.,* 2011), Malawi (Hotz and Gibson, 2005), Mongolia (Lander *et al.,* 2010), Peru (Creed de Kanashiro *et al.,* 1990; Lopez de Romana *et al.,* 1989; Roche *et al.,* 2011), Phillipines (Perlas *et al.,* 2004), and South Africa (Faber, 2005).

Dietary diversity is one of the indicators used to assess the adequacy of the complementary diet (WHO, 2008:7), and complementary feeding practices are influenced by factors such as maternal education, household wealth, exposure to media and access to antenatal care visits (Menon, 2012:2). Agricultural differences between countries also influence complementary feeding practices (Menon, 2012:2). Poor dietary diversity is found especially in developing countries – for example in South Asia (Joshi *et al.,* 2012:50; Kabir *et al.,* 2012:16; Patel *et al.,* 2012:34) less than 20%, and in Ghana less than a third (Issaka *et al.,* 2014:673) of infants aged six to 11 months have minimum dietary diversity. As discussed earlier, according to the WHO indicator, minimum dietary diversity is defined as consuming at least four out of seven food groups (WHO, 2008:7). With an increase in age the number of infants in a population that achieve minimum dietary diversity tend to increase – albeit to various extents. In Ghana (Issaka *et al.,* 2014:673) and Bangladesh (Kabir *et al.,* 2012:16) the number of infants at 18 to 23 months that met minimum dietary diversity was approximately 60% - two to three times more at this age compared to six to 11 months. In contrast in India, the number of infants achieving minimum dietary diversity remained low, with less than a quarter of children achieving it at 18 to 23 months of age (Patel *et al.,* 2012:34).

From initiation of complementary feeding with the grain, root and tuber group, more food groups are added with an increase in age – usually vegetables, dairy, fruit, eggs, legumes, nuts and seeds, and flesh foods depending on aforementioned factors. Especially in developing countries where socio-economic circumstances are very poor, the intake of flesh foods remain fairly low throughout the complementary feeding period (Gessese *et al.,* 2014:236; Mekbib *et al.,* 2014:38; Mananga *et al.,* 2014:4; Patel *et al.,* 2012:33). In the USA (a developed country), meat is consumed by a higher percentage of infants and young children – from six months in the form of commercial baby food and from nine months in non-baby food form (Fox *et al.,* 2006:S25). With an increase in age more processed type of meats are given to the children (Fox *et al.,* 2006:S25).

Commercial infant products are also consumed as a complementary food in both developed and developing countries. In developing countries, the consumption thereof is dependent on the household being able to afford it (Katepa-Bwalya *et al.,* 2015:4). In Nepal nearly a third of infants aged six to 23 months in that study population received a commercial infant cereal (known as 'Lito') (Chapagain *et al.,* 2013:445) and more than 45% of infants age six to 23 months in Bangladesh received commercial infant products (Saleh *et al.,* 2014:92). It is seen in developed countries (i.e. Germany and USA) that the consumption of commercial infant

products is high but it is also age dependant – nearly 75% of six month old infants in a German study received commercial infant food but by 24 months it decreased to 30% of children who still received it (Fotorek *et al.,* 2014:365). In an American study commercial infant products were the main source of meat, fruit and vegetables before age 12 months (Fox *et al.,* 2006:S22).

Sugary beverages, snacks and salty snacks are also consumed more with an increase in age – American infants were already introduced to these foods at age six months and by age 19 months almost all of the children ate it on a daily basis (Fox *et al.,* 2006:S28).

2.5.2 Complementary feeding practices of infants and young children in South Africa

2.5.2.1 Introduction of complementary foods

In South Africa the recommended age for introduction of solids is similar to the WHO guidelines – complementary foods should be introduced from six months of age while continuing to breastfeed for up to two years and beyond (DOH, 2013:14; WHO, 2003:10). The reality in South Africa does not reflect these guidelines. Various studies have shown that the introduction of complementary foods for the majority of infants often occur before six and even before four months (Budree *et al.,* 2016:4; Faber & Benadé, 2007:20; Faber *et al.,* 2016:531; Ghuman *et al.,* 2009:76; Mushapi *et al.,* 2008:38).

The 2012 SANHANES showed that the most common complementary first foods were commercial infant cereals (51.2% of the subjects), followed by homemade porridge (29%), pureed vegetables or fruit (4.4%), with the remaining 15.4% consisting of clinic-issued porridge, jarred baby foods, custard and other foods (less than 4% each) (Shisana *et al.*, 2013:5). Other smaller South African studies investigating complementary feeding practices also report that the primary complementary food to be introduced is soft porridge – mainly maize meal (Budree *et al.,* 2016:4; Faber, 2005:377; Faber & Benadé, 2007:19; Faber *et al.,* 2016:533; Mamabolo *et al.,* 2004:329; Theron *et al.,* 2006:382), but also other grains such as sorghum (Mamabolo *et al.,* 2004:329) and commercial infant cereals (Faber, 2005:378; Faber & Benadé, 2007:19; Faber *et al.,* 2016:533; Mamabolo *et al.,* 2004:329).

2.5.2.2 Nutrient intake, nutrient density and dietary diversity of the complementary diet

A small number of studies over the last decade looked at what foods infants received as their complementary diet in South Africa as well as the nutrient intake, nutrient density and dietary diversity thereof. These studies are summarized in Table 5.

Starch (grains, roots and tubers) foods remain the foods most consumed throughout infancy and into early childhood (Budree *et al.,* 2016:3; Faber *et al.,* 2016:535). As the consumption of

commercial infant cereal decrease over time, the intakes of maize meal porridge and bread increase (Budree *et al.,* 2016:6; Faber *et al.,* 2016:536).

There is also the frequent consumption of inappropriate foods such as fruit juices, salty snacks (chips), sugary foods and beverages by infants and young children in the complementary feeding period (Budree *et al.,* 2016:6; Faber, 2005:378; Faber & Benadé, 2007:21; Faber *et al.,* 2016:538; Mamabolo *et al.,* 2004:329; Theron *et al.,* 2006:384).

The studies that looked at nutrient densities showed an inadequate nutrient density of the complementary diet for calcium, iron and zinc but mostly an adequate nutrient density for protein (Faber, 2005:377; Faber *et al.,* 2016:534). Dietary diversity was reported on by two studies and different results are seen – in the Western Cape poor dietary diversity was seen at age six months for the majority of infants, however it improved greatly towards 12 months (see Table 5) (Budree *et al.,* 2016:4). Dietary diversity remained inadequate for a large percentage of children from age six to 24 months in a study done in KwaZulu-Natal (KZN) (Faber *et al.,* 2016:538). The results of the study done in KZN showed that DDS ≥ 4 was associated with higher nutrient density for various micronutrients (Faber *et al.,* 2016:53).

Table 2-5:   Overview of South African studies looking at dietary intake of infants and young children in the complementary feeding period

Study	Main findings
<u>Authors:</u> Budree *et al.,* 2016 <u>Aim:</u> To investigate feeding practices, quality of complementary feeding and association between feeding practices and nutritional status of infants in first year of life in a South African setting <u>Study design</u>*:* Longitudinal cohort study <u>Study sample:</u> zero to 12 months (n=1076); Peri-urban area, Western Cape <u>Dietary assessment:</u> FFQ at ages six, nine and 12 months	<u>Dietary diversity:</u> Food diversity increased with age. Only 5% of infants had minimum dietary diversity at six months but 75% at age 12 months. Grains, roots and tuber group most frequently consumed group at all ages Intake of dairy, fruit and vegetables, eggs and flesh foods increased with age <u>Other:</u> High consumption of inappropriate foods especially at age 12 months - crisps (32%), soft drinks (54%), refined sugary foods (51%) and fried foods (32%)
<u>Author:</u> Faber, 2005 <u>Aim:</u> To determine nutrient composition of complementary foods consumed by 6-12 month old South African infants <u>Study design:</u> Cross sectional survey <u>Study sample:</u> 6-12 months (n=475); Rural area, Valley of the Thousand Hills, KwaZulu-Natal <u>Dietary assessment:</u> 24 hour recall	<u>Nutrient intake:</u> Median intakes of calcium, magnesium, vitamin A, thiamine, riboflavin, vitamin B6 and Vitamin B12 ≥ AI for ages 6-12 months Median intake of iron, niacin, folic acid & vitamin C < AI <u>Nutrient density:</u> Less than half of desired nutrient density for calcium, iron and zinc Nutrient density of protein > than desired nutrient density <u>Infant products:</u> Infant cereal contributed ± 50% of iron intake and > 25% of total intake for magnesium, thiamine, niacin and vitamin B12 Ready-to-eat canned baby foods contributed < 15% of total intake for all micronutrients Infant cereal consumed by 31% of infants
<u>Author:</u> Faber & Benadé, 2007 <u>Aim:</u> To determine breastfeeding,	<u>Infant products:</u> Infant cereal, a popular first food and consumed at least 4x a week by 52% of infants

Study	Main findings
complementary feeding and nutritional status of six to 12 month old infants Study design: Cross sectional survey Study sample: 6-12 months; n=505; Low socio-economic rural area, Valley of the Thousand Hills, KZN Dietary assessment: FFQ	Other: Maize meal porridge (soft or stiff) consumed by majority of infants Relatively low intake of dairy products, animal foods and legumes Most popular vegetable – pumpkin (was eaten by a third of infants most days) Most popular fruit – oranges and bananas (was eaten by > 30% of infants most days) > 40% of infants consumed savoury snacks most days and 26% drank carbonated drinks at least 1x a week
Author: Faber *et al.*, 2016 Aim: To determine dietary diversity and nutrient density of the complementary diet and to relate the ND of the complementary diet to achievement of minimum dietary diversity Study design: Cross sectional survey Study sample: six to 24 months; n=158 (Rural area – Valley of the Thousand Hills); n=158 (Urban area – Pinetown, KZN) Dietary assessment method: 24 hour recall, FFQ	Nutrient density: A large number (> 60%) of infants had nutrient density < desired nutrient density for calcium, iron, zinc, riboflavin, vitamin B6 and niacin. Adequate nutrient density was found for protein, vitamin A and vitamin C Dietary diversity: Cereals, roots and tuber group is the most consumed group (> 85% of infants at all ages) 30-60% of infants consumed legumes, flesh foods and other fruit and vegetables – legumes consumed more by rural populations and flesh foods consumed more by urban populations Less than 25% of children achieved minimum dietary diversity at all ages DDS ≥ 4 associated with higher nutrient density for several micronutrients Infant products: A third of infants (six to 11 months) consumed infant cereals and ready-to-eat jarred baby food and intake decreased with age - < six % of infants consumed it at 18-24 months Other: > 80% of infants at all ages consumed soft maize meal porridge daily Oranges and bananas were the fruit consumed by most children at least once during the previous week Butternut (six to 11 months) and cabbage (> 12 months) were vegetables consumed by most children at least once during the previous week Consumption of fizzy drinks by 20%, salty snacks by ± 80% and sweets by ± 50% of infants > age 12 months

Study	Main findings
Author: Mamabolo *et al.*, 2004 Aim: To evaluate feeding practices and growth patterns of infants Study design: Cohort study Study population: one to nine months; one months: n=134, three months: n=149, six months: n=170 & nine months: n=132; semi-rural area, Mankweng, Limpopo Dietary assessment method: Questionnaire – one, three, six and nine months	Infant products: Commercial infant cereal mainly given supplementary to maize meal or sorghum. At six months 16% and at 9 months 22% of infants consumed it Other: Most common first foods are maize meal and sorghum (mabella) At six months < 40% received fruit, < 27% ate vegetables and < 20% protein rich food (meat and eggs) Variety increases with age Fruit juice consumed by ± 30% and 60% at six and nine months, respectively
Author: Theron *et al.,* 2006 Aim: To measure dietary intakes of young children and the impact of poor diets on stunting Study design: Cross sectional survey Study Population: 12-24 months; n=40 (urban area – Gauteng province), n=30 (rural area – Limpopo Province) Dietary assessment method*:* FFQ	Other: Animal protein sources –eggs, boiled chicken, chicken feet (urban) and fried egg, and pilchards (rural) Plant protein sources - canned beans (rural), soya (urban) Main carbohydrate sources were maize porridge (mostly unfortified), sugar from cold drinks and bread Most consumed fruit were apples and bananas Poor consumption of vegetables Carbonated cold drinks were the third (urban) and ninth (rural) most consumed food item

AI: adequate intake, DDS: dietary diversity score, FFQ: food frequency questionnaire, KZN: KwaZulu-Natal, QFFQ: quantified food frequency questionnaire

These studies (as summarized in Table 5) and other national surveys (i.e. the NFCS) (Labadarios *et al.,* 2008:253) show that the nutrient needs of infants and young children are often not met and that inappropriate feeding practices exist in South Africa. Strategies have been developed and research has been focusing on developing interventions to improve the nutritional status of infants and young children.

2.6 Evidence-based infant and young child feeding strategies to improve health and development

As mentioned earlier, almost 27% of South African children under five years of age are stunted (NDoH, Stats SA, SAMRC & ICF, 2017:27), putting malnutrition on the national agenda. Research conducted to investigate how malnutrition in infants and young children can be combated propose various interventions including promotion of breastfeeding, promotion of a diverse complementary diet and the improved consumption of micronutrient rich local foods, supplementation of certain key micronutrients (for example vitamin A supplementation for children six to 59 months, iron, zinc and multiple micronutrient supplementation) and fortification of staple foods (Bhutta *et al.,* 2013:10; Dewey & Adu-Afarwuah, 2008:32). Prevention and management of disease as well as the prevention and treatment of severe acute malnutrition (SAM) are also key interventions (Bhutta *et al.,* 2013:9). An additional strategy proposed by Dewey & Vitta (2013) is to enhance and optimize consumption and accessibility to specially fortified infant products, however further research is warranted to determine the optimal amounts of micronutrients these products have to contain to be both effective and safe (Dewey & Vitta, 2013). It has been suggested that when fortified infant products are provided or promoted that it should be combined with educational messages on breastfeeding as well as complementary feeding (Dewey & Vitta, 2013).

Inclusion of special fortified infant products as a potential strategy to improve the quality of the complementary diet and the role of a national food fortification programme in the complementary feeding period will be discussed in the following section.

2.6.1 Special fortified infant products as a strategy to improve the quality of the complementary diet

Several authors advocate the need for special infant products for the complementary diet (Dewey, 2013:2051; Vossenaar & Solomons, 2012:859), to ensure that the requirements for certain 'problem nutrients' are met. Problem nutrients, defined as nutrients for which the actual nutrient density of the intake does not meet the recommended density (Dewey & Brown, 2003:14), in developing countries are particularly iron and zinc, and to a lesser extent the B-vitamins, vitamin A, C and E (Dewey, 2013:2051). Vossenaar & Solomons (2012:865) found

that when infants aged six to 24 months were fed a complementary diet that consisted of 'family foods', several 'problem nutrients' were lacking – vitamin A, niacin, folate, calcium, iron and zinc. This study was based on the best case scenario family foods of a developing country (Guatemala) which is not necessarily the reality of many households, and therefore true nutrient intake might even have been lower. Thus, a breastfed infant that receives only family foods (no commercial infant products), will still lack some nutrients and special infant products may be necessary to meet the infant and young child's needs (Vossenaar & Solomons, 2012:868). Similarly, Dewey (2013) suggests that in order to provide infants who get more than half of their energy from cereals/grains, with adequate nutrition, other sustainable strategies should be developed. Steyn *et al.* (2006:66) states that the only sustainable long-term solution for compensating for a significantly inadequate dietary intake of problem nutrients is to consume sources of food that are rich in specific nutrients. This is especially applicable for children who cannot eat large portions of staple fortified foods (Steyn *et al.,* 2006:66).

A South African study done in infants six to 12 months of age compared intakes of infants who consumed commercial infant products with those who did not. They were divided into two age categories i.e. six to < nine months and nine to < 12 months. Consumers of commercial infant products in both age categories consumed significantly more calcium, iron, zinc, vitamin A, thiamine, riboflavin, niacin, vitamin B6, vitamin B12 and vitamin C than non-consumers (Faber, 2005:375). Infant cereals contributed 51% towards total iron intake for the consumers thereof and it also provided more than 25% of the total intake of vitamin B12, magnesium, thiamine and niacin (Faber, 2005:375). Concerning ready-to-eat canned baby foods, it contributed less than 15% towards total intake for all micronutrients and the author questioned whether the consumption of these products is justified, especially in a low socio-economic population (Faber, 2005:380). The author concluded that infant products do have a role in infant feeding, but that commitment is needed from industry to optimize the fortification thereof and to make it more affordable (Faber, 2005:380).

Fein *et al.,* (2008:S91) suggests that special 'baby foods' may be more suitable for consumption for infants than those foods available for the general population. Special baby foods do not contain certain additives such as sulphites, added sugar or salt and are fortified with micronutrients and are more intensely screened for contaminants (American Academy of Pediatrics, Committee on Nutrition, 2001:1210; Fein *et al.,* 2008:S91).

2.6.2 The role of a national food fortification programme to improve the quality of the complementary diet

2.6.2.1 The National food fortification programme (NFFP)

In 2003 it became mandatory in South Africa that maize meal and wheat flour (used for making bread) be fortified with vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron and zinc (South Africa, 2003). These are staple foods in South Africa and both (especially maize meal) contribute significantly to total energy, carbohydrate, niacin, thiamine and to a lesser extent protein, iron and zinc intake for children one to nine years of age as were seen in a secondary analysis of the 1999 National Food Consumption Survey (NFCS) (Steyn *et al.,* 2006:68). This mandatory fortification programme is known as the National Food Fortification Programme (NFFP) or the 'Fortified for Better Health' programme. It was implemented following research done by the South African Vitamin A Consultative Group (SAVACG) in 1994 that found that 33% of South African children six to 23 months had vitamin A deficiency, one out of ten of these children had iron deficiency and 25% of the children were stunted (SAVACG, 1996:355). The SAVACG group recommended fortification as one of the strategies to improve micronutrient intake and status in children (SAVACG, 1996:356). The NFCS identified bread and maize meal as possible vehicles for fortification due to it being staple foods in South Africa (meaning it is consumed regularly and it is affordable for the majority of households (Labadarios *et al.,* 2000; Steyn *et al.,* 2006:68). In a secondary analysis of the NFCS data, nutrient values of unfortified maize meal products and bread were substituted with nutrient values of the fortified products (Steyn & Labadarios, 2008:25). This was done to determine whether fortification of staple foods would make a difference to the nutrient intake of South African children. The nutrient adequacy ratio (NAR) ("the ratio of intake of a particular nutrient to its recommended dietary allowance (RDA)"), and the mean adequacy ratio (MAR) (the average of the NAR (Ruel, 2003:3913S)) were used to assess the nutrient value or contribution of the NFFP. The results showed that the fortification of maize meal and bread led to a ten percent increased MAR for micronutrients in both urban and rural settings (Steyn & Labadarios, 2008:25). Rural children had a significantly ($p<0.05$) higher NAR for thiamine, folic acid and iron compared to urban children (comparing fortified values) and this was ascribed to the greater amounts of maize meal porridge that rural children consume (437.3 g versus. 263.36 g). Even though intakes of selected micronutrients were increased, the MAR was still less than 100% in both rural and urban children due to the low NAR of other micronutrients (calcium, vitamin C, D and E) that is not part of the fortification mix (Steyn & Labadarios, 2008:25). The authors concluded that the fortification programme is likely to improve the micronutrient intake of children younger than 9 years old (Steyn, & Labadarios, 2008:26). This study was done with dietary data of children one to nine years old –

thus it does not reflect the contribution of the NFFP to the complementary diet of infants between six and 12 months of age.

Infants aged six to 12 months consume small amounts of maize meal porridge and bread (fortified products) (Faber *et al.,* 2016:529) and the contribution of the NFFP towards nutrient intake for this age group is most probably low.

2.7   Conclusion

Malnutrition in young children is a global problem. The nutritional needs of the first 1000 days are well known but remain unmet in various parts of the world. Nutrient density and dietary diversity are important concepts when studying the complementary diet and the importance of having adequate nutrient density and dietary diversity have been highlighted. Country specific complementary feeding recommendations that are related to international guidelines exist in South Africa and various strategies are implemented in an effort to improve the nutritional status of this vulnerable age group. The consumption of commercial fortified infant products in South Africa has been discussed and the possible role the NFFP might have in complementary feeding have been elucidated.

CHAPTER 3:   ARTICLE

The article titled: "Dietary intake and contribution of commercial infant products and fortified staple foods in a cohort of 6 to 18 month old children from a low socio-economic community in South Africa" will be submitted to Maternal and Child Nutrition. The article is therefore written according to the author instructions for Maternal and Child Nutrition (see annexure A) with the exception of exceeding the number of words, tables and figures, which for the purposes of submitting to Maternal and Child Nutrition will be amended prior to submission.

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Keywords: Complementary diet, dietary trends, commercial infant products, fortification program, nutrient density, dietary diversity, infants, children, South Africa

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ABSTRACT

Children under the age of 2 years require nutrient dense foods and a diverse diet to meet their increased requirements for growth and development. This cohort-observational study assessed energy and nutrient intake, nutrient density and dietary diversity of the complementary diet; and the contribution of commercial infant products and fortified staple foods (maize porridge and bread) in children followed from age 6 to 18 months from a peri-urban community in the North West province, South Africa. Dietary data was collected by means of a single 24 hour recall at ages 6, 12 and 18 months, and a food frequency questionnaire at ages 6, 8, 10, 12, 15 and 18 months. Nutrient density of the complementary diet was low for iron (94.6% of infants) and zinc (85.1%) at age 6 months; and iron (85.1% and 90%) and calcium (78.7% and 88.3%) at ages 12 and 18 months respectively. More than 70% of children did not consume a diverse diet (i.e. ≥ 4 food groups) at all ages. Consumers of commercial infant products had significantly higher intakes than non-consumers for all key micronutrients at age 6 months; and of calcium, iron and zinc at age 12 months. The complementary diets of consumers of fortified staple foods had significantly higher ($p<0.05$) nutrient densities for zinc and folate at age 6 months; and zinc, folate and vitamin B6 at age 12 months, and lower nutrient density for calcium at age 12 months than non-consumers. Commercial infant products contribute significantly to higher intakes of several key nutrients for consumers thereof from age 6 to 18 months. At 6 months fortified maize meal and bread contribute little to the complementary diet but contribution towards micronutrient intake increases with age. Strategies to improve the complementary diet quality should be combined and should consider cost and bioavailability amongst other factors.

Keywords: Complementary diet, dietary trends, commercial infant products, fortification program, nutrient density, dietary diversity, infants, young children, South Africa

Introduction

Children under the age of 2 years have high nutrient requirements because of rapid growth and development, and, because they consume relatively small amounts of foods, it is important that complementary foods should have a high nutrient density (Dewey, 2013). In the absence of an optimal, good quality complementary diet that meets the energy and nutrient needs, malnutrition

– especially stunting, and to a lesser extent wasting – ensues, all of which may contribute to morbidity and mortality (Black *et al.,* 2008; IFPRI, 2014).

Malnutrition contributes to infant and child morbidity and mortality by reducing immunity (IFPRI, 2014). It also negatively affects the cognitive development of a child, leading to lower education, lower productivity and income-earning potential; this may result in the individual becoming a social burden, which ultimately impacts the economy of a country (IFPRI, 2014; Prado & Dewey, 2014).

Malnutrition in developing countries, especially in children under five years of age, is a problem, with 50 million children globally being wasted, 1 in 4 children being stunted and the incidences of children being overweight and obese rising (UNICEF, 2015). In South Africa, malnutrition is also a major problem – according to the 2016 South African Demographic and Health survey (SADHS), 27% of children under 5 years of age are stunted (NDoH, Stats SA, SAMRC & ICF, 2017). Being overweight is also seen as a major nutritional problem in South Africa with 13% of children under 5 years being overweight (NDoH, Stats SA, SAMRC & ICF, 2017).

It has been suggested that the high levels of stunting and increasing occurrence of South African children being overweight and obese are in part due to poor breastfeeding and complementary feeding practices and the inadequate nutritional quality of the complementary diet (Du Plessis *et al.,* 2013; Mamabolo *et al.,* 2006). Studies have shown that the nutrient densities of the complementary diets of South African children are below the recommended densities – mainly for calcium, iron and zinc, but also for niacin and riboflavin (Faber, 2005; Faber *et al.,* 2016). Poor dietary diversity is also evident – less than 25% of urban and rural children consumed more than 4 out of the 7 recommended food groups in a study in the KwaZulu-Natal (KZN) province (Faber *et al.,* 2016).

A number of global strategies have been proposed to improve the complementary diets of infants and young children (Bhutta *et al.,* 2013; Dewey & Adu-Afarwuah, 2008; Dewey & Vitta, 2013). This includes the promotion of a diverse complementary diet and increased consumption

of micronutrient-rich local foods, supplementation of certain key micronutrients (i.e. vitamin A supplementation for children 6 to 59 months, iron, zinc and multiple micronutrient supplementation) and fortification of staple foods (Bhutta *et al.,* 2013; Dewey & Adu-Afarwuah, 2008). An additional strategy proposed by Dewey & Vitta (2013) is to enhance and optimize the consumption and accessibility of specially fortified infant products.

In 2003, the National Food Fortification Program (NFFP) was implemented in South Africa, mandating the fortification of two staple foods, namely maize meal and wheat flour (used for making bread), with vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron and zinc as part of the strategy to improve micronutrient intake and status in children (South Africa, 2003). Secondary data analyses of available food intake data showed that substituting unfortified bread and maize meal in the diet with the fortified equivalents improved micronutrient adequacy of the diets of 1 to 9 year old children (Steyn *et al.*, 2008). It has been suggested however that the NFFP might have little influence on infant nutrition as they consume relatively small amounts of the fortified staples (Faber, 2005).

A Guatemalan study has shown that it is challenging to meet infants' nutritional needs without including fortified infant food products in the complementary diet that is mainly derived from family foods that is typically consumed in a low income population. They therefore suggest the use of fortified infant food products - either in the form of home fortificants or pre-fortified infant foods (i.e. infant cereals) (Vossenaar & Solomons, 2012).

In South Africa iron content of fortified maize meal ranges from 2.6mg to 3.2 mg/100 dry product, whereas iron content of commercial infant cereal is substantially higher, ranging from 7.5mg to 33.3 mg/100 dry product (Wolmarans *et al.,* 2010). Commercial infant cereals may have a role in infant nutrition as it has been shown that micronutrient intakes were significantly higher for consumers of infant products compared to non-consumers (Faber, 2005), however the cost of these products needs to be considered as it may prohibit consumption among lower income communities (Shisana *et al.,* 2013).

A limited number of studies (Budree *et al.,* 2016; Faber, 2005; Faber *et al.,* 2016) have investigated the nutrient density and dietary diversity of the complementary diet or the dietary trends of infants aged 6 to 23 months, and limited information (Faber, 2005; Faber *et al.,* 2016) is available on the contribution of commercial infant products and fortified staple foods (maize meal and bread) to the complementary diet of South African children. Therefore, the study aimed to assess trends in dietary and nutrient intake, the dietary diversity and nutrient density of the complementary diet, as well as energy and nutrient contribution of commercial infant products and fortified staple foods from age 6 to 18 months, in a cohort of children from a peri-urban community in the North West province, South Africa.

Methods

Study design

The current cohort observational study reports dietary data collected as part of a randomised controlled trial (Tswaka study) which assessed the effect of small-quantity lipid based nutrient supplements (SQ-LNS) on child growth. Infants were enrolled into the randomised controlled trial at age 6 months, and were randomly allocated to one of the three branches of the study receiving either one of two types of small-quantity lipid based nutrient supplements (SQ-LNS) (in the form of a paste) or a control. The duration of the intervention was 6 months, which was followed by a 6-month post-intervention follow-up study. Dietary data of all children from all three branches were included in the current observational study. Data was collected from September 2013 to December 2015. Dietary data was collected for study participants at different time points using a single 24 hour recall and an unquantified food frequency questionnaire that were tested for face and content validity and have been previously used in similar studies (Faber *et al.*, 2016; Smuts *et al.*, 2005).

Study population and study participants

Recruitment of eligible study participants for the aforementioned randomised controlled trial (Tswaka study) was done at 5 healthcare centres and through door-to-door home visits in the peri-urban Jouberton area in the greater Matlosana Municipality in Klerksdorp in the North West

province of South Africa. Study participants were enrolled in the study at the age of 6 months. Infants were excluded if they had never been breastfed, had severe congenital abnormalities, severe anaemia (Hb < 70 g/l), severe malnutrition (weight-for-length z-score < -3SD), chronic disease, known food allergies or intolerances (i.e. to peanuts, soy, milk or lactose), received special nutritional supplements, had not been born as a singleton, or if the caregiver planned to relocate out of the study area in the following 7 months.

In total, 750 infants were enrolled in the study. Dietary data was collected using an unquantified food frequency questionnaire at age 6 months (n=741), age 8 months (n=538), age 10 months (n=431), age 12 months (n=505), age 15 months (n=188) and age 18 months (n=248). Dietary data was also collected by a single 24 hour recall at age 6 months (n=715), age 12 months (n=446) and at age 18 months (n=213). The decrease in number of participants with increasing age is due to a 31.5% drop out rate in the randomised controlled trial as well as a lower number of participants enrolled in the post-intervention follow-up survey. In some cases the food frequency questionnaire and/or 24 hour dietary recall were not done, as the respondent was unable to answer the food frequency questionnaire, or was not the fulltime caregiver on the day of recall.

Data collection

Trained fieldworkers interviewed the mother or caregiver (collectively referred to from here on forward as caregivers) in either English or the native language (Setswana) of the area. Socio-demographic information was collected using a questionnaire. Dietary data was collected using an unquantified food frequency questionnaire and a single 24 hour recall (See appendix C).

For the food frequency questionnaire there were four choices to indicate frequency of consumption during the past seven days. These were: 1) every day, 2) most days (not every day but at least four days per week), 3) once a week (at least once a week, but less often than 4 times a week) and 4) never. The unquantified food frequency questionnaire contained 31 items and included breast milk and formula milk, dairy products, commercial infant products (jarred baby foods and infant cereals), and different food items from the following food groups – grains,

roots and tubers, fruits and vegetables, flesh/animal foods, eggs, sweet and savoury snacks, various drinks other than milk, salt and fats and oils.

The fieldworkers were trained and provided with a manual outlining the procedures for administering a 24 hour recall. A standardised dietary kit containing examples of food, food containers, household utensils and photographs was used to estimate and record the reported amount of food eaten. In addition, dish-up and measure, using dry oats, was used to estimate and record the amount eaten, particularly for cooked food. The 24 hour recall enquired about what food and drink (including breast milk or formula milk) were consumed the previous day, what time it was consumed, how it was prepared and how much of the meal or drink was consumed.

Data processing

For the frequency of food consumption data, the options every day, most days and once a week were condensed into one option namely "at least once during the past week". Data is presented in terms of the percentage of infants and young children who consumed a food item at least once during the previous week at the specific time point.

For the 24 hour recall data, food intake reported in household measures was converted into weight using the South African Medical Research Council (SAMRC) Food Quantities Manual (Langenhoven *et al.*, 1991). The amount of breast milk intake was assumed according to age; 775 ml for exclusively breastfed infants and 675 ml for partially breastfed infants at age 6 months, 615ml at age 12 months and 550 ml at age 18 months (WHO*,* 1998). In the instance where other milk feeds (formula milk) were consumed together with breast milk, the volume of the other milk feed was subtracted from these amounts for the different age groups to obtain an estimated amount of breast milk consumed.

The reported energy and nutrient intakes exclude SQ-LNS provided to the active arms during the trial. The Kruskal-Wallis test showed that there were no statistically significant differences

between the three study groups within an age group for any of the nutrients, for either total intake or for the complementary diet.

The food intake was converted to energy, macro- and micronutrients using the SAS software package (version 9.4; SAS Institute Inc., Cary, North Carolina) in conjunction with the South African Food Composition Database (SAFCD) (Wolmarans *et al.*, 2010). The section on baby foods in the SAFCD has been updated (Chetty *et al.*, 2016; Van Graan *et al.,* 2016), prior to data analysis. The SAFCD vitamin A values are reported as retinol equivalents (µg RE) (Wolmarans *et al.,* 2010). The reference values for nutrient densities of the complementary diet also use µg RE (Dewey & Brown, 2003), whereas the DRIs give vitamin A as retinol activity equivalent (µg RAE) (Institute of Medicine, 2001). We calculated the vitamin A µg RAE, where 1 µg RAE = 1 µg RE of retinol when vitamin A was from animal and fortified foods and 1 µg RAE = 2 µg RE of retinol if vitamin A was from plant foods. In the sample, vitamin A was derived mostly from fortified and animal food sources, and the difference between µg RAE and µg RE values was small. We therefore use vitamin A µg RE values as given in the SAFCD throughout. Age appropriate Estimated Average Requirements (EAR), or in the absence of an EAR the Adequate Intake (AI) of the Dietary Reference Intakes (DRIs) were used as the reference for nutrient intake (Institute of Medicine (IOM), 1998; IOM, 2000; IOM, 2001; IOM, 2005; IOM, 2011).

The complementary diet was defined as all foods and beverages consumed excluding breast milk and formula milk. The complementary feeding period is a period of change from a breast milk and/or formula milk based diet to a diet including solid foods and other beverages (Fein *et al.,* 2008). Nutrient (macro- and micronutrient) densities (amount of nutrient per 100 kcal) of the complementary diet (excluding breast milk and formula milk) were calculated. The nutrient density of the complementary diet of infants who received breast milk but not formula milk was compared with the estimated desired nutrient density based on the DRIs as reported in the paper by Dewey and Brown (2003).

To determine the energy and nutrient contribution of commercial infant products (infant cereals, jarred products, baby juice and formula milk), fortified maize meal and bread to total intake, the food intake data was categorized into 6 food groups. These were (i) infant cereals, (ii) jarred baby foods, (iii) formula milk, (iv) fruit juice for infants, (v) fortified maize meal, and (vi) bread made with fortified wheat flour. Energy and nutrient contribution of each of these six food groups were calculated and expressed as a percentage of total intakes for the consumers thereof, where consumers are defined as those children who consumed the specific food group on the day of recall. Furthermore energy and nutrient intakes as well as nutrient density of the complementary diet from the combined commercial infant products and the combined NFFP foods (fortified maize meal and bread) of infants and young children who consumed these products were compared with those who did not.

The energy and nutrient contribution of breast milk, fortified maize meal and bread, commercial infant products and other foods (all food other than breast milk, commercial infant products and fortified maize meal and bread) towards total intake were calculated as a percentage of total intakes.

Data from the 24 hour recalls were used to calculate a dietary diversity score (DDS) for the complementary diet using the method proposed by the World Health Organization (WHO, 2008). Food items that were reported in the 24 hour recall of each individual were sorted into the seven food groups (grains, roots and tubers; legumes and nuts; dairy products; flesh foods; eggs; vitamin A rich fruit and vegetables; and other fruit and vegetables) given by the WHO for the purpose of calculating a dietary diversity score. A child was said to have minimum dietary diversity at least 4 or more out of the 7 food groups (WHO, 2008) were consumed on the day of recall. The percentage of children consuming a specific food group, as well as the percentage of infants who reached less than the minimum dietary diversity (< 4 food groups) for each age group was calculated.

Statistical analysis

IBM SPSS version 22 (IBM Company, Armonk, New York, USA) was used for statistical analyses of nutrient intake – to test for normality, to derive median and interquartile range values as well as to determine statistical differences between consumers and non-consumers of commercial infant products and fortified maize meal and bread. Data from the food frequency questionnaire is reported as frequencies. Continuous data (dietary data from 24 hour recall questionnaires) was tested for normality by using Shapiro-Wilks test and was not normally distributed and therefore was reported as the median and interquartile range (IQR). The Mann-Whitney U test was used to determine the significance of differences between intake of consumers and non-consumers of commercial infant products and fortified maize meal and bread respectively.

Ethical considerations

Ethical approval was granted for the current study by the Health Research Ethics Committee (HREC) of the North-West University (NWU-00345-16-A1). The current study is affiliated to the Tswaka study which was granted ethical approval by the HREC of the North-West University (NWU-00011-11-A1) as well as the ethics committee of the South African Medical Research Council (EC011-03/2012). Ethical approval for the post-intervention follow-up survey was granted by the HREC of the NWU. The study was reviewed by the Department of Health and Social Development and registered with the Directorate for Policy, Planning and Research. The Kenneth Kaunda District Department of Health granted permission for the Tswaka study to be conducted in the Matlosana area of Klerksdorp. Recruitment of participants was done at health care centres and information letters were available to parents or legal guardians of infants who seeked informed consent in addition to one-on-one information sessions (See appendix B). Informed consent was obtained from the mother or legal guardian of the child (in the case that the mother was younger than 18 years – informed consent was obtained from an older family member of the mother) (See appendix B). Only those infants whose parent or guardian signed the informed consent form were included in the study. Information letters and verbal information sessions regarding the trial was available in the native language of the area (Setswana) and

communicated in the preferred language of the potential participant. Parents or legal guardians had the right to withdraw their child from the study at any time without being obliged to give a reason and with no penalty or loss of benefits they were entitled to. Monitoring of adverse events or reactions were routinely done to ensure the safety and health of the participants and relevant action were taken to act in the best interest of the participant, even if it meant premature withdrawal from the study.

Results

Socio-economic information of participants

Socio-economic information is presented in Table 1. The majority (91.7%) of primary caregivers were the mothers (n=688) of the infants of which 9.2% were married. The majority of the caregivers had an education level of grade 10 or higher (80%). The median number of people in a household was 5 with a median number of only 1 person earning an income and 2 persons receiving a social grant. The majority of households had access to electricity (92.3%) and to tap water either inside or outside their dwelling (95.8%). Gender distribution of the infants was 51.6% male and 48.4% female.

Table 1:   **Socio-economic information of primary caregivers**

Caregiver characteristics (n=750)	
Relationship of caregiver with child (%)	
Mother	91.7
Other (father, grandmother, aunt, not-related)	8.3
Age, years (Mean, 95% CI)	28.4 (27.8, 29.0)
Level of education (%)	
Lower than grade 10/Form III/NTC 1	20.0
Grade 10/Form III/NTC 1	20.0
Grade 11/Form IV/NTC II	30.1
Grade 12/Form V/NTC III	24.8
Higher than grade 12/Form V/NTC III	5.2
Marital status (%)	
Unmarried	55.3
Married	10.7
Living together	28.3
Common-law wife	3.5
Other (divorced, widow)	2.2
Household characteristic (n=750)	
Number of people in household (median, IQR)	5 (4,7)
Number of people in household earning an income (median, IQR)	1 (0,1)
Number of people in household receiving a social grant (median, IQR)	2 (1,3)
Access to a flush toilet (%)	95.1
Access to water (%)	
Tap inside the dwelling	29.3
Tap outside the dwelling	66.5
Public tap	4.1
Electricity in the dwelling (%)	92.3
Infant characteristics (n=750)	
Gender (%)	
Male	51.6
Female	48.4

CI: Confidence interval, NTC: National Technical Certificate, IQR: Interquartile range

Trends of foods consumed from 6 to 18 months

Figures 1 to 7 illustrates the percentage of children – age 6 to 18 months – who consumed specific food items at least once during the previous week. This illustrates the increasing or

decreasing number of children that consumed a specific type of food and therefore the trend of food consumption over time based on foods consumed during the previous week.

Figure 1 illustrates the percentage of children who received breast milk, formula milk and cow's milk during the previous week. At the age of 6 months, 71.9% of infants were still breastfed, 47.5% received formula milk and 23.8% already received cow's milk (not necessarily as milk feeds). The number of children receiving breast milk and formula milk decreased to 54.1% and 28.1% respectively by age 12 months, and 34.3% and 7.3% respectively by age 18 months. The number of children receiving cow's milk (mostly mixed into foods) increased over time, to 77.2% by age 12 months and 91.3% by age 18 months.

As seen in figure 2, at age 6 months 80.4% of infants consumed commercial infant cereal and 55.3% jarred baby foods at least once during the previous week. Over the next few months of life, the intake thereof decreased and by age 12 months; 39% and 32.7% of children consumed commercial infant cereal and ready-to-eat jarred baby foods respectively. At age 18 months only a few children consumed these products during the previous week – 13.3% commercial infant cereal and 9.3% jarred baby foods.

Figure 3 illustrates that from age 6 to 12 months, there was an increase in the number of children consuming maize meal porridge (31% to 91.9%), cooked porridge other than maize meal (e.g. oats, mabele) (16.1% to 49.1%) and instant porridge (mostly maize meal) (13.5% to 34.1%); and these numbers increased slightly from age 12 to 18 months.

At age 6 months, 43.8% of the infants ate vegetables at least once during the previous week; this increased to 76.4% at age 12 months and 84.3% at age 18 months (figure 4). Pumpkin, followed by carrots were the vegetables mostly consumed at age 6, 12 and 18 months.

Intake of fruit increased over time, as seen in figure 4. At age 6 months, 26.5% of infants consumed fruit at least once during the previous week; intake increased more than two fold to 69.3% at age 12 months and 78.2% at age 18 months. At age 6 months, banana was the fruit

mostly consumed (~ 69% of infants eating fruit), followed by oranges (~ 17% of infants eating fruit). Variety of fruit increased at ages 12 to 18 months, with the addition of apples and pears.

Figure 5 shows consumption of animal foods during the previous week. Chicken was the main animal food source for most infants – the number of children eating it increased with 21.9% at age 6 months to more than threefold to 74.9% at age 12 months and 85.5% at age 18 months. From ages 6 to 18 months, there was an increase in the percentage of children who ate meat (5.1% to 56.0%), fish (2.7% to 28.6%) and liver (10.5% 37.1%) at least once during the previous week.

The intake of beverages other than milk feeds is illustrated in figure 6. Rooibos tea was consumed by 27.7% of children at age 6 months, and almost double to 52.1% at age 12 months, and 56.5% at age 18 months during the previous week. Carbonated drinks, cordials (i.e. Oros) and fruit juice were consumed by 12.8%, 13.6% and 26.5% of infants at age 6 months; it increased to 39.4%, 41.8% and 34.5% of children at age 12 months and 56.9%, 46.8% and 30.2% at age 18 months respectively during the previous week.

Figure 7 shows the intake of chips and sweets during the previous week. At 6 months of age 20% and 31.2% of infants ate sweets and chips, and by 18 months of age the majority of children (73.4% and 83.9% respectively) consumed it.
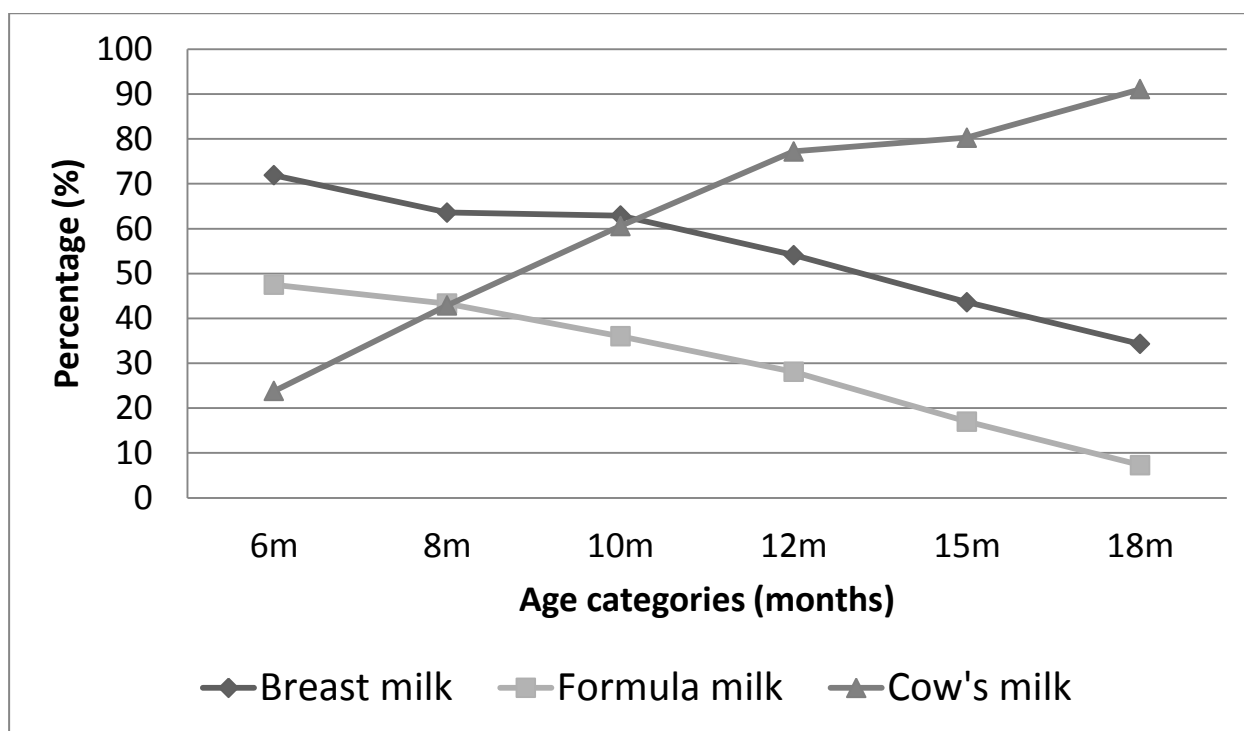
Figure 1: Percentage of children who consumed breast milk, formula milk and cow's milk at least once during the past week from age 6 to 18 months
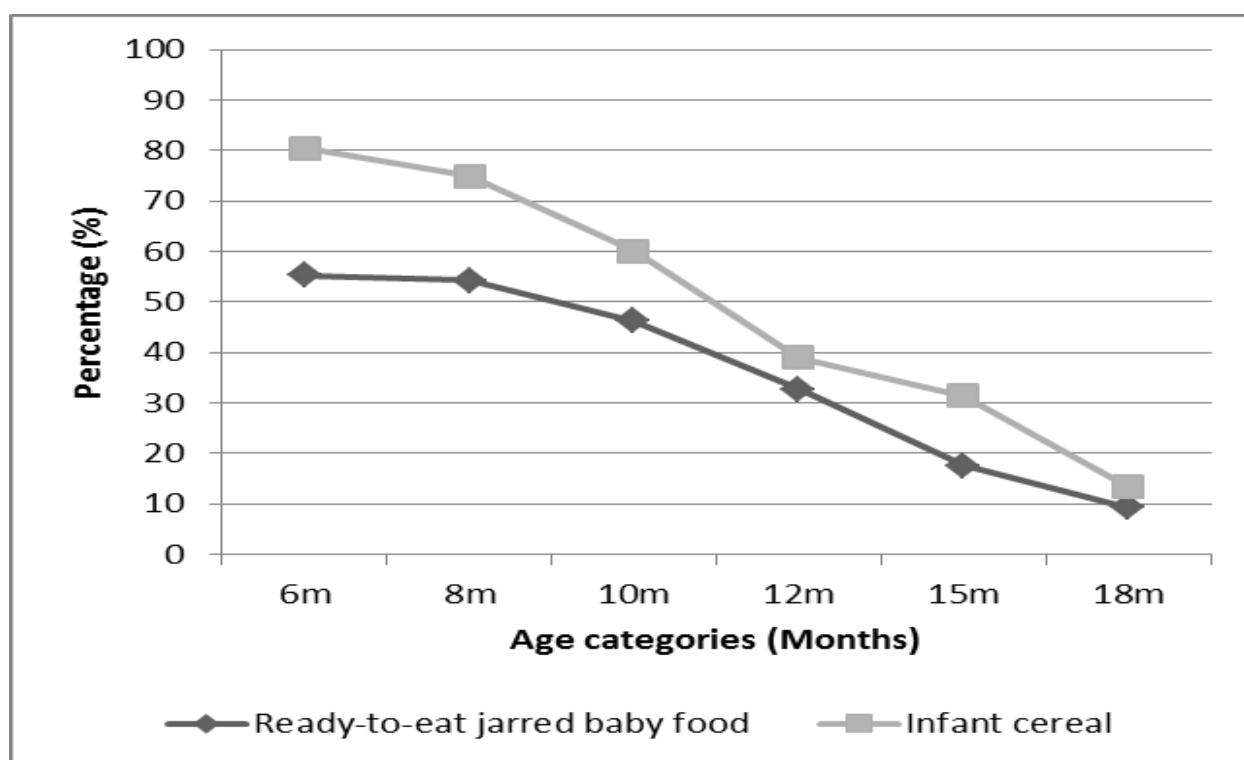
Figure 2: Percentage of children who consumed ready-to-eat jarred baby food and infant cereals at least once during the past week from age 6 to 18 months
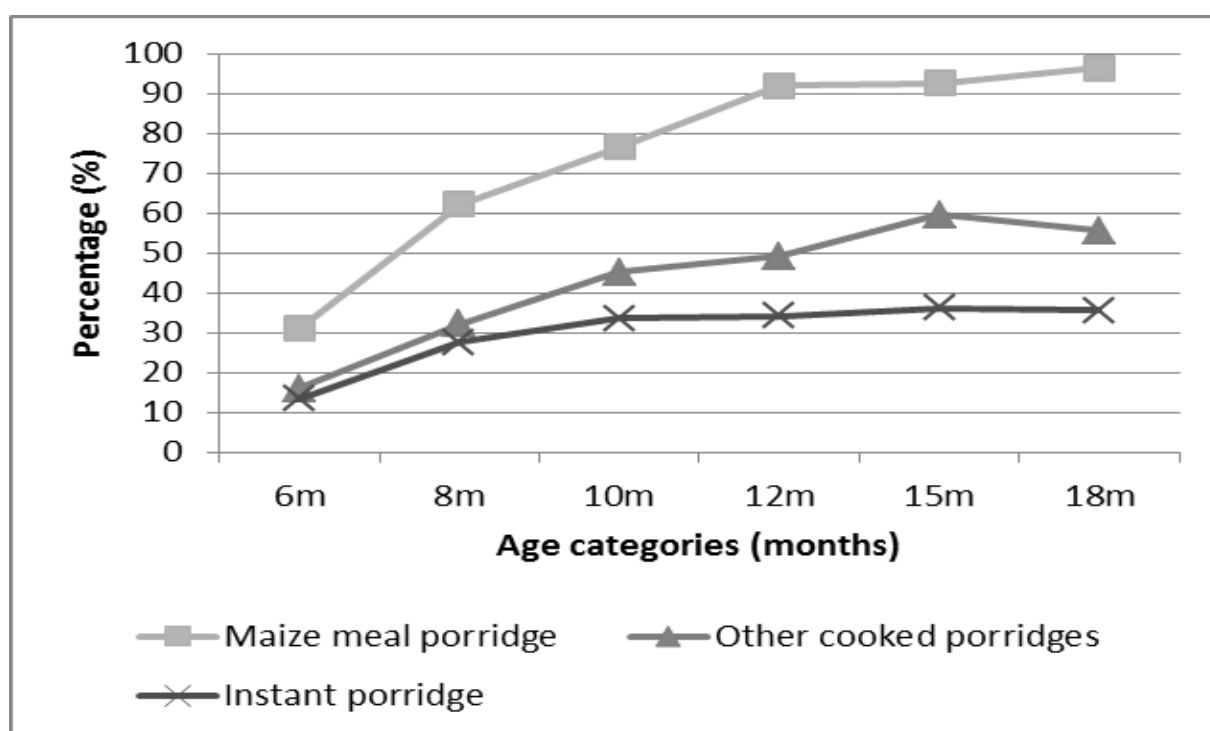
Figure 3: Percentage of children who consumed cereal and porridges at least once during the past week from age 6 to 18 months
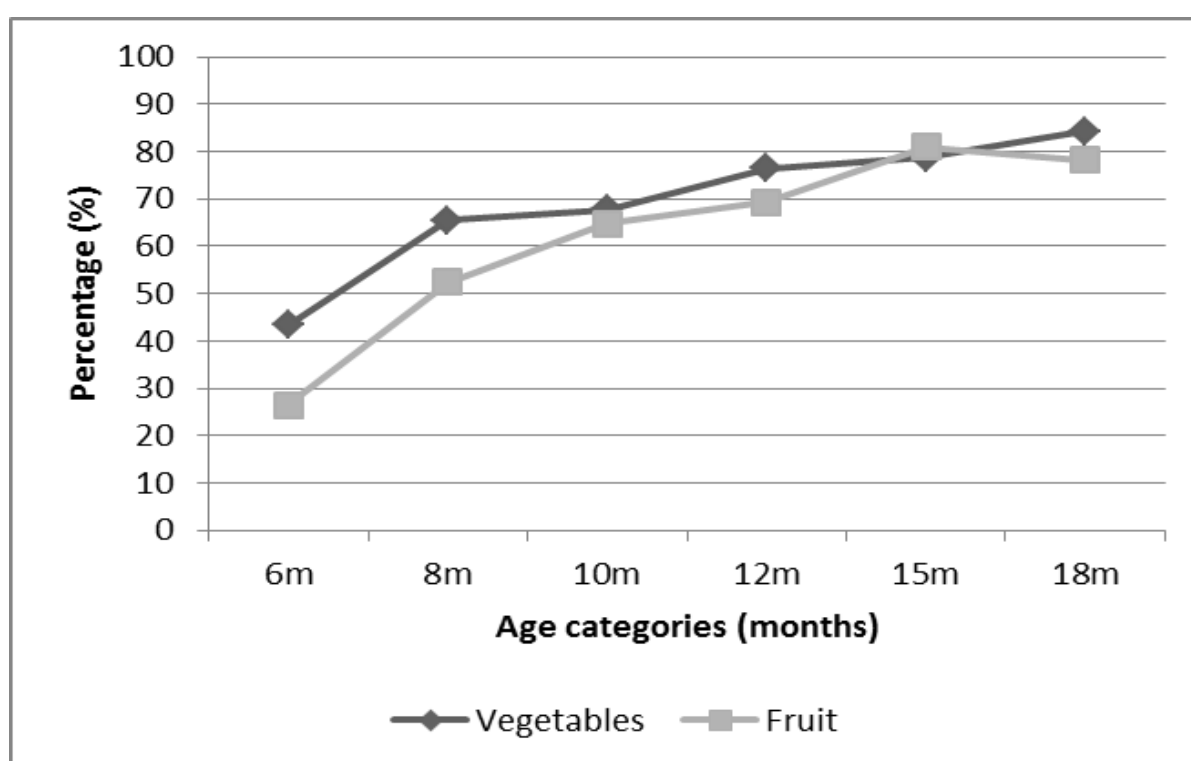
Figure 4: Percentage of children who consumed fruits and vegetables at least once during the past week from age 6 to 18 months
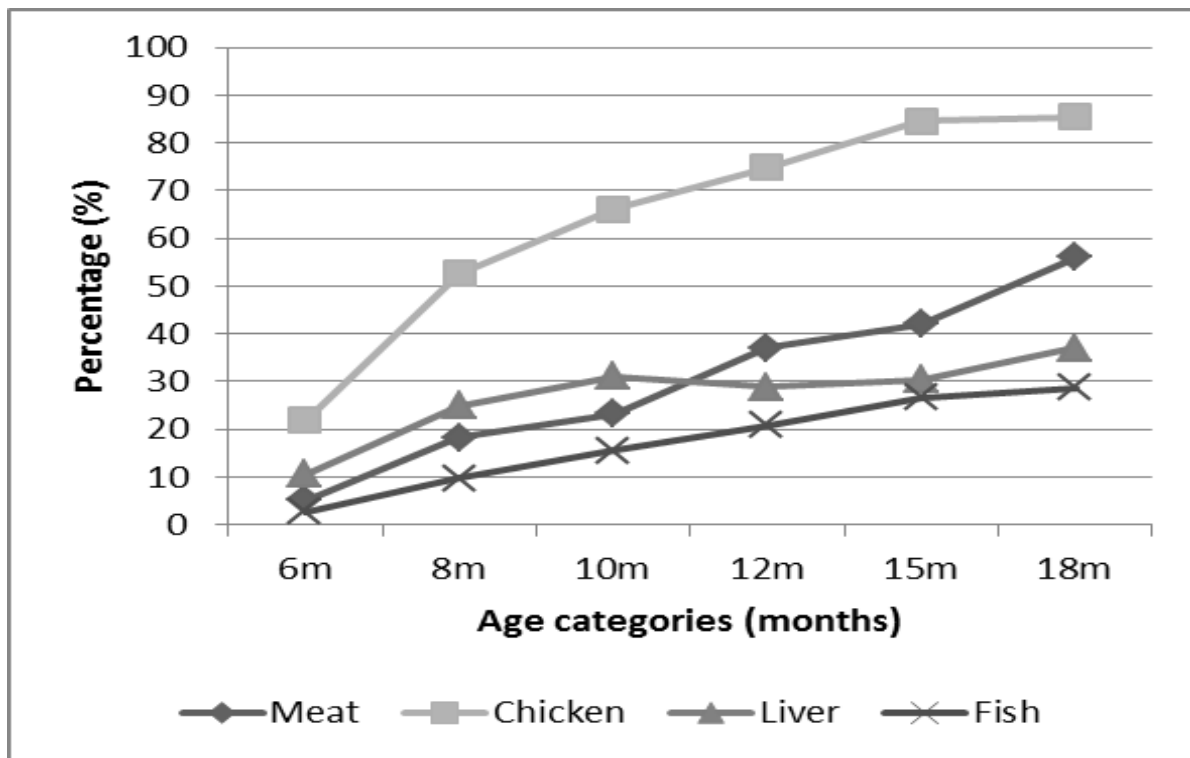
Figure 5: Percentage of children who consumed different animal protein at least once during the past week from age 6 to 18 months
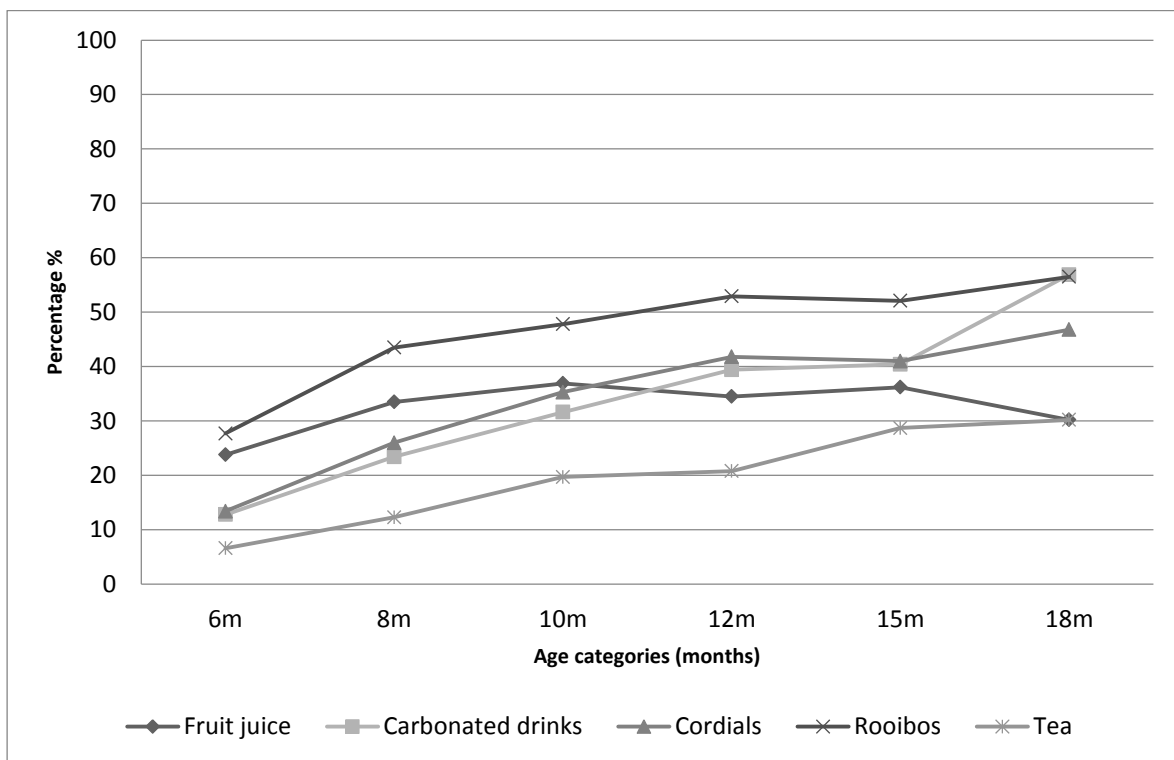
Figure 6: Percentage of children who consumed different drinks at least once during the past week from age 6 to 18 months
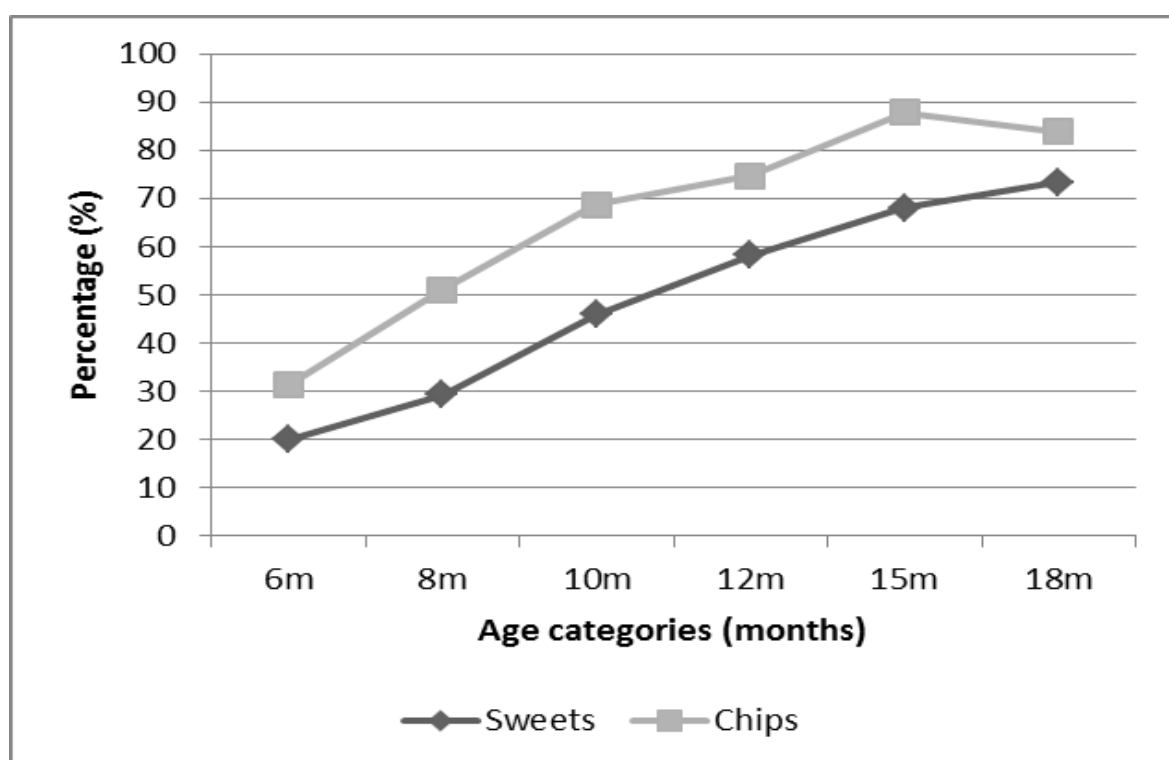
Figure 7: Percentage of children who consumed sweets and chips at least once during the past week from age 6 to 18 months

Total dietary intake

Total energy and nutrient intake of infants for whom 24 hour recall data were available is presented in Table 2. Included in the table are reference values for energy, macro and micronutrients and the percentage of infants who had intakes below the comparable reference value. Median intakes of calcium, vitamin A, thiamine, riboflavin, niacin, vitamin B6, vitamin B12 and vitamin C were all above the respective AI values at 6 months of age and thus a low probability of inadequate intake for these nutrients can be assumed. Iron and zinc intake was below the EAR for 62% and 47% of 6 month old infants, and ~ 75% of children at age 12 and 18 months had intake of calcium below the EAR.

Table 2: **Median and Interquartile ranges (IQR) for total energy and nutrient intake for infants at age 6, 12 and 18 months**

	DRI 6 months 12 & 18 months	6 months (n=715) Median (IQR) % < DRI	12 months (n=446) Median (IQR) % < DRI	18 months (n=213) Median (IQR) % < DRI
Energy (kJ)[a]	[a]	2857 (2419; 3367) *37.1%*	3779 (3079; 4498) *27.6%*	4402 (3551; 5463) *24.4%*
Protein (g)	1.0 g/kg/d[b] 0.87 g/kg/d[b]	12.5 (9.7; 16.8)	21.9 (15.1; 28.6) *3.6%*	29.0 (21.0; 38.5) *2.8%*
Protein %E	-- 5-20%	7.4 (6.2; 8.9)	9.6 (7.8; 11.9)	11.7 (9.0; 13.2)
Fat (g)	30[c] --[d]	32.7 (30.1; 36.3)	35.0 (26.1; 42.6)	32.0 (22.2; 44.0)
Fat %E	-- 30-40	42.4 (37.2; 47.4)	35.2 (28.0; 40.1)	28.6 (21.0; 34.0)
Carbohydrates (g)	95[c] 100[b]	83 (69; 104)	119 (95; 148)	147 (121; 190)
CHO %E	-- 45-65	49.5 (45.7; 54.4)	53.5 (48.1; 59.3)	57.4 (52.4; 63.4)
Calcium (mg)	260[c] 500[b]	357 (276; 468)	368 (276; 494) *75.8%*	346 (239; 497) *75.1%*
Iron (mg)	6.9[b] 3.0[b]	5.4 (2.2; 9.5) *61.5%*	5.1 (3.4; 7.6) *18.6%*	5.9 (4.6; 7.8) *8.5%*
Zinc (mg)	2.5[b] 2.5[b]	2.65 (1.65; 4.33) *46.6%*	4.39 (3.12; 6.02) *13.7%*	5.81 (4.30; 7.26) *3.8%*
Vitamin A (µg RE)[f]	500[c] 210[b]	648 (513; 890)	592 (453; 809) *6.5%*	489 (304; 723) *13.1%*
Thiamine (mg)	0.3[c] 0.4[b]	0.41 (0.24; 0.62)	0.66 (0.44; 0.89) *19.9%*	0.86 (0.63; 1.13) *4.7%*
Riboflavin (mg)	0.4[c] 0.4[b]	0.58 (0.39; 0.86)	0.81 (0.57; 1.14) *10.3%*	1.02 (0.66; 1.66) *7.0%*
Niacin (mg)	4[c] 5[b]	4.8 (3.0; 7.1)	7.0 (4.9; 9.5) *25.1%*	8.6 (6.3; 11.6) *14.6%*
Vitamin B6 (mg)	0.3[c] 0.4[b]	0.350 (0.201; 0.549)	0.697 (0.461; 0.998) *17.7%*	1.040 (0.732; 1.430) *4.2%*
Folate (µg)	80[c] 120[b]	62 (44; 116)	138 (86; 219) *40.6%*	216 (148; 287) *16.4%*
Vitamin B12 (µg)	0.5[c] 0.7[b]	0.9 (0.7; 1.3)	1.13 (0.74; 1.66) *20.9%*	1.19 (0.69; 2.07) *24.9%*
Vitamin C (mg)	50[c] 13[b]	62 (45; 82)	48 (33; 70) *6.5%*	34 (17; 57) *7.0%*

[a] EER (in kilojoules – kJ) of the US DRI published by the Institute of Medicine (IOM, 2002/2005): age 6 months: (boys 2709; girls 2535), 12 months: (boys 3245; girls 2985), 18 months: (boys 3702; girls 3465)
[b] EAR of the US DRI published by the Institute of Medicine (IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2005; IOM, 2011)
[c] AI of the US DRI published by the Institute of Medicine (IOM, 1998; IOM, 2000; IOM, 2001; IOM, 2005; IOM, 2011)
[d] Not determined – insufficient evidence/data to set reference values
[e] Given as µg RE as the South African Food Consumption Database gives µg RE, vitamin A µg RE, and vitamin A µg RAE values were quite similar in this population due to vitamin A derived mostly from fortified and dairy sources
DRI: Dietary Reference Intakes, EER: Estimated Energy Requirements, mg: milligram, µg: microgram, IQR: Interquartile range, RE: Retinol Equivalents

Nutrient density of the complementary diet

The nutrient density of the complementary diet is presented in Table 3. Only the nutrient densities of the complementary diets of breastfed infants who were not receiving formula milk feeds are presented since reference values for nutrient densities of the complementary diet is based on the complementary diet of breastfed infants (Dewey & Brown, 2003). At age 6 months, ≥ 90% of the infants' complementary diets had a low nutrient density of iron and zinc and 66% had a low nutrient density of niacin; at ages 12 and 18 months, ≥ 85% of children's complementary diets had a low nutrient density of iron and ≥ 75% of calcium.

Table 3:   **Median and interquartile range of nutrient densities of the complementary diet for infants still breastfeeding but receiving no formula milk feeds at ages 6, 12 and 18 months**

	Reference[a] 6 months 12 & 18 months	6 months (n=406) Median (IQR) *%Low density*	12 months (n=202) Median (IQR) *%Low density*	18 months (n=60) Median (IQR) *%Low density*
Energy (kJ)		903 (592; 1382)	2109 (1506;2696)	3054 (2396;4014)
Protein (g/100 kcal))	1.0 0.9	2.27 (1.73; 3.19) *1.5%*	2.74 (2.10; 3.46) *0.2%*	2.79 (2.22; 3.56) *0%*
Calcium (mg/100 kcal)	40 63	66 (35; 90) *28.6%*	34(21; 56) *78.7%*	30 (17; 43) *88.3%*
Iron (mg/100 kcal)	5.3 1.2	1.59 (0.82; 2.80) *94.6%*	0.66 (0.55; 0.93) *85.1%*	0.65 (0.57; 0.80) *90.0%*
Zinc (mg/100 kcal)	1.1 0.4	0.49 (0.22; 0.75) *91.4%*	0.56 (0.44; 0.66) *18.3%*	0.57 (0.51; 0.69) *10.0%*
Vitamin A (µg RE/100 kcal)	81 5	76 (50; 187) *50.7%*	48 (34; 104) *1.0%*	42 (30; 58) *0%*
Thiamine (mg/100 kcal)	0.08 0.07	0.12 (0.06; 0.24) *31.5%*	0.10 (0.08; 0.12) *14.4%*	0.09 (0.08; 0.09) *8.3%*
Riboflavin (mg/100 kcal)	0.08 0.06	0.10 (0.06; 0.17) *38.7%*	0.09 (0.06; 0.14) *23.3%*	0.10 (0.07; 0.16) *15.0%*
Niacin (mg/100 kcal)	1.5 0.9	1.08 (0.79; 1.73) *66.5%*	0.93 (0.72; 1.26) *43.6%*	0.81 (0.70; 1.20) *53.3%*
Vitamin B6 (mg/100 kcal)	0.12 0.08	0.09 (0.03; 0.18) *58.1%*	0.10 (0.08; 0.13) *25.2%*	0.12 (0.10; 0.14) *11.7%*
Folate (µg/100 kcal)	11 19	12.0 (5.1; 37.1) *44.8%*	20.0 (12.3; 30.4) *43.1%*	23.7 (16.0; 30.2) *36.7%*
Vitamin C (mg/100 kcal)	11 0	10.5 (6.3; 16.4) *50.2%*	3.6 (1.4; 6.7) *78.2%*	3.3 (1.2; 5.4) *0%*

[a] Dewey & Brown K.H (2003)

Commercial infant products

Nutrient contribution towards total intake

The energy and nutrient contribution of commercial infant products towards total intake is shown in figure 8. The contribution of the different types of commercial infant products (i.e, cereal, jarred foods and formula milk) is shown in figures 9 - 11. Commercial infant products were consumed on the day of recall by 591 (83%) of infants at age 6 months, and by 205 (46%) infants at age 12 months. As shown in figure 8, these products contributed more than 90% of iron intake, ≥ 70% of thiamine and niacin intakes, and ≥ 50% of zinc, riboflavin, vitamin B6, folate and vitamin C intakes at age 6 months; and just more than 50% of total iron and vitamin C intakes, and more than a third of total calcium, zinc, vitamin A, thiamine, riboflavin, niacin and vitamin C intakes at age 12 months. Data for age 18 months is not presented as only a small number of children (n=33; 15%) consumed infant products on the day of recall.

Infant cereals were consumed on the day of recall by 502 (70%) infants at age 6 months and 119 (27%) infants at age 12 months. As shown in figure 9, these products contributed > 70% of total iron, > 40% niacin and > 50% thiamine intakes at age 6 months, and ~ 50% of iron and ~ 33% of folate intakes at age 12.

Jarred infants products were consumed on the day of recall by 197 (28%) infants at age 6 months and 43 (10%) infants at age 12 months. As illustrated in figure 10, jarred infant products contributed < 20% of total intake for vitamin B6 and vitamin C at age 6 months, and < 10% for most other micronutrients at both ages.

Formula milk was consumed on the day of recall by 309 (43%) infants at age 6 months and 123 (28%) infants at age 12 months. As shown in figure 11, formula milk contributed to approximately two thirds of consumers' zinc and vitamin B12 intake, 44% of iron intake and 50-60% of total riboflavin and vitamin B6 intake at age 6 months, and 40-50% of total fat, calcium, zinc, vitamin A, riboflavin, vitamin B12 and vitamin C intakes, and 38% of iron intake at age 12 months.

The contribution of baby juice is not shown as it was consumed on the day of recall by only a small number of children at all ages (6 months, n=25 (3%); 12 months, n=17(4%)).
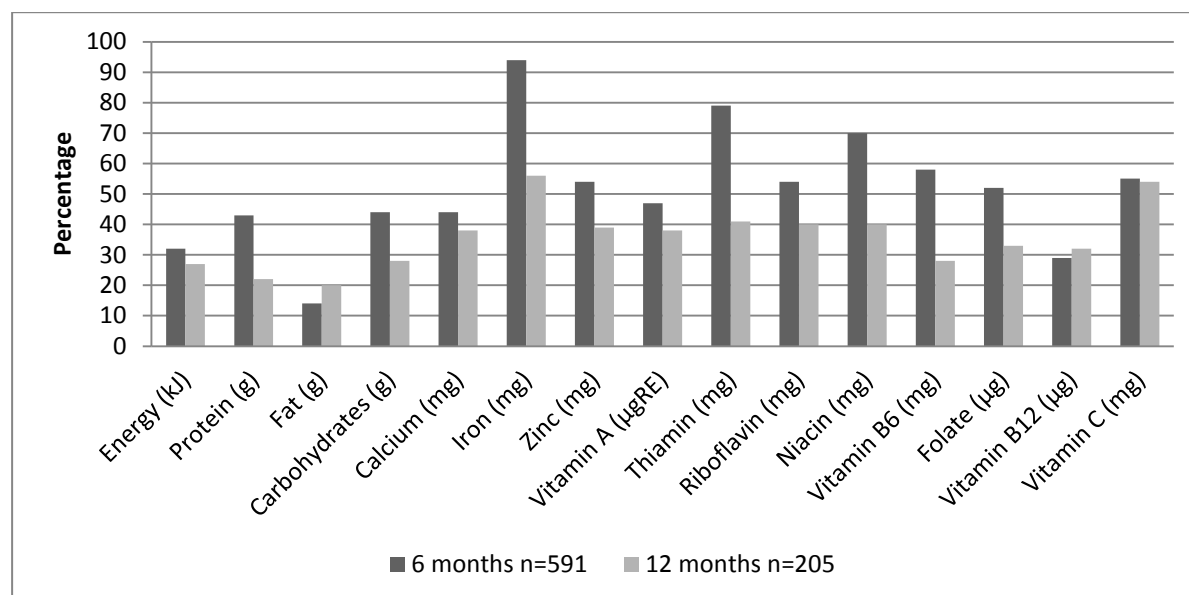
Figure 8: **Percentage contribution of commercial infant products towards total energy and nutrient intake of consumers of commercial infant products at ages 6 and 12 months**
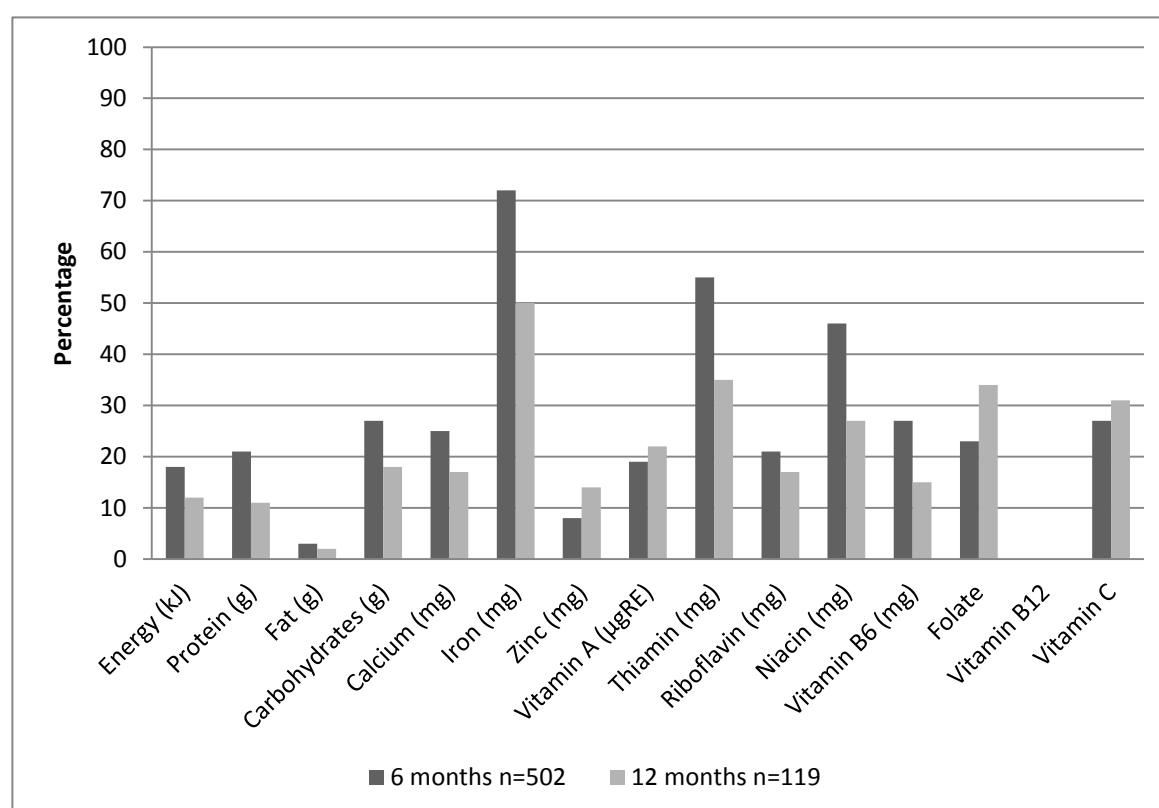
Figure 9: **Percentage contribution of commercial infant cereal towards total energy and nutrient intake of consumers at ages 6 and 12 months**
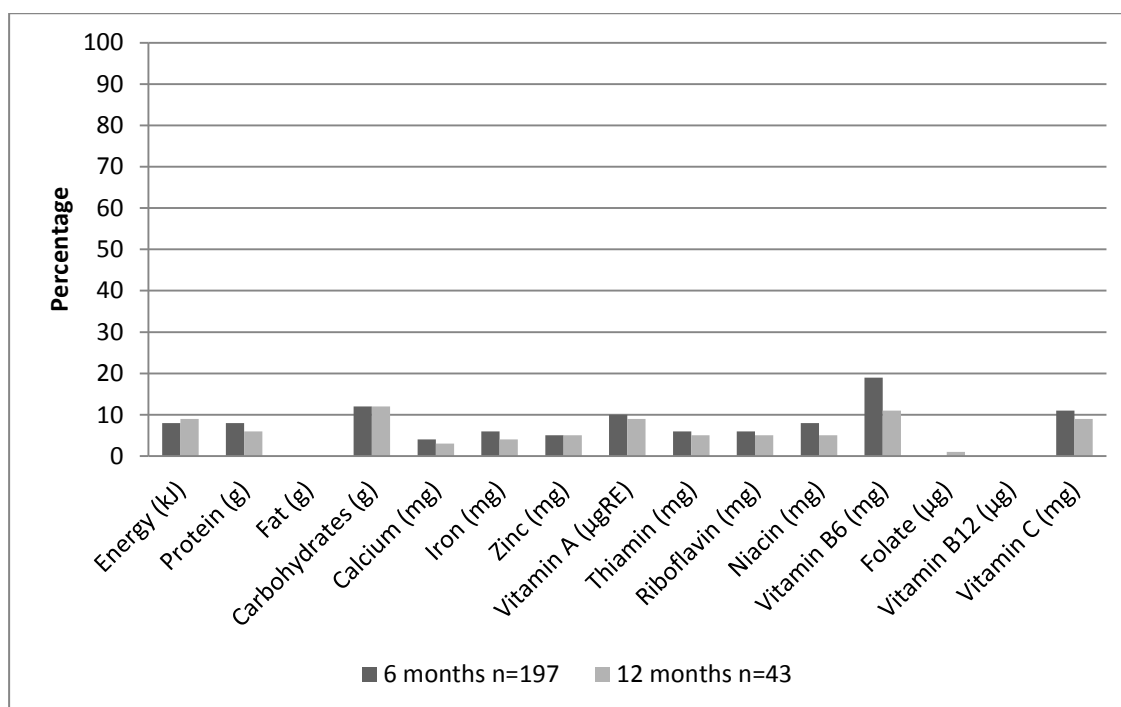
Figure 10: Percentage contribution of jarred foods to total energy and nutrient intake of consumers at ages 6 and 12 months
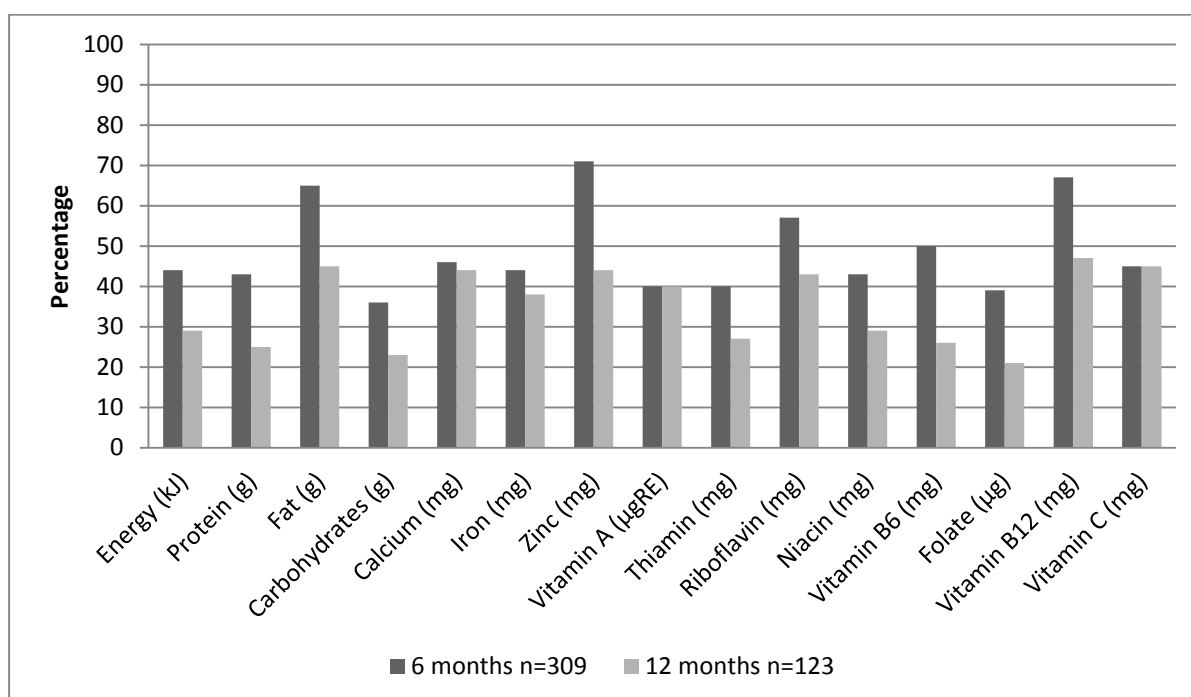
Figure 11: Percentage contribution of formula milk towards total energy and nutrient intake of consumers at ages 6 and 12 months

Total nutrient intake: consumers of commercial infant products versus non-consumers

Nutrient contribution towards total nutrient intake is presented in Table 4 for children who consumed these products on the day of recall (referred to as consumers) versus children who did not consume any of these products on the day of recall (non-consumers). Data for age 18 months is not presented as only a small number of children (n=33; 15%) consumed infant products at this age on the day of recall. At age 6 months, consumers of commercial infant products had significantly higher intakes ($p < 0.05$) of all key micronutrients, energy, protein and carbohydrates except for fat in comparison with non-consumers (Table 4). At age 12 months, consumers of commercial infant products had significantly higher intakes ($p < 0.05$) of calcium, iron, zinc, vitamin A, thiamine, riboflavin, niacin, vitamin B12 and vitamin C compared to non-consumers on the day of recall.

Nutrient densities of the complementary diet: consumers of commercial infant products versus non-consumers

Table 5 shows the nutrient density values of the complementary diet for consumers and non-consumers. Because the complementary diet was defined as all foods and beverages consumed excluding breast milk and formula milk (Fein *et al.* 2008), formula milk feeds were not considered when defining infants as either consumers or non-consumers when comparing the nutrient density of the complementary diet. The number of consumers and non-consumers presented in Table 5 (reporting on the complementary diet) are therefore different than those presented in Table 4 (reporting on total nutrient intake). In contrast to Table 3, children were included in this section whether they were breastfed or not, as nutrient densities were not compared to reference values in this instance. The nutrient density of the complementary diet for consumers of commercial infant products (excluding formula milk feeds) was significantly higher ($p < 0.05$) for protein, calcium, iron, vitamin A, riboflavin, niacin, vitamin B12 and vitamin C at age 6 months, and for calcium, iron, vitamin A, thiamine, riboflavin, niacin and vitamin C at age 12 months, compared to non-consumers.

Table 4: **Total energy and nutrient intake of consumers[a] versus non-consumers[b] of commercial infant products**

	6 months (n=715) Median (IQR)			12 months (n=446) Median (IQR)		
	Consumers (n=591)	Non-consumers (n=124)	P-value[c]	Consumers (n=205)	Non-consumers (n=241)	P-value[c]
Energy (kJ)	2912 (2524; 3408)	2334 (2301; 3093)	**< 0.001**	3630 (3028; 4437)	3898 (3099; 4585)	0.123
Total Protein (g)	13.1 (10.3; 17.6)	8.5 (7.8; 12.7)	**< 0.001**	22.4 (15.1; 28.6)	21.2 (15.1; 28.9)	0.846
Total Fat (g)	32.6 (29.9; 36.6)	33.6 (31.1; 34.1)	0.280	32.9 (25.8; 41.8)	36.9 (26.4; 43.5)	0.197
Carbohydrates (g)	85.7 (71.6; 105.0)	63.6 (53.5; 87.5)	**< 0.001**	114.8 (93.7; 142.5)	121.5 (95.5; 150.9)	0.141
Calcium (mg)	376 (298; 487)	248 (236; 336)	**< 0.001**	405 (307; 536)	342 (236; 469)	**< 0.001**
Iron (mg)	6.4 (3.6; 10.3)	0.8 (0.2; 2.1)	**< 0.001**	7.1 (5.1; 9.6)	3.9 (2.8; 5.5)	**< 0.001**
Zinc (mg)	3.04 (1.81; 4.84)	1.66 (1.32; 2.41)	**< 0.001**	4.90 (3.21; 7.05)	4.10 (3.06; 5.31)	**< 0.001**
Vitamin A (µg RE)	695 (564; 952)	496 (462; 541)	**< 0.001**	703 (523; 1112)	557 (424; 779)	**< 0.001**
Thiamine (mg)	0.47 (0.32; 0.68)	0.15 (0.08; 0.28)	**< 0.001**	0.74 (0.48; 0.96)	0.57 (0.40; 0.83)	**< 0.001**
Riboflavin (mg)	0.64 (0.45; 0.92)	0.31 (0.31; 0.48)	**< 0.001**	0.92 (0.66; 1.27)	0.72 (0.49; 1.03)	**< 0.001**
Niacin (mg)	5.3 (3.5; 7.6)	2.1 (1.6; 3.5)	**< 0.001**	7.6 (5.8; 9.9)	6.5 (4.3; 8.9)	**< 0.001**
Vitamin B6 (mg)	0.4 (0.2; 0.6)	0.2 (0.1; 0.3)	**< 0.001**	0.7 (0.5; 0.9)	0.7 (0.5; 1.0)	0.958
Folate (µg)	66 (46; 132)	44 (38; 78)	**< 0.001**	137 (83; 237)	138 (86; 214)	0.605
Vitamin B12 (µg)	0.9 (0.7; 1.4)	0.8 (0.7; 0.9)	**< 0.001**	1.3 (0.9; 1.8)	1.0 (0.7; 1.6)	0.003
Vitamin C (mg)	67 (51; 88)	38 (35; 43)	**< 0.001**	65 (49; 91)	36 (26; 50)	**< 0.001**

[a] Consumer of commercial infant products indicates that the child consumed these products as part of the complementary diet on the day of recall;
[b] Non-consumer indicates that the child has not consumed these product as part of the complementary diet on the day of recall
[c] p<0.05 indicate significant differences and is formatted in bold type

Table 5: Energy content and nutrient density of the complementary diet of consumers[a] versus non-consumers [b] of commercial infant products[c]

[e]	6 months (n=665) Median (IQR)			12 months (n=446) Median (IQR)		
	Consumers (n=558)[d]	Non-consumers (n=107)	P-value[e]	Consumers[d] (n=149)	Non-consumers (n=297)	P-value[e]
Energy (kJ)	991 (631; 1456)	1046 (558; 1685)	0.696	2210 (1637; 2958)	2536 (1787; 3487)	**0.013**
Total Protein (g/100 kcal)	2.3 (1.8; 3.3)	2.0 (1.5; 2.7)	**0.001**	2.8 (2.2; 3.5)	2.7 (2.1; 3.4)	0.415
Total Fat (g/100 kcal)	1.9 (0.8; 2.5)	1.6 (0.8; 3.0)	0.559	2.4 (1.7; 3.1)	2.5 (1.9; 3.3)	0.191
Carbohydrates (g/100 kcal)	16.9 (15.7; 19.3)	16.8 (15.6; 19.8)	0.435	15.7 (13.3; 17.3)	15.2 (13.2; 16.7	0.215
Calcium (mg/100 kcal)	69 (39; 92)	46 (97; 66)	**< 0.001**	42 (26; 67)	33 (18; 52)	**< 0.001**
Iron (mg/100 kcal)	1.7 (1.2; 3.1)	0.7 (0.4; 0.8)	**< 0.001**	1.1 (0.8; 1.4)	0.6 (0.5; 0.8)	**< 0.001**
Zinc (mg/100 kcal)	0.5 (0.2; 0.8)	0.5 (0.4; 0.6)	0.269	0.6 (0.5; 0.7)	0.6 (0.5; 0.6)	0.286
Vitamin A (μg RE/100 kcal)	98 (61; 211)	41 (26; 55)	**< 0.001**	76 (45; 119)	42 (29; 71)	**< 0.001**
Thiamine (mg/100 kcal)	0.11 (0.05; 0.22)	0.13 (0.05; 0.23)	0.574	0.11 (0.09; 0.13)	0.09 (0.07; 0.11)	**< 0.001**
Riboflavin (mg/100 kcal)	0.11 (0.07; 0.17)	0.07 (0.03; 0.12)	**< 0.001**	0.11 (0.07; 0.15)	0.09 (0.06; 0.14)	**< 0.001**
Niacin (mg/100 kcal)	1.22 (0.89; 1.87)	0.76 (0.54; 0.96)	**< 0.001**	1.02 (0.79; 1.42)	0.87 (0.67; 1.22)	**< 0.001**
Vitamin B6 (mg/100 kcal)	0.08 (0.03; 0.17)	0.07 (0.02; 0.16)	0.482	0.10 (0.07; 0.13)	0.11 (0.08; 0.13)	0.113
Folate (μg/100 kcal)	9.45 (5.10; 32.34)	16.74 (8.87; 23.16)	0.068	21.00 (11.25; 32.78)	19.20 (12.26; 27.90)	0.100
Vitamin B12 (μg/100 kcal)	0.1 (0.0; 0.2)	0.0 (0.0; 0.2)	**0.007**	0.1 (0.1; 0.2)	0.1 (0.0; 0.2)	0.081
Vitamin C (mg/100 kcal)	12 (8; 17)	4 (1; 6)	**< 0.001**	7 (4; 12)	3 (1; 4.87)	**< 0.001**

[a] Consumer of commercial infant products indicates that the child consumed these products as part of the complementary diet on the day of recall

[b] Non-consumer indicates that the child has not consumed these product as part of the complementary diet on the day of recall

[c] Excluding formula milk feeds, as per definition used to define the complementary diet

[d] Excluding infants who received only breast milk and/or formula milk feeds

[e] p<0.05 indicate significant differences and is formatted in bold type

Fortified maize meal and bread

Nutrient contribution of fortified maize meal and bread for consumers of these products

The contribution of fortified bread and/ or maize meal towards total energy and nutrient intake for consumers is shown in figure 12 and the contribution of the individual foods – maize meal porridge and bread made with fortified wheat flour is shown in figures 13 and 14. Fortified maize meal and bread were consumed by 167 (23%) infants at age 6 months, 362 (81%) children at 12 months and 203 (95%) children 18 months on the day of recall. For these products, only the fortified micronutrients (vitamin A, thiamine, riboflavin, niacin, pyridoxine, folic acid, iron and zinc) are reported together with energy and macronutrients. As shown in figure 12, NFFP foods contributed ~20% of carbohydrate, zinc and niacin intake; ~25% of iron and thiamine intake and ~33% of vitamin B6 and folate intake at age 6 months, approximately a third of carbohydrate, iron and zinc intakes and ≥50% thiamine, vitamin B6 and folate intake at age 12 months and >40% of iron and zinc intake; >50% of thiamine and vitamin B6 intake and >70% of folate intake at age 18 months.

Fortified bread was consumed by 49 (11%) children at age 12 months and 37 (17%) children at age 18 months on the day of recall. This data is not shown for age 6 months as there were too few consumers thereof (n=5; 1%). As shown in figure 13, bread contributed <25% towards total intake of macronutrients and the fortified micronutrients, except for vitamin B6 towards which it contributed >40% of total intake at ages 12 and 18 months.

Fortified maize meal porridge was consumed by 164 (23%) infants at age 6 months, 344 (78%) children at age 12 months and 197 (92%) children at age 18 months on the day of recall. As shown in figure 14 maize meal porridge contributed 11% of total energy and <33% for all macronutrients and fortified micronutrients intake at age 6 months, ≥33% of iron, zinc, thiamine, vitamin B6 and folate intake at age 12 months and 28% of total energy, 40% of iron and zinc, and >50% of thiamine and folate intakes at age 18 months.
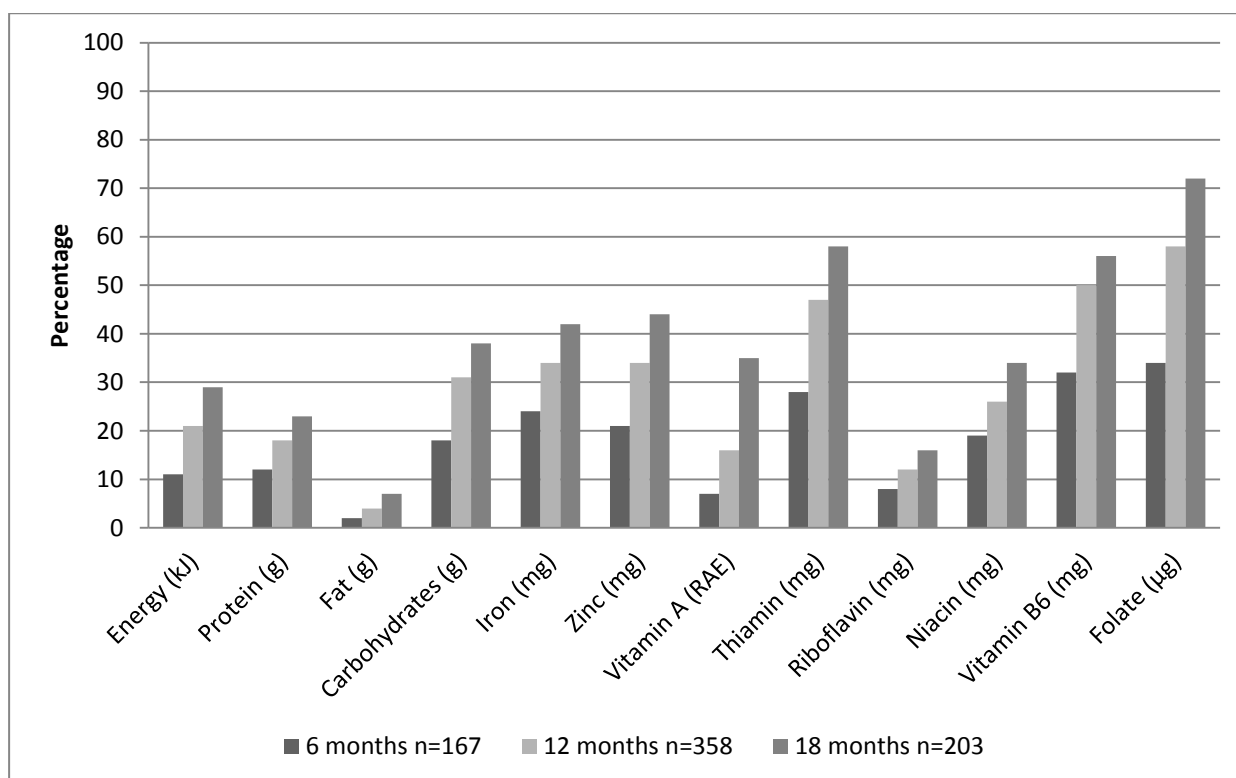
Figure 12:   **Percentage contribution of fortified bread and maize meal to total intake of consumers at ages 6, 12 and 18 months**
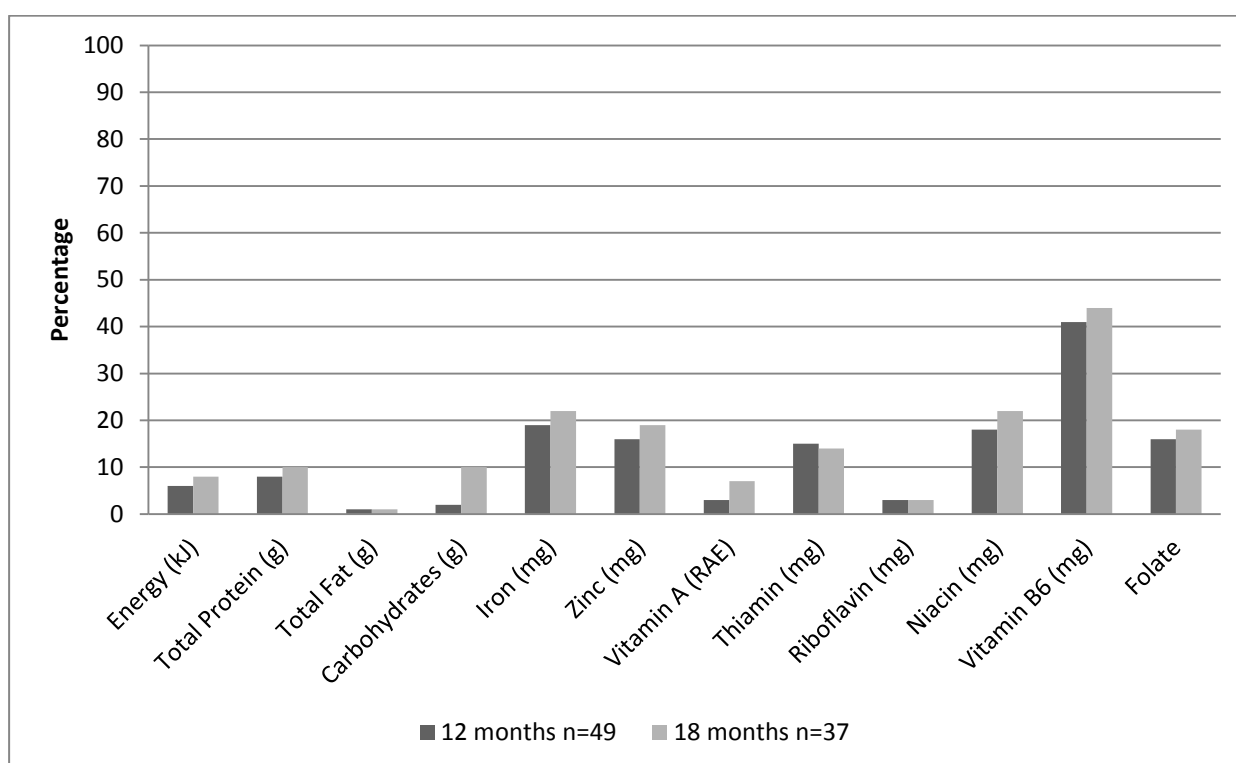
Figure 13:   **Percentage contribution of bread to nutrient intake of consumers at age 12 and 18 months**
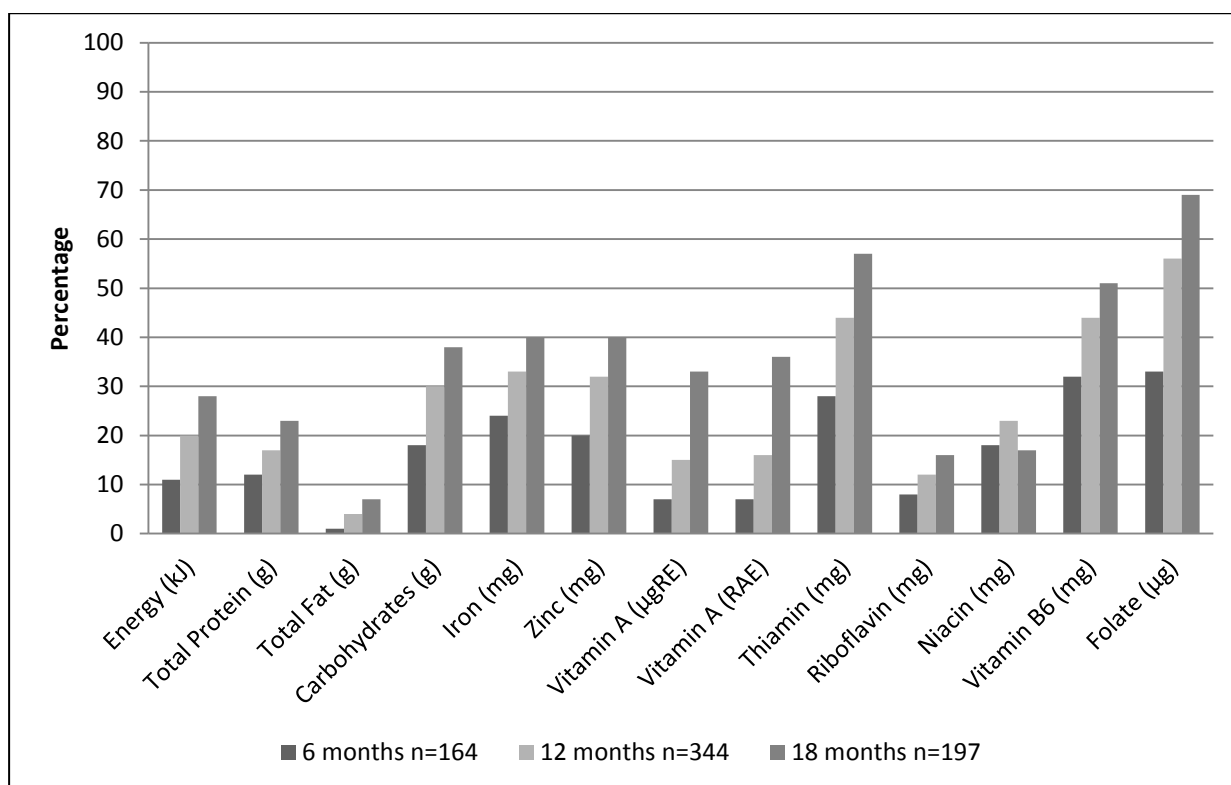
Figure 14: Percentage contribution of maize meal porridge to nutrient intake of consumers at age 6, 12 and 18 months

Total nutrient intake: Consumers of fortified maize meal and bread versus non-consumers

Total energy and nutrient intake for consumers (children who consumed fortified maize meal and bread during the 24 hour recall period) and non-consumers (children who did not consume these products during the 24 hour recall period) are given in Table 6. The number of non-consumers at age 18 months on the day of recall were too small to include in analysis thus for comparison between consumers and non-consumers, data for this age group was omitted.

Intake of energy, protein, carbohydrates, zinc, vitamin B6 and folate were significantly higher (p<0.05) for consumers at age 6 months than non-consumers conversely iron and vitamin A intake of non-consumers were significantly higher than consumers. At age 12 months consumers of fortified maize meal and bread had significantly higher (p<0.05) intakes of energy, protein, carbohydrates, zinc, vitamin B6, folate, thiamine and niacin compared to non-consumers.

Nutrient densities of the complementary diet: consumers of fortified maize meal and bread versus non-consumers

The energy intake from and nutrient densities of the complementary diet for consumers and non-consumers are given in Table 7. The nutrient density values are not compared to reference values (for breastfeeding children) and are therefore presented for all children, regardless whether they were breastfeeding or not. Energy intake and nutrient density of zinc and folate for consumers at 6 months, and energy intake and nutrient density of zinc, folate and vitamin B6 for consumers at 12 months were significantly higher ($p<0.05$) compared to non-consumers. Nutrient density of calcium, iron, vitamin A, riboflavin, niacin and vitamin C were significantly higher ($p<0.05$) for non-consumers at ages 6 and 12 months compared to consumers.

Table 6: Total energy and nutrient intake of consumers [a] versus non-consumers [b] of fortified maize meal and bread

	6 months Median (IQR)			12 months Median (IQR)		
	Consumers (n=167)	**Non-consumers (n=548)**	**P-value[c]**	**Consumers (n=362)**	**Non-consumers (n=84)**	**P-Value[c]**
Energy (kJ)	3067 (2607; 3666)	2811 (2376; 3275)	**< 0.001**	3856 (3137; 4616)	3369 (2612; 4128)	**< 0.001**
Total Protein (g)	13.0 (10.2; 18.8)	12.3 (9.5, 16.2)	**0.012**	22.3 (15.7, 29.6)	17.8 (12.6, 24.4)	**< 0.001**
Total Fat (g)	32.9 (30.4; 38.2)	32.7 (30.0, 35.9)	0.243	35.5 (25.3, 42.8)	32.6 (26.9, 41.7)	0.494
Carbohydrates (g)	91.3 (73.7; 113.9)	81.7 (66.9; 100.9)	**< 0.001**	122.4 (98.1, 152.4)	102.9 (78.0, 128.1)	**< 0.001**
Added Sugar (g)	3.2 (0.9; 9.2)	4.5 (1.1, 9.2)	0.348	10.3 (4.2, 19.8)	9.4 (4.5, 17.9)	0.532
Total Fibre (g)	2.2 (1.1; 3.7)	1.1 (0.5; 2.1)	**< 0.001**	5.9 (3.9; 8.0)	3.2 (1.4; 6.3)	**< 0.001**
Calcium (mg)	352 (266; 463)	363 (277; 468)	0.302	362 (273; 483)	399 (301; 537)	0.095
Iron (mg)	3.3 (1.8; 6.9)	5.9 (2.7; 10.1)	**< 0.001**	5.0 (3.3; 7.2)	5.4 (3.7; 9.3)	0.076
Zinc (mg)	2.89 (2.09; 4.47)	2.59 (1.49; 4.26)	**0.017**	4.60 (3.33; 6.07)	3.32 (2.10; 4.93)	**< 0.001**
Vitamin A (µg RE)	612 (487; 818)	672 (523; 925)	**0.003**	602 (467; 890)	670 (466; 977)	0.406
Thiamine (mg)	0.39 (0.24; 0.63)	0.42 (0.25; 0.62)	0.765	0.69 (0.47; 0.91)	0.53 (0.37; 0.81)	**0.003**
Riboflavin (mg)	0.56 (0.38; 0.79)	0.59 (0.40; 0.88)	0.338	0.82 (0.58; 1.16)	0.77 (0.51; 1.03)	0.261
Niacin (mg)	4.1 (2.7; 6.4)	4.9 (3.1; 7.2)	0.052	7.1 (5.0; 9.6)	6.2 (4.2; 8.9)	**0.037**
Vitamin B6 (mg)	0.4 (0.2; 0.7)	0.34 (0.18; 0.50)	**< 0.001**	0.8 (0.5; 1.1)	0.5 (0.3; 0.6)	**< 0.001**
Folate (µg)	87 (58; 146)	56 (41; 96)	**< 0.001**	152 (105; 231)	70 (47; 127)	**< 0.001**
Vitamin B12 (µg)	0.9 (0.7; 1.3)	0.9 (0.7; 1.3)	0.384	1.1 (0.7; 1.7)	1.1 (0.8; 1.5)	0.486
Vitamin C (mg)	50 (38; 73)	65 (48; 84)	**< 0.001**	45 (32; 64)	66 (46; 97)	**< 0.001**

[a] Consumers of fortified maize meal and bread indicates that the child consumed these products as part of the complementary diet on the day of recall
[b] Non-consumer indicates that the infant has not consumed these products as part of the complementary diet on the day of recall
[c] p<0.05 indicate significant differences and is formatted in bold type

Table 7: **Nutrient density (Nutrients per 100 kcal) of the complementary diet [a]: consumers [b] versus non-consumers [c] of fortified maize meal and bread at ages 6 and 12 months**

	6 months			12 months		
	Consumers (n=167)	Non-consumers (n=498)	P-value[d]	Consumers (n=362)	Non-consumers (n=81)	P-value[d]
Energy (kJ)	1219 (694; 1858)	935 (605; 1363)	**< 0.001**	2521 (1884; 3420)	1834 (1294; 2564)	**< 0.001**
Total Protein (g/100 kcal)	2.37 (1.69; 3.00)	2.17 (1.72; 3.34)	0.398	2.74 (2.10; 3.45)	2.88 (2.13; 3.48)	0.880
Total Fat (g/100 kcal)	1.87 (0.81; 2.73)	1.83 0.84; 2.45)	**0.038**	2.43 (1.82; 3.15)	2.42 (1.69; 3.36)	0.791
Carbohydrates (g/100 kcal)	16.89 (14.68; 19.10)	16.89 (15.73; 19.58)	0.101	15.22 (13.23; 16.95)	15.32 (13.01; 17.39)	0.780
Added Sugar (g/100 kcal)	1.19 (0.00; 2.38)	1.90 (0.67; 3.08)	**< 0.001**	1.61 (0.56; 2.80)	2.01 (0.80; 3.26)	0.058
Total Fibre (g/100 kcal)	0.75 (0.60; 1.05)	0.56 (0.35; 0.92)	**< 0.001**	0.94 (0.72; 1.18)	0.81 (0.44; 1.29)	**0.010**
Calcium (mg/100 kcal)	51.37 (23.99; 70.39)	70.51 (37.69; 94.58)	**< 0.001**	33.21 (20.10; 51.64)	48.66 (27.24; 72.51)	**< 0.001**
Iron (mg/100 kcal)	0.85 (0.59; 1.29)	1.74 (1.19; 3.21)	**< 0.001**	0.66 (0.55; 0.88)	1.05 (0.68; 1.57)	**< 0.001**
Zinc (mg/100 kcal)	0.53 (0.38; 0.65)	0.44 (0.16; 0.76)	**0.005**	0.56 (0.48; 0.67)	0.43(0.31; 0.58)	**< 0.001**
Vitamin A (µg RE/100 kcal)	54.31 (38.83; 105.73)	99.10 (60.93; 223.39)	**< 0.001**	45.47 (32.44; 94.50)	66.27 (36.26; 118.88)	**0.033**
Thiamine (mg/100 kcal)	0.10 (0.03; 0.21)	0.12 (0.06; 0.23)	0.094	0.10 (0.07; 0.11)	0.10 (0.07; 0.13)	0.139
Riboflavin (mg/100 kcal)	0.07 (0.05; 0.12)	0.11 (0.07; 0.17)	**< 0.001**	0.09(0.06; 0.14)	0.10 (0.06; 0.15)	0.420
Niacin (mg/100 kcal)	0.81 (0.64; 1.20)	1.24 (0.89; 1.92)	**< 0.001**	0.90 (0.68; 1.26)	1.03 (0.79; 1.41)	**0.016**
Vitamin B6 (mg/100 kcal)	0.06 (0.03; 0.14)	0.09 (0.03; 0.18)	0.072	0.11 (0.08; 0.13)	0.07 (0.06; 0.11)	**< 0.001**
Folate (µg/100 kcal)	19.32 (12.84; 30.28)	7.51 (5.02; 27.12)	**< 0.001**	21.19 (14.83; 29.77)	7.59 (5.10; 22.33)	**< 0.001**
Vitamin B12 (µg/100 kcal)	0.07 (0.00; 0.16)	0.010 (0.00; 0.19)	0.106	0.10 (0.04; 0.18)	0.11(0.05; 0.16)	0.724
Vitamin C (mg/100 kcal)	5.08 (3.53; 9.32)	12.59 (8.11; 17.65)	**< 0.001**	3.39 (1.43; 5.60)	7.77 (4.30; 14.83)	**< 0.001**

[a] Complementary diet excludes formula milk feeds and infants who consumed only breast milk or formula feeds the day of recall.
[b] Consumers of fortified maize meal and bread are those who consumed these foods on the day of recall
[c] Non-consumers are those who did not consume these foods on the day of recall
[d] p<0.05 indicate significant differences and is formatted in bold type

Contribution of breast milk, commercial infant products, fortified maize meal and bread and other foods (foods not included in the former groups) to total intake at ages 6, 12 and 18 months

The mean contribution that breast milk, commercial infant products, fortified maize meal and bread, and 'other foods' (all other foods consumed besides breast milk, commercial infant products, fortified maize meal and bread – i.e. fruits and vegetables, meat, chicken and fish, eggs, other grains and cereals, cow's milk, yoghurt etc.) made to total intake of energy, macronutrients and micronutrients at all three ages, were calculated and this is shown in figures 15, 16 and 17.

At age 6 months, breast milk was the largest contributor of energy, fat and vitamin B12. Commercial infant products were the largest contributor of protein, carbohydrates and all key vitamins (except vitamin B12) and minerals.

At age 12 months, 'other foods' were the largest contributor of energy, protein, carbohydrates, zinc, calcium, vitamin A, riboflavin, niacin and vitamin B12. The main contributors of iron and vitamin C were commercial infant products and the main contributors of thiamine, vitamin B6 and folate were fortified maize meal and bread.

'Other foods' were the main contributor of energy, protein, fat, calcium, vitamins A, C, and B12, riboflavin and niacin at age 18 months. Fortified maize meal and bread, and 'other foods' contributed equal amounts of carbohydrates, zinc and iron, and fortified maize meal and bread contributed the most thiamine, vitamin B6 and folate.
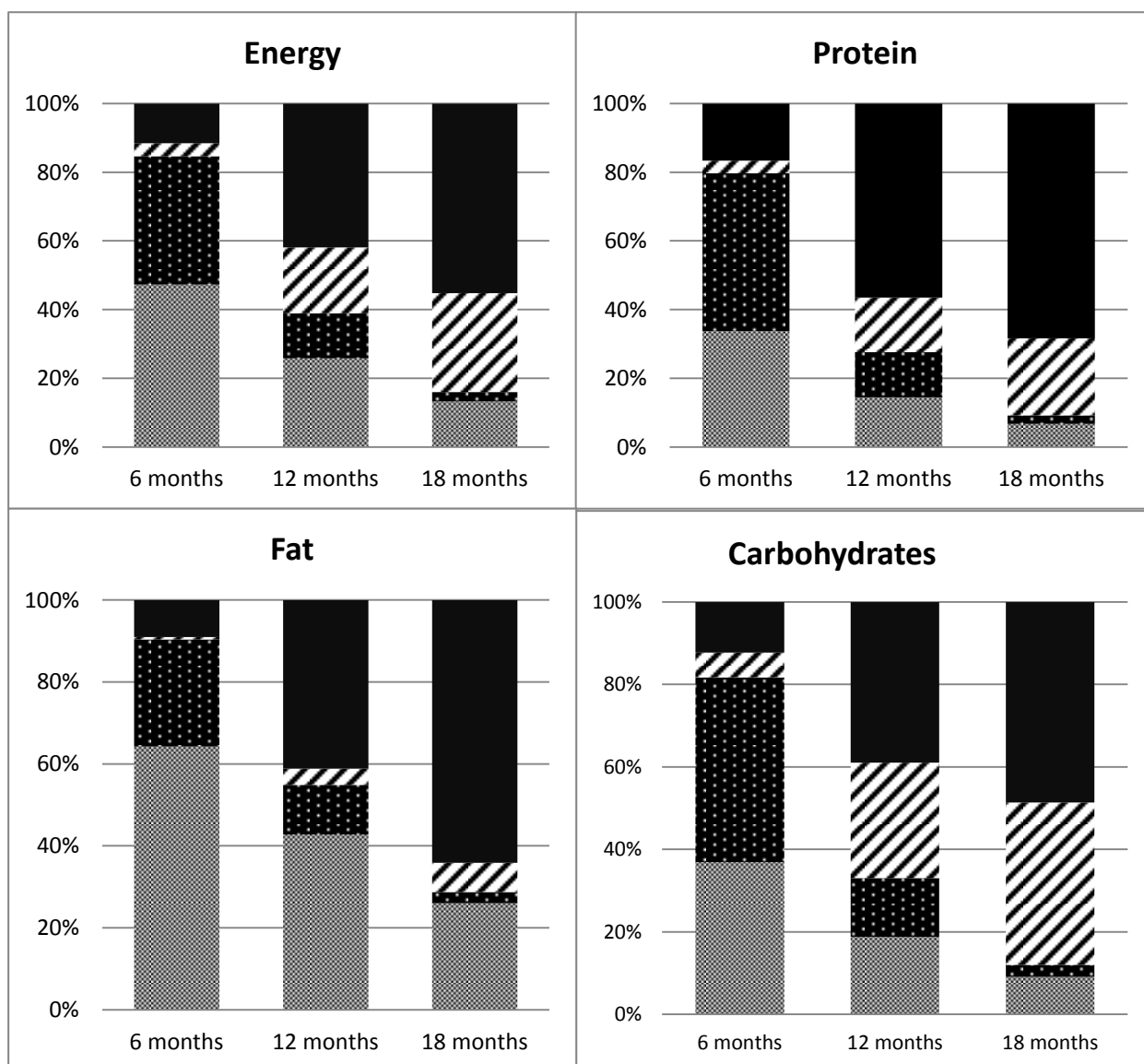
Figure 15: **Percentage contribution of breast milk, commercial infant products, fortified maize meal and bread (NFFP foods) and other foods to energy and macronutrient intake at 6, 12 and 18 months**

- Other'
- NFFP
- Commercial Infant Products
- Breast milk
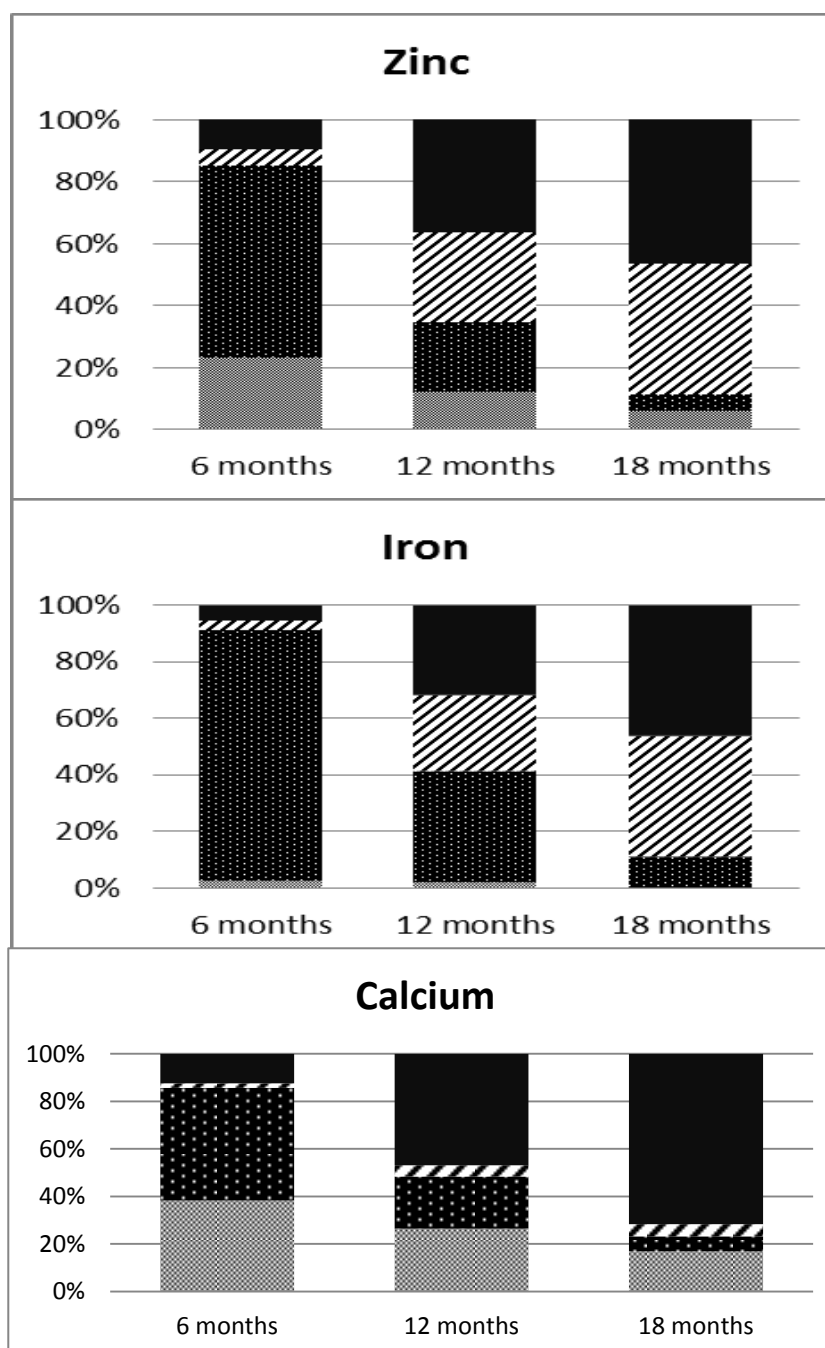
Figure 16: Percentage contribution of breast milk, commercial infant products, fortified maize meal and bread (NFFP foods) and other foods to key mineral intake at 6, 12 and 18 months
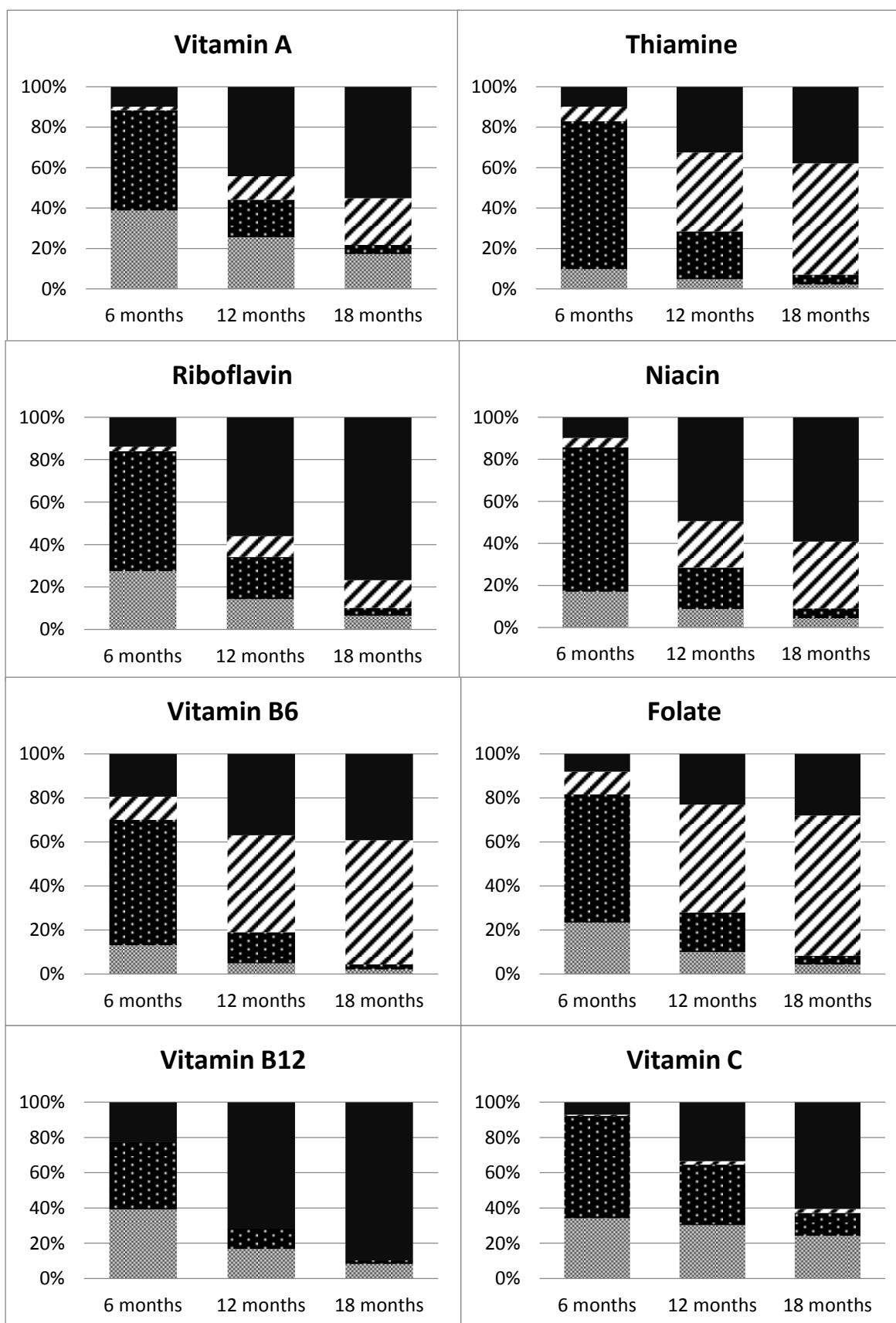
Figure 17: **Percentage contribution of breast milk, commercial infant products, National Food Fortification Programme (NFFP) foods and other foods to key vitamin intake at 6, 12 and 18 months**

Dietary diversity

Table 8 shows the percentage of children who consumed a certain food group at each age as well as those infants who had a DDS < 4. The food group most consumed by the majority of children at all three ages is the grains, roots and tuber group. At age 6 months the second and third most popular consumed food groups were dairy, and other fruit and vegetables; at 12 months flesh foods and other fruit and vegetables, and at 18 months flesh foods and dairy. The percentage of children who consumed less than four food groups were 95.6% at age 6 months, 79.7% at age 12 months and 71.8% at age 18 months.

Figure 8: **Percentage of children who consumed specific food groups on the day of recall and DDS for the complementary diet, excluding breast milk and formula milk feeds by age category**

	6 months (n=665)	12 months (n=443)	18 months (n=213)
Grains, roots and tubers	94.1%	99.3%	100%
Legumes and nuts [a]	2.7%	11.7%	10.3%
Flesh foods	3.8%	41.1%	63.4%
Dairy [b]	36.4%	35.4%	55.4%
Egg	4.7%	8.6%	8.9%
Vitamin A rich vegetables and fruit	13.4%	24.8%	21.6%
Other vegetables and fruit	29.8%	37.7%	40.8%
DDS < 4	95.9%	79.7%	71.8%

[a] Includes peanut butter
[b] Includes formula milk mixed with porridge; excludes formula milk feeds
Jarred baby foods were grouped according to the main ingredient
Percentages in the table indicate percentage of children consuming each of the seven food groups except for the last row which indicates the percentage of children who consumed fewer than four of the seven groups (i.e. who did not meet minimum dietary diversity.)

Discussion

The aim of this study was to assess trends in dietary and nutrient intake, dietary diversity and nutrient density of the complementary diet as well as energy and nutrient contribution of commercial infant products and fortified bread and maize from ages 6 to 18 months in a cohort of children from a peri-urban community in the North West Province, South Africa. A low intake of iron and zinc at age 6 months and calcium at ages 12 and 18 months was seen as well as

the complementary diet having a low nutrient density of iron and zinc at age 6 months, and iron and calcium at ages 12 and 18 months. Alongside low nutrient density is poor dietary diversity (Moursi *et al.,* 2008), and in the present study more than 70% of the children at all three ages did not meet minimum dietary diversity. Commercial infant products were consumed by the majority of infants at age 6 months and contributed to significantly higher intakes of energy, protein, carbohydrates and all key micronutrients (and the majority of micronutrients at age 12 months) for consumers thereof, compared to non-consumers. Fortified maize meal and bread were only widely consumed at 12 and 18 months, but not at 6 months. Consumers of fortified maize meal and bread had a higher nutrient intake of zinc and folate at ages 6 and 12 months but a lower iron intake and calcium and iron nutrient density compared to non-consumers.

Trends of food consumption

All children included in the study were initially breastfed (based on inclusion / exclusion criteria of the Tswaka study (randomised controlled trial) that the dietary intake data was collected for). At age 6 months, 71.9% of the infants were still breastfed; however continued breastfeeding was practised by less than 35% of children at age 18 months, reflecting poor adherence to recommendations that breastfeeding should be continued up to 2 years and beyond (WHO, 2003). The national prevention of mother to child transmission (PMTCT) of the Human Immunodeficiency Virus (HIV) guidelines at the time the study was conducted (DOH, 2010), recommend exclusive breastfeeding for the first 6 months with continued breastfeeding up to 12 months for mothers who are HIV positive and this could also have influenced the duration of breastfeeding in some of the infants in the current study population. Breastfeeding is high on international and national health agendas. Breast milk is advocated as the preferred milk feed because of its various health and other benefits – especially in the context of poor socio-economic circumstances and the HIV pandemic (Bhutta *et al.,* 2013; DOH, 2011; WHO, 2001; WHO, 2010). In South Africa continued breastfeeding rates are low – the SADHS of 2016 showed that only 47% of children aged 12 to 17 months and 19% of children aged 18 to 23 months were still breastfed (NDoH, Stats SA, SAMRC & ICF, 2017). Lack of support by family

and employees to breastfeeding mothers have been suggested as one of the reasons as to why low continued breastfeeding rates exist in South Africa, (DOH, 2011; Thomas *et al.,* 2017).

The complementary feeding period is a period of change from breast milk and/or formula milk based diet to a diet including solid foods and other beverages (Fein *et al.,* 2008). While breast milk continues to be an important source of nutrition from age 6 months onwards, it is important that a good quality complementary diet then be introduced as breast milk alone does not provide sufficient nutrition to meet the infant's needs anymore (WHO, 2003). Children under the age of 2 years have high energy and nutrient needs and require nutrient dense foods in order to meet these increased needs for growth and development (Dewey, 2003). The WHO (2003) recommends that a variety of foods be introduced and the consumption of flesh foods and eggs as well as vitamin A rich fruits and vegetables are emphasized. The provision of low nutrient value drinks such as sugary drinks, tea and coffee to infants and young children are discouraged (WHO, 2003). Consumption of fortified complementary foods and micronutrient supplements are suggested, especially in developing countries where intake of flesh foods are often inadequate, limiting intake of iron and zinc (WHO, 2003).

To illustrate trends in dietary intake from 6 to 18 months, food frequency data was collected in the present study population. The indicator "consumed at least once during the past week" was used to show the percentage of children at every age in 2 to 3 monthly intervals who were introduced to a food or drink item. At age 6 months, commercial infant products such as commercial infant cereal (80.4%) and jarred baby foods (55.3%) were the most commonly consumed foods, but the number of children consuming these foods by age 18 months were minimal (< 15%). Commercial infant cereal forms part of the complementary diet to various extents in different study populations in South Africa. A study done in the Western-Cape province showed that similar to our findings that a large percentage (> 80%) of infants aged 6 months in that study population consumed commercial infant cereal (Budree *et al.,* 2016). However, both a rural and urban study population in the KwaZulu-Natal province had only 33% of infants aged 6 to 11 months consuming infant cereal with declining numbers of children (<

6%) consuming it by ages 18 to 24 months (Faber *et al.,* 2016). Another study done in KwaZulu-Natal has shown that 52% of infants consumed commercial infant cereal at ages 6 to12 months (Faber & Benadé, 2007). Furthermore a study in Limpopo showed that at 9 months 21.9% of infants received commercial infant cereal at least once a week (age 6 month data not available) (Mamabolo *et al.,* 2004).

Maize porridge is the most frequently consumed food in children 1 to 9 years (Labadarios, *et al.,* 2000) and as shown by Faber *et al.* (2016) it is also frequently consumed from an even younger age in certain areas in South Africa. In the current study population as well as for a Western Cape study population (Budree *et al.,* 2016), fewer infants consumed maize meal porridge than commercial infant cereal at age 6 months; however, with increase in age maize porridge was consumed by more infants in both study populations.

Less than a quarter of infants at age 6 months received flesh foods during the past week. The recommendation of the WHO is that from age 6 months onwards complementary foods should be introduced of which meat, fish and poultry should be eaten "daily or as often as possible" (WHO, 2003). Since the indicator looked at whether the food was consumed at least once during the preceding week it is not expected that these foods would be eaten immediately at or before age 6 months. Intake of animal (flesh) foods should however increase from this age. Indeed, by age 12 and 18 months the majority of children in our study population ate chicken during the preceding week; however fewer children ate liver, meat and fish. Poor intake of animal (flesh) foods have consistently been shown in the complementary diets of South African children, especially before the age of 12 months (Budree *et al.,* 2016; Theron *et al.,* 2006; Faber *et al.,* 2016; Faber & Benadé, 2007). The main reason for this might be due to the high cost of these foods (WHO, 2003; Dewey & Vitta, 2013). The poor intake of iron rich complementary foods such as meat may contribute to the development of iron deficiency anaemia; furthermore neurocognitive development might also be affected as the intake of meat is associated with improved cognitive outcomes (Agostini *et al.,* 2008).

Sugary drinks, sweets and salty snacks (chips) were introduced from an early age and a large number of children consumed it at ages 12 and 18 months. Similar findings were noted by Faber and Benadé (2007) and Budree *et al.* (2016). Because of negative health consequences of these foods such as dental caries, displacement of more nutritious foods and the risk of becoming overweight and obese, the introduction of these foods in the complementary period are discouraged (Agostini *et al.,* 2008; WHO, 2003).

The scientific reasoning behind these aforementioned recommendations from the WHO with regards to the complementary diet is that the intake of the recommended foods / food groups will promote the intake of sufficient amounts and variety of nutrients needed to meet the growth and development requirements of infants and young children (WHO, 2003).

In order to see how, and if recommendations are being followed by a population it, can be insightful to gather information on when foods are introduced and what types of food and drink are being consumed at different ages. The cohort design of the current study is ideal for showing trends over time and limit confounding factors that could influence changes over time. The large sample size at age 6 months is an advantage however the decreasing sample size towards 12 and 18 months may be somewhat limiting. In addition to the types of food consumed, the nutrient intake of children in our study population has been investigated and is discussed in the next section.

Total nutrient intake and nutrient density of the complementary diet

In our study population at age 6 months, the 24 hour recall data has shown that a large percentage of children did not meet the total dietary intake requirement for iron (61.5%) and zinc (46.6%) while at age 12 and 18 months 75% of children did not meet the requirement for calcium. Not only were there large numbers of infants not meeting iron and zinc requirements at age 6 months, but the nutrient density for these nutrients were also below the average desired values. Similarly low nutrient densities for iron (> 85%) and calcium (75%) were found for 12 and 18 month old children. These findings are consistent with other studies that have shown that the complementary diets of children in South Africa (Faber, 2005; Faber *et al.,* 2016) and

other developing countries are lacking in multiple micronutrients, especially for some of the so-called 'problem nutrients' like iron, zinc and calcium (Campos *et al.,* 2010; Dewey & Brown, 2003; Dewey & Vitta, 2013; Kimmons *et al.,* 2005; Vossenaar & Solomons, 2012).

In this study it was seen that breast milk still made important contributions towards energy, macronutrients and certain micronutrients (i.e. calcium and vitamin B12) intakes at 6 months but contributed negligible amounts of iron. The amounts of breast milk consumed were based on estimated values due to the recognized difficulty of quantifying breast milk intake (WHO, 1998). Iron in breast milk has good bioavailability, but it does contain minute amounts thereof (Agostini *et al.,* 2008). It is well recognized that > 90% of iron needs have to be provided by the complementary diet from age 6 months (Agostini *et al.,* 2008). As discussed earlier, few infants in our study consumed flesh foods at age 6 months which may be a major contributing factor to the 'inadequate' intake of iron and zinc.

Intake of milk feeds (breast milk and formula milk) decreased with age as shown by the food frequency data, and while an upward trend of cow's milk usage was seen with increasing age, it was mostly cow's milk mixed into foods and not necessarily milk feeds. Per capita intake showed that breast milk and commercial infant products each contributed approximately 40% towards total calcium intake at age 6 months however at 12 and 18 months contribution from these feeds towards calcium intake were much lower. Other food sources became the major contributor of calcium at these ages (50% and 80% at 12 and 18 months respectively). A major contributor of calcium to the diet of young children in South Africa is milk or milk powder (Steyn *et al.,* 2006) and consumption of insufficient amounts of milk contributes to inadequate calcium intake (Black *et al.,* 2002, Dror & Allen, 2013). It could be that when children were weaned from breast- or formula milk feeds, it was not replaced with sufficient amounts of cow's milk feeds and that the other food sources given were foods containing low amounts of calcium.

Nutrient intake data does present with some limitations. With the use of a 24 hour recall it is relied upon the respondent's memory for data collection and this is a known limiting factor in dietary research. The use of a single 24 hour recall usually limits the ability to determine

adequacy of the total diet in terms of energy and nutrient intake due to the wide day-to-day within person nutrient variation (Murphy *et al.*, 2006). However with more than 1 day of recall, cost, practical difficulties and time becomes an issue and a recent paper by Padilha *et al.* (2017) suggests that for most micronutrients (including iron, zinc and calcium which are the problem nutrients in the current study), a single 24 hour dietary recall record have sufficient correlation with usual intakes of energy and nutrients in children younger than 23 months. Reference nutrient density values to assess dietary intake must also be used with caution. This is related to uncertainties with regards to the appropriate reference values to use for the development of reference nutrient density values (Dewey & Brown, 2003). Calculation of recommended nutrient density values used estimated breast milk nutrient values from a specific population and it is known that nutrient content of breast milk differs between populations depending on maternal dietary intake (Black *et al.,* 2008; Dewey & Brown, 2003). Furthermore the nutrient density reference values (Dewey & Brown, 2003) of children aged 12 months and older that were used for comparison in the current study were calculated using recommended daily allowance (RDA) values. When assessing nutrient intake of groups, it is recommended that EAR values be used and not RDA values, as the usage of the RDA as a 'cut-point' in nutrient intake assessment of groups may lead to an overestimation of the proportion of the group at risk of inadequate intake (Otten *et al.,* 2006).

Dietary diversity of the complementary diet

A variety of foods is needed to meet essential nutrient requirements (Arimond & Ruel, 2004). Dietary diversity can be a good predictor of dietary quality – especially to indicate low nutrient adequacy (Moursi *et al.,* 2008). A recent South African study showed that complementary diets with higher dietary diversity had higher nutrient densities for certain key nutrients such as iron and zinc (Faber *et al.,* 2016). In the current study more than 95% of infants had a DDS less than 4 at age 6 months – this is not unusual as at 6 months foods are being introduced and a large variety is not expected yet. However more than 70% of children at age 12 and 18 months still had low dietary diversity. This is not a unique finding in the South African context, as low dietary

diversity has been reported for both adults and children (Faber *et al.,* 2016; Labadarios *et al.,* 2011; Steyn *et al.,* 2006).

The reasoning behind the cut-off for 4 out of 7 food groups is that it is thought that with the consumption of at least 4 food groups it would mean that at least a fruit or vegetable, an animal source product and a staple food from the grain, root or tuber group is consumed and that this may be associated with a better quality diet (WHO, 2008). When the dietary diversity indicator was developed, the aim was to determine how well the 7 group indicator could predict a mean micronutrient density adequacy (MMDA) (which includes vitamin A, thiamine, riboflavin, vitamin B6, folate, vitamin C, calcium, zinc and vitamin B12) of ≥ 75%. Consumption of ≥ 4 out of 7 food groups is assumed to reach a MMDA of ≥ 75% and thus a better quality diet (Working group on infant and young child feeding indicators, 2007:5).

In our study the most consumed food group was grains, roots and tubers at all three ages. Legumes, flesh foods and eggs were some of the least consumed groups at 6 months but while legumes and eggs remained the least consumed foods, the intake of flesh foods increased and it was the second most consumed food group at 12 and 18 months. Other South African studies have also shown that the grain, roots and tuber group was the most consumed group (Budree *et al.,* 2016; Faber *et al.,* 2016) and that legumes was one of the least consumed groups (Budree *et al.,* 2016). Consumption of eggs may be encouraged as it is a nutrient rich and energy dense affordable food source that can contribute significantly towards the intake of protein, vitamin A, thiamine, riboflavin, folate, vitamin B12 and B6 (Wolmarans *et al.,* 2010).

Contribution of commercial infant products, and fortified maize meal and bread – comparison of consumers and non-consumers

The current study is one of only a few studies in South Africa looking at the contribution of commercial infant products, and fortified maize meal and bread to the complementary diet (Faber, 2005; Faber *et al.,* 2016).

Our results showed that commercial infant products made significant contributions to the intake of various micronutrients for the consumers thereof in this study population, similar to other populations in South Africa (Faber, 2005; Faber *et al.,* 2016). At age 6 months, commercial infant products (of which commercial infant cereal, followed by formula milk were the products most consumed) were the largest contributors of most nutrients – most notably iron, zinc and several B vitamins. For consumers of commercial infant products, the nutrient intake and nutrient density of the complementary diet were significantly higher for key micronutrients, compared to non-consumers, and this finding is congruent with findings of another South African study in an infant population in terms of higher nutrient intake (Faber, 2005). In the current study, commercial infant products were consumed less with the increase in age but consumers of these products (formula milk and infant cereal) still had significantly higher intakes of several micronutrients compared to non-consumers at age 12 months. Commercial infant products (infant cereal and formula milk) were the largest contributors of iron at age 12 months however similar to the findings of Faber (2005), the nutrient contribution from ready-to-eat jarred baby foods was low. Vossenaar & Solomons (2012) suggested that the complementary diet will probably not meet recommended intakes of the 'problem nutrients' without the consumption of commercially fortified infant products. Commercial infant cereals are fortified with several micronutrients and can contain 7.5 mg to 50 mg iron per 100 g dry product (Wolmarans *et al.,* 2010). Even though infant cereal was the main commercial infant product consumed at 6 months by the majority of infants and that for the consumers thereof it did contribute more than 70% of their total iron intake, total iron intake and iron density of the complementary diet of this study population is still low at this age. Thus commercial infant products may have a major role in meeting the needs of the complementary feeding phase but cannot be solely relied upon as a source of micronutrients and consumption of other micronutrient rich food sources (such as flesh foods) and diversification of the diet should still be encouraged. Bioavailability of iron from fortified commercial infant products is also an issue that should be considered – depending on the type of iron compound that is used to fortify a product, the bioavailability may be low and

therefore the absorption by and effect thereof in the body is limited (Glinz *et al.,* 2017, Quintaes *et al.,* 2017).

Furthermore it has been argued that the frequent consumption of commercial infant products may be a potential problem because of the cost of these products and it was proposed that homemade porridge would be much more affordable as it is a staple food for most families (Shisana *et al.,* 2013). However, Faber (2005) suggests that despite the fortification of the South African staple – maize meal – its impact on infant nutrition might be low as infants consume relatively small amounts thereof.

A small percentage of infants (23%) consumed fortified maize meal and bread at least once during the previous week at age 6 months but at age 18 months more than 90% of infants consumed it at least once during the previous week. At 6 and 12 months consumers of these products had significantly higher intakes of zinc, vitamin B6 and folate compared to non-consumers. At 6 months these foods contributed to less than a third of all nutrient intakes when looking at per capita intake whereas at 18 months per capita intake showed that fortified maize meal and bread contributed more than 40% towards total intake of iron, zinc, thiamine, vitamin B6 and folate (these are some of the fortified nutrients of the NFFP). This could possibly be ascribed to the smaller quantities of these foods consumed at 6 months compared to 12 and 18 months. With an increase in age fortified maize and bread starts to contribute more to dietary intake of young children especially for zinc (a problem nutrient), vitamin B6 and folate. Maize meal porridge has a low nutrient density (Faber & Benadé, 2007). The complementary diet of consumers of fortified maize and bread shows significantly higher energy intake and significantly lower nutrient density for calcium, iron, vitamin A, riboflavin and niacin compared to non-consumers. Especially at age 6 months, it is likely that non-consumers of fortified maize meal and bread are consumers of commercial infant products and these products contain higher levels of iron per 100 g than the fortified maize meal and bread for example. This may explain why non-consumers of fortified bread and maize meal have higher dietary iron intake and density – because they consume products that are fortified at higher levels. In terms of

calcium, it is not one of the fortified micronutrients of the NFFP and thus one would not expect these products to contribute greatly towards the dietary intake thereof.

Efforts to improve nutrient intake and nutrient density of the complementary diet

Fortification of staple foods (at adequate levels), improved consumption of under-utilized local foods, improved access to and consumption of special fortified infant products and use of micronutrient supplements added to foods have been proposed as strategies to improve nutrient intake and density of the complementary diet (Bhutta *et al.*, 2013; Dewey & Vitta, 2013; Osendarp *et al.,* 2016).

These efforts to improve infant and young child feeding should be combined and accompanied by targeted educational messages on breastfeeding and complementary feeding guidelines (Dewey & Vitta, 2013). Our findings reflect poor adherence to complementary feeding guidelines in terms of continued breastfeeding up to 2 years, encouragement of a variety of food and the introduction of animal source foods from 6 months (WHO, 2003). The guideline to "avoid giving tea, coffee, sugary drinks, and snacks that are high in sugar, fat or salt" (Du Plessis *et al.,* 2013; WHO, 2003) is also not adhered to. At healthcare visits these messages must be emphasized together with encouraging adequate intake of dairy products for this age group when weaning from breast milk or formula milk feeds.

Suggestions for future research

Future research could investigate commercial infant products in terms of the required amount of food that needs to be consumed (practicality), availability, and bioavailability of problem nutrients from these foods to meet the requirements of the complementary feeding period. It would also be valuable to investigate why commercial infant products are so popular in some communities. This could expose misled beliefs related to commercial infant products and may assist in formulating factual educational messages in order for mothers to be counselled to choose effective, valuable products and to avoid expensive, unnecessary products that do not contribute towards valuable nutrient intake. Furthermore, the current fortification program in

South Africa (NFFP) is not aimed at the complementary feeding period (South Africa, 2003; SAVACG, 1996) and the possibility of developing a targeted product, fortified at higher levels to meet the requirements of young children (6 to 23 months) may be investigated under the scope of the NFFP.

Conclusion

In conclusion dietary trends observed in this study population illustrated poor continued breastfeeding rates, large numbers of infants consuming commercial infant products at 6 months and decreasing numbers at 18 months with an opposite trend for maize meal consumption. Few children consumed flesh foods other than chicken at all 3 ages. Compared to recommendations the consumption of salty snacks, sweets and sugary beverages were quite high at all ages. Low intake and nutrient density of key nutrients – especially iron, zinc and calcium – were also seen. Low dietary diversity was found for the majority of children across all 3 age groups. Commercial infant products were consumed by the majority of 6 month old infants and it made significant contributions to key micronutrients at this age, with an increase in age fewer children consumed these foods, however it still contributed significant amounts of key nutrients. Fortified maize meal and bread did not make significant contributions to key micronutrients at age 6 months, however with an increase in age towards 18 months it started to play a larger role in terms of nutrient intake. Interventions should focus on combining strategies such as fortification of staple foods and the consumption of specially fortified commercial infant products with educational messages such as diversification of the diet and improved use of local available nutrient dense foods.

Key messages

- Nutrient density of the complementary diet was low for a large percentage of children for iron at 6, 12 and 18 months, zinc at 6 months and calcium at 12 and 18 months.

- More than 70% of children at all three ages did not meet minimum dietary diversity.

- Consumers of commercial infant products had significantly higher intakes and nutrient density of most micronutrients (including calcium, iron and zinc) compared to non-consumers at all three ages.

- Consumers of fortified maize meal and bread had significantly higher intakes of zinc, vitamin B6 and folate and made larger contributions to total intake for some nutrients from 12 months onwards. At 6 months contribution of these foods to total dietary intake were minimal.

- Interventions should focus on combining strategies such as fortification of staple foods and consumption of commercial infant products with counselling strategies such as diversification of the diet.

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CHAPTER 4:   GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

4.1   Introduction

This final chapter summarises and concludes the main findings in relation to the aims and objectives of the mini-dissertation and makes recommendations for future research on the subject at hand based on the current findings and existing literature reviewed. The strengths and limitations are also discussed in order to provide guidance for future research.

4.2   Summary of main findings

The aim of this study was to assess trends in dietary intake, dietary diversity, nutrient intake and nutrient density of infants followed from ages six to 18 months in a peri-urban community of the North-West province, South Africa.

The specific objectives were to:

- Observe trends in types of foods consumed at two to three monthly intervals from ages six to 18 months

- Determine dietary intake in terms of energy, macronutrients and micronutrients, nutrient density and dietary diversity in infants at ages six, 12 and 18 months

- Determine the contribution of commercial infant foods (infant formula, infant cereals, baby juice and jarred baby foods) and the National Food Fortification Programme

4.2.1   Objective 1: Observe trends in types of foods consumed at two to three monthly intervals from ages six to 18 months.

Dietary trends are based and reported on for a frequency of consumption of at least once during the previous week. At age six months 71.9% of infants were still breastfed but by age 18 months only 35% were still breastfed. Commercial infant cereal and jarred baby foods were respectively consumed by 80.4% and 55.3% of infants at age six months but the consumption thereof decreased to 13.3% and 9.3% towards 18 months. A third of infants consumed maize meal porridge at age six months, however by 18 months almost all infants (91.1%) were introduced to it. Chicken was the flesh food consumed by the largest number of children at all three ages (21.9% at six months, 74.9% at 12 months and 85.5% at 18 months), and red meat, liver and fish were not widely introduced at any age. Carbonated drinks, sweets and chips were

already consumed at least once the previous week by 12.8%, 31.2% and 20% of infants at six months and by 56.9%, 73.4% and 83.9% of children age 18 months.

4.2.2 Objective 2: Determine dietary intake in terms of energy, macronutrients and micronutrients, nutrient density and dietary diversity in infants at ages six, 12 and 18 months.

A low total intake of iron and zinc was seen for 61.5% and 46.6% respectively of infants aged six months. 75.8% and 75.1% of children aged 12 and 18 months respectively had low total calcium intakes. Low nutrient densities of iron and zinc at six months, and iron and calcium at 12 and 18 months of the complementary diet have been found. More than 70% of children at all three ages did not consume four or more out of seven food groups and therefore does not have minimum dietary diversity.

4.2.3 Objective 3: Determine the contribution of commercial infant foods (infant formula, infant cereals, baby juice and jarred baby foods) and the National Food Fortification Programme.

For the consumers of commercial infant products – at age six months, the infants' total intake of commercial infant products contributed > 90% of iron intake, ≥ 70% of thiamine and niacin intakes and ≥ 50% of zinc, riboflavin, vitamin B6, folate and vitamin C intakes. At age 12 months it still contributed to > 50% of the infants' total iron and vitamin C intakes. Consumers of commercial infant products on the day of recall had a significantly higher intake of all nutrients (except fat) at age six months, and of calcium, iron, zinc, vitamin A, thiamine, riboflavin, niacin, vitamin B12 and vitamin C at 12 months compared to non-consumers on the day of recall. Commercial infant products were the major contributor of protein, carbohydrate and all key micronutrients (except vitamin B12) and of iron and vitamin C at 12 months on the day of recall when looking at per capita intake.

At age six months the contribution of fortified maize meal and bread to total nutrient intake were minimal; at age 12 months, of total intake, these foods contributed more than 50% of thiamine, vitamin B6 and folate; and at age 18 months, of total intake, fortified maize meal and bread contributed > 40% iron and zinc, > 50% thiamine and vitamin B6 and > 70% folate intakes for consumers thereof. Consumers of these products at age 12 months had significantly higher intakes of zinc, vitamin B6, folate, thiamine and niacin compared to non-consumers on the day of recall. Non-consumers of NFFP foods had a significantly higher nutrient density of calcium, iron, vitamin A, riboflavin and niacin at age 12 months on the day of recall. Fortified maize meal and bread were the main contributors of vitamin B6, folate and thiamine at ages 12 and 18 months on the day of recall when looking at per capita intake.

4.3   Conclusion

In conclusion dietary trends observed in this study population illustrated poor continued breastfeeding rates, large numbers of infants consuming commercial infant products at six months and decreasing numbers at 18 months with an opposite trend for maize meal consumption. Few children consumed flesh foods other than chicken at all 3 ages. Compared to recommendations the consumption of salty snacks, sweets and sugary beverages were quite high at all ages. Low intake and nutrient density of key nutrients – especially iron, zinc and calcium was also seen. Low dietary diversity was found for the majority of children across all three age groups. Commercial infant products were consumed by the majority of 6 month old infants and it made significant contributions to key micronutrients at this age. With an increase in age fewer children consumed these foods, however it still contributed to significant amounts of key nutrients. Fortified maize meal and bread did not make significant contributions to key micronutrients at age six months, however with an increase in age towards 18 months it started to play a larger role in terms of nutrient intake. Interventions should focus on combining strategies, such as fortification of staple foods, and consumption of commercial infant products with counselling strategies such as diversification of the diet.

4.4   Strengths and limitations

Strengths of this study include:

- Dietary data of infants and young children was collected as part of the randomised controlled trial (Tswaka study) and it was seen that a large percentage (83%) of this population consumed commercial infant products on the day of recall, especially at six months. Even though the South African Food Composition Database (SAFCD) did contain values for certain commercial infant products (i.e. formula milk, infant cereal and jarred foods), it was incomplete and out-dated. Thus before nutrient analysis of the dietary data for the Tswaka study, the baby food group of the SAFCD were updated where possible based on the list of foods compiled from the 24 hour recalls collected as part of the Tswaka study.

- The Tswaka study had three fieldworkers who were thoroughly trained and assigned specifically for the collection of dietary data. This is beneficial as fewer fieldworkers ensure less variability between them and decreases bias in the way dietary data is collected. Continuous monitoring, discussing and solving of issues as they arose ensured reduced variability across fieldworkers.

- The fieldworkers were recruited from the community in which the study was done. This meant that the fieldworkers were familiar with the dietary practices and local foods as well as preparation methods which provides valuable insight and may help to improve the

authenticity of the types of foods recorded. The fieldworkers also share the same language as the mothers who were interviewed and this is also a strength as it assists to ensure that what is reported is clearly understood.

- The same children were followed up over time (cohort observational study) – thus dietary data was collected for the same children at different time points. Changes in dietary patterns over time are thus influenced by fewer confounding factors as opposed to when dietary data of different infants at different ages are compared – such as in a cross-sectional survey.

Limitations of the study include:

- The Tswaka randomised controlled trial investigated the addition of a SQ-LNS to the complementary diet of infants and children with various outcomes (i.e. anthropometric and cognitive measures). It is possible that the addition of the SQ-LNS to the complementary feed could affect the amount of food that the mother gives to the child or that she maybe omits food items that she would in other circumstances have added to the meal therefore not giving a complete true reflection of the complementary feeding practices/diets typically provided to children of this age in this community. However mothers were counselled not to omit or change anything to the complementary diet and to continue like they would have done without the study.

- Breast milk intakes were estimated due to the recognized difficulty of quantifying breast milk intake (WHO, 1998). Furthermore nutrient content of breast milk is also different between populations depending on maternal dietary intake and reference breast milk nutrient values are based on a specific population that may differ from the current population (Black *et al.,* 2008; Dewey & Brown, 2003).

- With the use of the 24 hour recall a common limitation is that collection of data relies on the respondent's memory which may affect the accuracy of data.

- When a 24 hour recall method is used, more than one day of recall is needed to show true usual intake (Murphy *et al.,* 2006:1551), however cost and practical difficulties become an issue. Although using a single 24 hour recall could be considered a limitation, it has recently been suggested that for most micronutrients one day of dietary recall have sufficient correlation with usual intakes of energy and nutrients in children younger than 23 months (Padilha *et al.,* 2017).

- Although the nutrient contribution from different food items such as the commercial infant products were shown towards total dietary intake, the actual bioavailability and uptake of nutrients from these foods were not investigated. Depending on the type of iron compound

that is used to fortify a product (i.e. commercial infant products), the bioavailability may be low and therefore the absorption by and effect thereof in the body is limited (Glinz *et al.,* 2017, Quintaes *et al.,* 2017).

- The HIV and TB status of the infants and children in this study is unknown. The presence of either of these diseases might affect usual dietary intake and increase the nutritional needs of a patient (WHO, 2009). This should be kept in mind when dietary intake is compared to reference values (reference values are based on nutritional needs of healthy children) (Dewey & Brown, 2003).

4.5   Suggestions for future research

- Although infant cereal have been shown to make large contributions to nutrient intake (especially iron intake) in infants in South Africa (Faber, 2005:377), and it is commonly introduced as a first food in urban and peri-urban South African communities (Faber, 2005:377; Faber & Benadé, 2007; Faber *et al.,* 2016; Mamabolo *et al.,* 2004; Shisana *et al.*, 2013) all communities are probably not able to afford it (Shisana *et al.,* 2013). Future research could investigate or compare the cost of commercial infant products with animal source foods or other locally available foods.

- It can also be valuable to investigate and compare commercial infant products with other complementary foods such as animal source foods and other nutrient dense foods in terms of amounts to be consumed (practicality), availability, affordability and bioavailability of problem nutrients from these foods to meet the nutrient needs of the complementary feeding period.

- It would also be valuable to investigate why commercial infant products are so popular in some communities in order to focus educational messages and to assist mothers in choosing effective, valuable products and to avoid expensive products that do not contribute towards valuable nutrient intake.

- As suggested by others (Faber, 2005:373) and shown in this study, the NFFP does not really contribute significantly to nutrient intake <12 months (this age group was not specifically the target of the program) (South Africa, 2003; SAVACG, 1996). This show a need for an affordable, readily available product which is fortified at suitable levels to meet increased needs of infants and young children in the complementary phase. Future research may investigate the feasibility and acceptability of such a product as well as the optimal levels at which it has to be fortified.

4.6   Recommendations for improved practice and policies

Strategies to improve nutrient intake and nutrient density of the complementary diet:

- Following the above mentioned suggested research, the possibility of developing a targeted (staple food) product, fortified at increased levels to meet the requirements of young children (six to 23 months) may be investigated under the scope of the NFFP.

- Educational messages provided by health care providers must emphasize messages focusing on the importance of continued breastfeeding (and appropriate replacement milk feeds when weaning from breast milk) beyond six months, the intake of a varied diet, the benefits and optimal consumption of commercially fortified infant products and fortified maize meal and bread as well as the consumption of animal source foods – especially organ meats (liver) whenever it is feasible. Furthermore improved consumption of legumes and eggs as more affordable protein and micronutrient sources can be encouraged and stronger emphasis should be placed on discouraging the consumption of sugary drinks, sweets and salty snacks.

When attempting to improve the quality of the complementary diet, strategies should be implemented as a combined effort and not in isolation. Thus, instead of relying on a single strategy – for example fortification of staple foods – strategies can be combined – for example the provision of micronutrient supplementation, consumption of specially fortified infant products, counselling or education on use of locally available nutrient dense foods as well as fortifying staple foods at appropriate levels.

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ANNEXURE A: AUTHOR GUIDELINES OF THE JOURNAL, MATERNAL AND CHILD NUTRITION

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Stevens, G. A., Bennett, J. E., Hennocq, Q., Lu, Y., De-Regil, L. M., Rogers, L., … Ezzati, M. (2015). Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: A pooled analysis of population-based surveys.Lancet Global Health, 3, e528–e536.

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Author Services enables authors to track their article - once it has been accepted - through the production process to publication. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The author will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript. Visit http://authorservices.wiley.com/bauthor/ for more details on online production tracking and for a wealth of resources including FAQs and tips on article preparation, submission and more.

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Maternal and Child Nutirion now uses eLocators instead of page numbers. The use of eLocators supports Wiley's transition from print, page-based publication workflows to a modern, web-first environment that reflects the future of journal publishing. eLocators are unique identifiers for an article that serve the same function page numbers have traditionally served in the print world. Your article will now have a unique identifier (eLocator) instead of a page number. The eLocator will become the primary means of citation, just as page numbers have been in the past. The eLocator appears as the last identifier in a citation, replacing the page number. For further details, you can refer the eLocators page on the Author Guidelines page of the journal.

ANNEXURE B: INFORMATION SHEET AND CONSENT FORM USED IN RECRUITMENT PROCESS OF TSWAKA STUDY

INFORMATION SHEET

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

Project leader: Prof Marius Smuts
Co-project leader: Prof Mieke Faber

Dear Parent / Legal Guardian

Who are we?
We are from the North-West University (PUKKE), Potchefstroom and the Medical Research Council, Cape Town. We are studying the effect of newly-developed nutritional supplements on the growth and development of babies. The supplements are in the form of a paste and can be mixed with the food babies normally eat. We invite you and your baby to participate in this important research study.

Why are we doing this?
Iron and fatty acids in foods are important for the growth and development of babies. For optimal growth and development of babies, the different types of fatty acids in food need to be present in the right amounts. The aim of this study is to test two types of nutritional supplements in order to see if these supplements can improve the growth and development of babies. This will be done by measuring nutritional status, growth and development of babies after they have eaten the supplement mixed with their usual food every day for six months.

What do we expect from participants during the study?
Seven hundred and fifty (750) babies and their mothers (or primary caregiver) will be recruited through the local clinics. All babies will be 6 months old at the start of the study and will be followed up until they are 12 months old. Only mothers who planned to stay in the Jouberton area for at least the next 7 months can take part in the study. Only apparently healthy babies with no known allergy to soy, peanut, milk/lactose and fish, who are currently breastfeeding or have previously breastfed, will be included in the study. The products contain allergens from soy, milk, and fish, and may also contain traces of peanuts. Twins cannot participate in the study.

Participants will be divided into three groups. The first group will receive a fortified fat-based paste that contains essential fatty acids with other added fatty acids as well as a substance that may improve the absorption of iron. The second group will receive a paste that contains essential fatty acids. Both products contain soy. The third group will not receive any supplement during the 6-month study period, but they will receive a 6-month supply of one of the the fat-based pastes when the baby is 12 months old. Each child has an equal chance to be in any of the three groups. The amount of nutrients (e.g. iron and fatty acids) used in the two supplements is safe and no side effects such as nausea or diarrhoea is expected. The supplement will be provided free of charge to

all study participants. Mothers will be asked to mix a certain amount of the supplement with the child's usual food daily for 6 months, preferably the first meal of the day.

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

When your baby is 6 and 12 months old, you will be asked to go with your baby to the research site which is at the Baptist Church. During these two visits, we will ask the following from you:
- You will be asked questions about your household (at the start of the project), the foods that your baby eats and drinks, any illnesses that your baby had during the previous weeks, and development that your baby has achieved.
- You will be asked to recall the foods and drinks that your baby consumed the day before.
- Your baby's weight, length, head circumference and upper arm circumference will be measured.
- Your weight and height will be measured (at the start of the project).
- You will be maybe asked to express a small amount of breast milk (approximately ¼ cup). We will measure the fatty acids and iodine in the breast milk. After the fatty acids and iodine have been measured, the remaining breast milk will be discarded according to standard procedures.
- A nursing sister will take a 4 mL (less than one teaspoon) blood sample from the vein in your baby's arm to measure the levels of nutrients in blood. If your baby is showing too much resistance during this process, blood will not be taken from him/her. The procedure is completely safe.
- You will be maybe asked to provide a small amount of urine (at the start and end of the project). We will measure the iodine in the urine.
- We will collect a small amount of urine from your baby using a special nappy. We will measure the iodine in the urine.

You and your baby will be asked to further visit the research site when the baby is 8 and 10 months old. During these two visits you will be asked questions about the foods that your baby eats and drinks, and your baby's weight and length will be measured.

You will also be asked to record daily how much product your baby consumed and to report illness.

A field worker will visit you at home once a week. During these visits the fieldworker will ask you questions on the usage of the supplement, illnesses that your baby may experience and developmental milestones that your baby has achieved.

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

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

What will the benefit be for my child who participates?
Your child will receive the nutritional supplement, free of charge, for 6 months. Your child will be monitored for the 6-month period and, should anything abnormal be found, be referred to the local clinic or a medical doctor for the necessary treatment. You will also gain information on your child's nutritional status and development.

What will the risks be for my child who participates?
The nutritional supplement is safe and should not harm your child or make your child sick.
Your child may experience some discomfort when the blood samples are taken or when the weight and length are taken. This discomfort will be minimised as the staff taking these measurements will be experienced. If your child does not want to cooperate, the procedures will be stopped.

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

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

Who can you contact if there are any queries?
For more information on the study you may contact Prof Marius Smuts at 018-299 4670 or 082 451 0486 **OR** Prof Mieke Faber at 021-938 0404 or 0824602946.

The study has been approved by the Ethics Committee of North-West University (NWU), the Ethics Committee of the Medical Research Council, as well as the Department of Health. If you have any queries or problems regarding the study, you can contact either Prof Amanda Lourens the chairperson of the NWU Ethics Committee at (018) 2992606 or Prof Danie du Toit who is the chairperson of the MRC Ethics Committee at (021) 9380341 or you can send an e-mail to adri.labuschagne@mrc.ac.za.

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

Thank you!

Tswaka

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

MRC
SOUTH AFRICA

UNIVERSITY OF
KWAZULU-NATAL

CONSENT FORM

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

I voluntary agree to take part in the study.

I have been informed about and understand the purpose of the study.

I have been informed about and understand the advantages and possible side-effects that may result from procedures.

I understand that I can withdraw my consent at any time without being penalised as far as my routine health care is concerned.

I have been informed that all information will be treated as confidential.

I understand that my baby can be in any of the three groups. If my baby is in either group 1 or group 2, I will receive the nutritional supplement free of charge for six months (starting when my baby is 6 months old) and must mix one portion of the supplement with my baby's normal food every day. If my baby is in group 3, I will receive a 6-month supply of the supplement when my baby is 12 months old.

I understand that, regardless of in which group my baby is, my baby and I need to go to the research site when my baby is 6 and 12 months old for the following:
-I will be asked questions about my household (at the start of the project), the foods that my baby eats and drinks, any illnesses that my baby had during the previous weeks, and development milestones that my baby has achieved.
- I will be asked to recall the foods and drinks that my baby consumed the day before.
- My baby's weight, length, head circumference and upper arm circumference will be measured.
- My weight and height will be measured (at the start of the project).
- I will be asked to express a small amount of breast milk (approximately ¼ cup).
- I will be asked to prove a small amount of urine (at the start and end of the project).
- A small amount of urine will be collected from my baby by using a special nappy.
- A nursing sister will take 4 mL (less than one teaspoon) blood from the vein in my baby's arm.

I understand that my baby and I also need to go to the research site when my baby is 8 and 10 months old. During these two visits I will be asked questions about the foods that my baby eats and drinks, and my baby's weight and length will be measured.

I understand that a field worker will visit me at home once a week. During these visits the fieldworker will ask me questions on the usage of the supplement, illnesses that my baby had and developmental milestones that my baby has achieved.

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

If I have any queries or problems regarding the study, I can contact either Prof Amanda Lourens the chairperson of the NWU Ethics Committee at (018) 2992606 or Prof Danie du Toit who is the chairperson of the MRC Ethics Committee at (021) 9380341 or I can send an e-mail to adri.labuschagne@mrc.ac.za.

ANNEXURE C: 24 HOUR RECALL AND FOOD FREQUENCY QUESTIONNAIRE RECORDING FORMS

24-hr DIETARY RECALL

Baby's code: [ ][ ][ ][ ]

Date of the interview (dd/mm/yyyy):

[ ][ ] / [ ][ ] / [2][0][1][ ]

Fieldworker's code: [ ][ ]

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.

Time of day	What food and drink	How was it prepared? What was added?	How much was eaten
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:		

FOOD FREQUENCY

Baby's code: | | | | |

Ask for each food item, one at a time, how often the child usually eats the specific food item. The last week (or last seven days) should be taken as guideline, therefore the frequency that the child ate the food item during the last week. Make a cross on the option that describes the mother's answer the best). The options are as follows: Every day
> Most days: not every day, but at least 4 times per week
> Once a week: less than 4 times per week, but at least once per week
> Never

Food item	Frequency of intake during the last week			
	Baseline	**Month 2**	**Month 4**	**Month 6 (end)**
Date (dd/mm/yyyy):				
Fieldworker's code:				
Breastmilk	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Formula milk *If formula milk was used, please give name of the formula milk:*	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never ....
Cow's milk / amasi / maas Milk powder e.g. Klim, Nespray	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Yoghurt / danone	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Baby foods in a jar e.g. Purity	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Infant cereals or infant porridge e.g. Nestum, Cerelac, Cream of Maize, Baby Mabele	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never

Food item	Frequency of intake during the last week			
	Baseline	**Month 2**	**Month 4**	**Month 6 (end)**
Porridge made with maize meal (soft, stiff or crumbly)	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Cooked porridge, other than maize meal porridge e.g. oats, mabele	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Instant porridge, e.g. instant Maize, Mabele	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Bread	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Rice	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Potatoes	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Vegetables, any type (NOT potatoes) *If vegetables were eaten, please name the type of vegetables eaten mostly:*	1___Every day 2___Most days 3___Once a week 4___Never 1 .... 2 .... 3	1___Every day 2___Most days 3___Once a week 4___Never 1 .... 2 .... 3	1___Every day 2___Most days 3___Once a week 4___Never 1 .... 2 .... 3	1___Every day 2___Most days 3___Once a week 4___Never 1. .... 2. .... 3. ....
Fruit juice (includes juice squeezed from the fruit)	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never

Food item	Frequency of intake during the last week			
	Baseline	Month 2	Month 4	Month 6 (end)
Fresh fruit (any type) *If fruit were eaten, please name the type of fruit eaten mostly:*	1___Every day 2___Most days 3___Once a week 4___Never 1 .... 2 .... 3	1___Every day 2___Most days 3___Once a week 4___Never 1 .... 2 .... 3	1___Every day 2___Most days 3___Once a week 4___Never 1 .... 2 .... 3	1___Every day 2___Most days 3___Once a week 4___Never 1. .... 2. .... 3. ....
Eggs	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Red meat (beef, pork, mutton) / stew / sausage / mince meat	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Chicken / poultry	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Liver (e.g. chicken liver, beef liver, sheep liver etc)	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Fish (fresh or canned)	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Sweets / Chocolates	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Chips / Cheese curls / Niknaks	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Fizzy cold drink e.g. Coke	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never

Food item	Frequency of intake during the last week			
	Baseline	**Month 2**	**Month 4**	**Month 6 (end)**
Juice concentrate, mix with water e.g. Oros	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Rooibos	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Tea, normal	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Sugar (any type), eaten as such, in drinks (e.g. tea) or added to food	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
Salt (added to food)	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
How often did you use oil when preparing the baby's food?	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
How often did you use margarine when preparing the baby's food? [any type of margarine]	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never
How often did you use peanut butter when preparing the baby's food?	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never	1___Every day 2___Most days 3___Once a week 4___Never