South African Journal of Clinical Nutrition 2023; 36(3):126–135
https://doi.org/10.1080/16070658.2022.2141051

SAJCN
ISSN 1607-0658 EISSN 2221-1268

ARTICLE

Energy and nutrient contribution of different food groups to the dietary intake of 6- to <9-month-old infants in a low socioeconomic community in North West Province, South Africa

Tshiphiri Mukwevho[a], Cornelius M Smuts[a], Hannah Asare[a] and Mieke Faber[a,b]

[a]Centre of Excellence for Nutrition (CEN), North-West University, Potchefstroom, South Africa
[b]Non-Communicable Diseases Research Unit, South African Medical Research Council, Tygerberg, South Africa
*Correspondence: mieke.faber@mrc.ac.za

Objective: A study was undertaken to determine the energy and nutrient contribution of different food groups to the dietary intake of 6- to <9-month-old infants.
Design: An observational study was conducted using baseline data of a preliminary randomised controlled trial that aimed to determine the effect of egg consumption on infant growth.
Setting and subjects: Participants resided in a peri-urban community (Jouberton) in North West province, South Africa. The study included 6- to <9-month-old infants ($n = 155$); 24-hour dietary recall data were available for $n = 144$.
Results: Most infants consumed either two (29.2%) or three (42.4%) out of eight food groups. The grains/roots/tubers group was consumed by 95.8% of infants; for consumers thereof, it contributed 75.5% of iron, 53.0% of thiamine and 42.5% of folate. Breast milk and dairy were consumed respectively by 64.4% of infants. For breastfed infants, breast milk was the major contributor of energy and fat, and some micronutrients (calcium, zinc, vitamin A, vitamin C, niacin and riboflavin); but they had lower intakes ($p < 0.05$) for all micronutrients except vitamin A compared with non-breastfed infants. For consumers (16.7%) of animal-source foods (ASFs), these contributed 42.8% for vitamin B12 and 33.4% for protein; and intake of protein, riboflavin and vitamin B12 was higher ($p < 0.05$) for consumers compared with non-consumers. The least consumed food groups were legumes (0.7%), flesh foods (6.9%) and eggs (10.4%).
Conclusion: Grains/roots/tubers, dairy and breast milk made a major contribution to the intake of key nutrients. Animal-source foods were not consumed frequently, but for consumers thereof made a substantial contribution as well.
Recommendation: Strategies to improve dietary diversity should encourage continued breastfeeding, aim to increase intake of food groups not frequently consumed and promote locally available food.

Keywords: dietary diversity, food groups, infants, nutrient adequacy, nutrient contribution, South Africa

Introduction

Good nutrition and optimal feeding practices during infancy ensure child growth and development. The complementary feeding period is the largest part of the 'first 1000 days of life', which is considered a window of opportunity for preventing malnutrition and its consequences.[1] At age six months, nutrient-rich complementary foods should be introduced, along with continued breastfeeding, to meet infants' high nutrient requirements.[2] However, complementary foods in low- and middle-income countries (LMICs) are often nutritionally inadequate and are deficient in several micronutrients, with iron, zinc and calcium being considered 'problem nutrients'.[3,4] Poor diet and inappropriate complementary feeding practices are the most common drivers of malnutrition in early childhood.[5] Furthermore, growth faltering commonly occurs between the ages of 6 and 24 months in LMICs.[6] Hence, promoting optimal nutrition during the complementary feeding period is a health priority.[7]

Dietary diversity has been recognised as an important indicator of a healthy diet.[8,9] Consuming a diversified diet that includes a variety of food items increases the likelihood of nutrient adequacy among infants and young children.[10] According to the most recent guidelines for measuring minimum dietary diversity (MDD), 6- to 24-month-old children should consume at least five out of eight food groups.[11] Several studies have shown that MDD is often not achieved in LMICs,[8,12–15] and complementary foods are mostly 'grains, roots and tubers', followed by a few animal products and a few fruits and vegetables.[8,14,15]

Reaching MDD is a challenge in South Africa.[13] The 2016 South African Demographic and Health Survey (SADHS) showed that only 23% of 6- to 8-month-old infants met the criteria for MDD. The 2016 SADHS further showed that only 23% of 6- to 23-month-old children received a minimum acceptable diet (which considers breastfeeding status, numbers of meals and dietary diversity), with the proportion of children receiving a minimum acceptable diet being lowest in the lower wealth quintiles.[16]

In South Africa, fortified infant cereal and maize meal are frequently consumed during infancy.[17] While some information is available on the nutrient contribution of fortified staple foods and commercially available infant products to dietary intake in infants and young children,[18] information on the potential nutrient contribution of the other food groups has not been widely investigated. The aim of this study was to determine the contribution of different food groups to the total dietary intake of 6- to <9-month-old infants in a low socioeconomic community in North West province, South Africa.

Methods

Study population and study design

This study was conducted in Jouberton, which is a peri-urban area in the greater Matlosana Klerksdorp municipality in North West province, South Africa. The study area is 200 km from Johannesburg. This paper is part of a preliminary study for the Eggcel-growth study, which aims to determine the effect of providing one egg per day for 6 months on infants' growth, motor development, micronutrient and morbidity status. The required sample size for the Eggcel-growth study is 500 participants, and enrolment started in February 2020. However, in the last week of March 2020, enrolment of participants was stopped because South Africa's national lockdown regulations due to the COVID-19 pandemic came into effect. At the time, 155 study participants had been enrolled, and they remained in the trial. As the sample size of 155 is inadequate to measure intervention outcomes, the trial is therefore referred to as the preliminary Eggcel-growth study.

Trained fieldworkers recruited study participants (mother–infant pairs), explained the nature of the study to the mothers and performed a pre-screen to assess potential eligibility. Mothers who were interested and potentially eligible were given an information sheet to take home. Before enrolment, at age 6 to <9 months, infants were screened for final eligibility, and their mothers were asked questions to ensure that they understood what was required and comprehended the consent process. Only infants whose mother or legal guardian provided signed consent were enrolled in the study.

Exclusion criteria included known allergies/intolerances to eggs, severe anaemia (haemoglobin < 70 g/L), severe acute malnutrition (weight-for-length Z-score < –3), obvious congenital abnormalities, not born a singleton, the mother being younger than 18 years at enrolment and the mother planning to relocate within 9 months after enrolment. For this study, baseline data for the 155 participants enrolled in the preliminary Eggcel-growth study were used, with the focus on dietary intake.

Data collection

Measurements

Mothers/caregivers were interviewed by trained fieldworkers in English or their home language (Setswana). Socioeconomic information (such as level of education, age, marital status and household characteristics) and early feeding practices were collected using a structured questionnaire.

Trained fieldworkers collected information on dietary intake of the infants by interviewing the mothers/caregivers using a single multi-pass 24-hour dietary recall. A standardised dietary kit was used to assist the mother/caregiver to describe and estimate the amount of food and beverages consumed by the infant during the previous day. The dietary kit contained examples of relevant food, food wrappers and containers, commonly used household utensils (e.g. spoons and bowls) and a photobook. In addition, the portion size for cooked food was estimated using the 'dish-up and measure' method. For infant cereal and formula milk, the amounts for the dry product and the liquid were recorded separately, where possible.

Food intake data recorded in household measures were converted to grams using the Food Quantities Manual for South Africa.[19] The amount of breast milk intake was estimated according to age, with 675 ml for breastfed infants at age 6 months.[20] Food intake data were converted to energy, macro- and micronutrients using the South African food composition database [21] and STATA software (StataCorp, College Station, TX, USA). Energy and nutrient intakes for the total diet were calculated. Adequacy of nutrient intake was determined by calculating the percentage of infants with intakes below the age-appropriate estimated average requirements (EAR); for nutrients for which there is no EAR, median intake was compared with the adequate intake (AI).[22–24] The mean adequacy ratio (MAR) was calculated by, first, calculating nutrient adequacy ratios (NAR) for 11 micronutrients (ratio of an individual's intake to the recommended intake) and then calculating the average of the 11 NARs (with NARs higher than 1 being truncated to 1).[25]

To calculate dietary diversity and determine the energy and nutrient contribution of different food groups, foods were categorised into eight food groups, namely (i) breast milk, (ii) 'grains, roots and tubers', (iii) legumes and nuts,(iv) dairy, (v) flesh

Table 1: Food-group classification for the foods and drinks reported during the 24-hour recall period

Breastmilk:
Breastmilk
Grains, roots, and tubers:
Infant cereals
Maize meal porridge (soft, stiff)
Breakfast cereals (weetbix)
Bread (white, brown)
Home-made bread
Rice
Potatoes
Sweet potatoes
Legumes and nuts:
Peanut butter
Dairy:
Infant formula
Yoghurt
Cow's milk (maas, fresh milk)
Flesh foods:
Organ meats (chicken liver, beef lung)
Chicken
Minced meat
Sausage
Eggs:
Eggs
Fruits and vegetables:
Apple
Banana
Pear
Beetroot
Gem squash
Baby foods (fruit)
Baby foods (vegetables)
100% baby fruit juices
100% baby vegetable juices
Vitamin A-rich fruits and vegetables:
Mango
Apricot
Papaya
Carrots
Butternut
Dark green vegetables
Baby foods (vitamin A-rich vegetables)
100% baby vitamin A-rich vegetable juices
100% baby vitamin A-rich fruit juices

Note: Baby juices and baby foods were grouped according to the main ingredient foods, (vi) eggs, (vii) vitamin A-rich fruits and vegetables and (viii) other fruits and vegetables.[11] For each infant, foods consumed during the 24-hour-recall period were allocated to the appropriate food group (Table 1). For each food group consumed the previous day, a score of one was given; the MDD was calculated as the number of infants who consumed at least five of the eight food groups on the day of recall. Energy and nutrient contribution for each of the respective food groups was calculated and expressed as a percentage of total intake of the nutrient. For each food group, nutrient density was calculated (amount of nutrient provided by the food group per 418 kJ/100 kcal provided by the food group). Nutrient contribution and nutrient density of food groups are reported for consumers only, where consumers are defined as those infants who consumed the specific food group during the recall period.

Statistical analysis

IBM SPSS version 27 was used for statistical analyses (IBM Corp, Armonk, NY, USA). The data were tested for normality using the Shapiro–Wilks test. As the data were not normally distributed, results are reported as the median and interquartile range (25th and 75th percentiles). To compare the differences between consumers (consumed at least one food from the food group during the recall period) and non-consumers (did not consume any food from the food group during the recall period) of different food groups, the Mann–Whitney *U* test was used. For each food group, Spearman correlation analysis was done between kilojoule (kJ) provided by the food group and the MAR. For all analyses, the significance was set at $p < 0.05$.

Ethical consideration

This study was approved by the Human Research Ethics Committee of North-West University (NWU-00258-21-A1). For the study to be done in the community, approval was sought through community-based structures. Mothers/caregivers gave informed consent before any study processes started.

Table 2: Sociodemographic and household characteristic of study participants

Characteristics	Total ($n = 155$)
Infants:	
Age (months), median (IQR)	7 (6, 8)
Gender: Males, *n* (%)	78 (50.3)
Females, *n* (%)	77 (49.7)
Mother/caregiver:	
Relationship to infant: Mother, *n* (%)	145 (93.5)
Other (father, grandma, aunt), *n* (%)	10 (6.5)
Age (years), median (IQR)	28 (24; 33)
Education, Grade 10 or higher, *n* (%)	125 (80.6)
Married, *n* (%)	14 (9.0)
Household:	
Number of people in household; median (IQR)	6 (4; 7)
People in household employed (median, IQR)	1 (0; 1)
People in household receiving child grant (median, IQR)	2 (2; 3)
Flush toilet at home, *n* (%)	139 (89.7)
Tap water at home,[a] *n* (%)	144 (94.1)
Electricity inside the home, *n* (%)	134 (86.5)

[a]Either inside (34.6%) or outside (59.5%) the house, missing $n = 2$.

Results

Sociodemographic and household characteristics

A total of 155 participants were enrolled in the study (Table 2). The median age of the infants was 7 months; 50.3% of infants were males and 49.7% females. The interviewees were mostly the mother of the infant (93%), only (9%) were married and most (80.6%) had an education level of grade 10 or higher. The median age of the mothers/caregivers was 28 and the median number of people in the household was 6. Most households had access to electricity (86.4%) and to tap water either inside (34.6%) or outside (59.5%) their home.

In total, 43% of the infants had been introduced to solid foods at age 3 months or younger. Commercial infant cereal was the most commonly given first solid food (> 50% of infants).

Total dietary intake

From the 155 infants enrolled in the study, dietary intake was not available for 11 infants as they were not in full-time care of the respondent during the full 24-hour recall period. Dietary intake data were therefore available for 144 infants. Total energy, macro- and micro-nutrient intakes are summarised in Table 3. Iron and zinc intakes were below the EAR for 58.3% and 27.1% of infants, respectively. For all the other micronutrients, except for niacin, median intake was above the AI value, and therefore the likelihood of these nutrients being deficient in the diet is assumed to be low. The median MAR of 0.9 suggest the probability of the diet being inadequate for some micronutrients as it did not reach 1.

Food group consumption

Figure 1 shows the consumption of different food groups by infants during the recall period. The most consumed food

Table 3: Median intakes and interquartile ranges for total energy and nutrient intakes for infants at age 6 to <9 months ($n = 144$)

Nutrient	DRI 6–12 months	Median (IQR) % < EAR
Energy (kJ)	See note[a]	3 030 (2 601; 3 587)
Protein (g)	1.0 (g/kg)[b]	15.0 (11.0; 20.3)
Fat (g)	30[b]	33.5 (29.5; 37.6)
Carbohydrates (g)	95[c]	91 (75.4; 116.8)
Calcium (mg)	260[d]	424 (317; 553)
Iron (mg)	6.9[b]	6.0 (2.7; 9.7) 58.3%
Zinc (mg)	2.5[b]	3.4 (2.4; 5.2) 27.1%
Vitamin A (µg RE)	500[c]	663 (518; 857)
Thiamine (mg)	0.3[c]	0.5 (0.3; 0.9)
Riboflavin (mg)	0.4[c]	0.6 (0.4; 0.9)
Niacin (mg)	4[c]	3.9 (2.6; 5.7)
Vitamin B6 (mg)	0.3[c]	0.4 (0.2; 0.6)
Folate (µg)	80[c]	95.4 (63.2; 158.6)
Vitamin B12 (µg)	0.5[c]	1.0 (0.5; 1.4)
Vitamin C (mg)	50[c]	69.7 (49.5; 96.4)
MAR	1	0.9 (0.8; 1.0)

DRI: dietary reference intakes; g: grams; mg: milligram; µg: microgram; IQR: interquartile range; MAR: Mean adequacy ratio; RE: retinol equivalents.
[a]Energy intake in kilojoules of the US DRI published by the Institute of Medicine.[23] age 6 months (boys 2 709; girls 2 535).
[b]EAR of the US DRI published by the Institute of Medicine.[22]
[c]AI of the US DRI published by the Institute of Medicine.[22]
[d]AI of the US DRI published by the Institute of Medicine for calcium and vitamin D.[24]

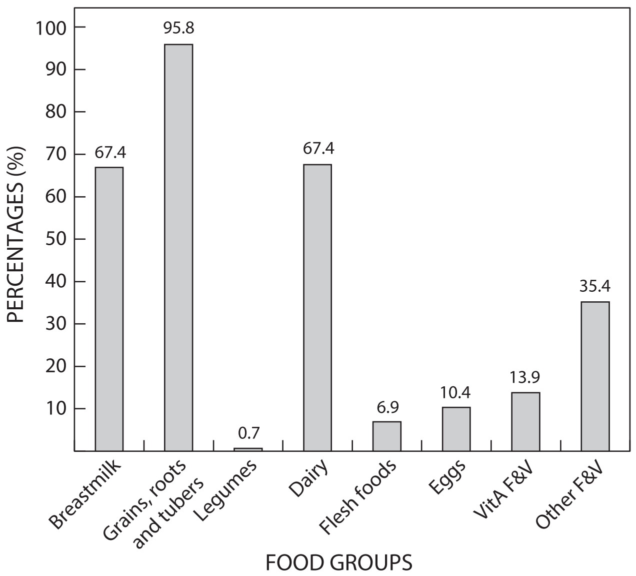

Figure 1: Percentage of infants who consumed different food groups on the day of recall ($n = 144$). 'Grains, roots, and tubers' include infant cereals; dairy includes formula milk; F&V: fruits and vegetables.

group was 'grains, roots, and tubers' (95.8%; $n = 138$), followed by breast milk (67.4%; $n = 97$). The least consumed food groups were legumes (0.7%; $n = 1$), flesh foods (6.9%; $n = 10$), eggs (10.4%; $n = 15$) and vitamin A-rich fruits and vegetables (13.9%, $n = 20$). Most infants ate either two (29.2%) or three (42.4%) food groups on the day of recall. Only 6.3% infants reached the MDD (at least five groups).

Because of the small number of infants per food group, the legume group was excluded from all further analysis, while flesh foods and eggs were combined to create the animal-source foods (ASFs) group (16.7%; $n = 24$), and vitamin A-rich fruits and vegetables were combined with the other fruits and vegetables group to create the fruits and vegetables group (42.4%; $n = 61$). The further analysis, therefore, included only five food groups.

Percentage contribution of different food groups towards total intake of consumers

The percentage contribution of each of the five food groups towards the total energy and nutrient intake of consumers is listed in Table 4.

Breast milk was consumed during the recall period by 97 (67.4%) infants and based on an estimated intake of 675 ml[20] contributed 63.9% of total energy, 49.2% of protein and 82.5% of fat intake. For consumers thereof, breast milk was estimated to contribute to at least 50% of intake for vitamin A, calcium and vitamin C; 40–50% for zinc, riboflavin, folate and vitamin B12; and 36.9% for niacin.

'Grains, roots, and tubers' were consumed during the recall period by 138 (95.8%) infants and contributed 23.6% of energy intake. For consumers thereof, 'grains, roots, and tubers' contributed mostly to intakes of iron (75.4%), followed by thiamine (53.0%), niacin, vitamin B6 and folate (40–50%) and zinc (37.6%).

Dairy, which includes formula milk, was consumed during the recall period by 97 (67.4%) infants. For consumers thereof, dairy contributed 21.1% of energy and 38.5% of protein intake; at least 50% of intake for riboflavin and vitamin B12; 48.1% for calcium; and 30–40% for zinc, thiamine and vitamin B6.

ASFs were consumed during the recall period by 24 (16.7%) infants. For consumers thereof, ASFs contributed 10.0% of energy, 33.4% of protein and 42.8% of vitamin B12 intake.

Fruits and vegetables were consumed during the recall period by 61 (42.4%) and contributed 5.9% of total energy intake. For consumers thereof, the contribution of fruits and vegetables to total intake was less than 20% for all micronutrients. For those who consumed vitamin A-rich fruits and vegetables, the vitamin A contribution was 23.7%.

Table 4: Percentage contribution of different food groups towards total energy and nutrient intake of consumers at age 6 to <9 months

Factor	Breast milk ($n = 97$) Median (IQR)	Grains, roots and tubers ($n = 138$) Median (IQR)	Dairy ($n = 97$) Median (IQR)	Animal-source foods[a] ($n = 24$) Median (IQR)	Fruits and vegetables ($n = 61$) Median (IQR)
Energy	63.9 (55.8; 73.9)	23.6 (16.7; 32.1)	21.1 (11.5; 52.6)	10.0 (5.4; 15.7)	5.9 (3.6; 14.7)
Protein	49.2 (39.9; 65.6)	25.5 (16.8; 38.5)	38.5 (18.7; 63.3)	33.4 (21.3; 40.4)	4.2 (1.7; 7.4)
Fat	82.5 (76.2; 93.1)	4.6 (2.3; 9.1)	20.7 (9.8; 76.7)	15.5 (5.4; 31.5)	0.3 (0.1; 0.7)
Carbohydrates	51.0 (40.3; 61.1)	36.6 (27.3; 46.2)	20.9 (10.4; 42.9)	0.5 (0.2; 1.1)	10.7 (5.8; 24.2)
Calcium	57.1 (42.5; 69.7)	22.5 (8.6; 35.0)	48.1 (27.8; 81.6)	2.8 (0.8; 6.9)	1.5 (0.6; 3.5)
Iron	4.8 (2.8; 9.2)	75.4 (46.9; 87.8)	24.8 (6.3; 50.3)	19.2 (7.2; 35.8)	4.9 (1.8; 9.1)
Zinc	41.8 (31.8; 52.0)	37.6 (24.1; 51.2)	37.4 (17.1; 64.4)	15.2 (9.6; 24.5)	3.3 (1.6; 7.3)
Vitamin A	62.3 (48.3; 78.0)	21.7 (11.0; 35.6)	22.5 (11.1; 63.3)	6.4 (1.2; 12.3)	3.4 (0.6; 27.2)
Thiamine	4.0 (2.3; 6.0)	53.0 (37.3; 70.7)	32.2 (10.5; 57.2)	8.5 (4.5; 21.9)	4.9 (2.0; 9.3)
Riboflavin	44.9 (32.3; 60.2)	22.0. (12.5; 36.6)	52.4 (30.5; 76.1)	17.5 (6.3; 36.3)	4.0 (1.4; 7.6)
Niacin	36.9 (25.1; 51.0)	46.9 (31.7; 60.7)	27.6 (5.5; 53.1)	3.3 (0.9; 27.2)	8.1 (3.1; 14.4)
Vitamin B6	21.6 (14.9; 32.0)	49.0 (29.0; 65.7)	33.1 (15.9; 55.9)	7.6 (3.0; 17.5)	16.0 (6.5; 35.4)
Folate	41.5 (30.6; 55.5)	42.5 (27.0; 63.0)	24.4 (8.5; 52.0)	11.8 (0.1; 25.2)	1.3 (0.0; 5.0)
Vitamin B12	42.3 (28.8; 73.4)	5.0 (0.0; 32.0)	55.0 (32.4; 81.9)	42.8 (30.2; 70.9)	0
Vitamin C	53.8 (37.4; 70.2)	31.8 (15.0; 48.7)	21.2 (3.6; 54.8)	0	17.3 (4.9; 32.2)

IQR: interquartile range.
[a]Animal source foods are a combination of flesh foods and eggs.

Total nutrient intake for consumers versus non-consumers of different food groups

Nutrient intakes for consumers and non-consumers of different food groups are reported in Table 5. Only six infants did not consume any food from the 'grains, roots, and tubers' food group; intakes for consumers and non-consumers are therefore not reported. Consumers of breast milk had significantly ($p < 0.05$) higher intakes for energy and fat, but lower intakes for all micro-nutrients, except for vitamin A, compared with non-consumers. Consumers of dairy had significantly ($p < 0.05$) higher intakes for fat and all micronutrients compared with non-consumers. Consumers of ASFs had significantly ($p < 0.05$) higher intakes for energy, protein, fat, riboflavin, niacin and vitamin B12 compared with non-consumers. Lastly, consumers of fruits and vegetables had significantly ($p < 0.05$) higher intakes for vitamin A, vitamin B6 and vitamin C compared with non-consumers.

Nutrient densities for consumers and non-consumers of different food groups

The median and interquartile range for nutrient densities (amount of specific nutrient per 418kJ) for consumers and non-consumers are reported in Table 6. Only six infants did not consume any food from the 'grains, roots, and tubers' food group; nutrient densities for consumers and non-consumers are therefore not reported. Infants who received breast milk had significantly ($p < 0.05$) lower nutrient densities for protein and all micronutrients compared with infants who did not receive breast milk. Those who consumed dairy had significantly ($p < 0.05$) higher nutrient densities for protein and all micronutrients except vitamin A when compared with non-consumers. Consumers of ASFs had significantly ($p < 0.05$) higher nutrient densities for protein and vitamin B12 and significantly lower nutrient density for vitamin C compared with non-consumers. Consumers of fruits and vegetables had significantly ($p < 0.05$) higher nutrient densities for vitamin A and vitamin C when compared witho non-consumers.

Association of food group consumption and nutrient adequacy

The association between kilojoules provided by each food group respectively and the MAR is summarised in Table 7. MAR was positively correlated with two food groups, respectively ('grains, roots, and tubers'; and dairy; $p < 0.001$), suggesting that a higher intake of these two food groups is associated with higher micronutrient adequacy of the diet.

Discussion

In this paper, we describe the contribution of different food groups to dietary intake for energy, macro- and micronutrients in infants 6 to <9 months of age from a low socioeconomic community in North West province. Most infants consumed either two or three of the eight food groups on the day of recall; and only 6.3% reached the MDD. The most consumed food group was 'grains, roots, and tubers', followed by breast milk and dairy. The least consumed food groups were legumes, flesh foods and eggs, which is similar to the findings of previous studies done in different parts of South Africa.[13,14]

For consumers thereof, 'grains, roots, and tubers' contributed about a quarter of total energy intake and at least a third of the intake for various micronutrients. This food group includes fortified infant cereals as well as fortified maize meal, both of which are frequently consumed during infancy in South Africa.[17,26] According to legislation, maize meal and wheat flour are fortified with eight micronutrients as part of the National Fortification Programme.[27] Findings from a previous study done in the same area showed that for consumers thereof, maize meal contributed more than a third of total intake for iron, zinc, vitamin A, and folate at age 12 months, and infant cereals contributed more than 50% of total intake for iron and thiamine at age 6 months.[18] The significant contribution of the 'grains, roots, and tubers' food group to the intake of micronutrients such as iron, thiamine, niacin, vitamin B6 and folate can therefore be attributed, at least to a large extent, to fortified maize meal and infant cereals.

The 'grains, roots, and tubers' group provided 75% of total iron intake. Although this food group was consumed by 95.8% of the study sample and included fortified maize meal/wheat flour and fortified infant cereal, more than half of the infants had an iron intake below the EAR, highlighting the difficulty of meeting iron requirements at this age. Findings from a study in Indonesia showed that consuming fortified infant foods was associated with lower dietary diversity, which limits infants' exposure to foods of differing textures and flavours, and over-reliance on fortified foods should thus be avoided.[28]

During the recall period, 67.4% of the study sample received breast milk. This is very similar to breastfeeding rates reported for 6-month-old infants in North West province (71%)[18] and 9 month-old infants in the Western Cape (60%).[13] It should, however, be noted that the WHO recommends continued breastfeeding up to age 2 years or beyond.[29]

For consumers thereof and based on an estimated intake of 675 ml,[20] breast milk was the major contributor of energy and fat intake, and contributed significantly to intakes of protein, calcium, vitamin A intake zinc, riboflavin and folate. These findings are similar to those found in Mexico[30] and China[31] for infants 6–11 months of age. However, intakes of all micronutrients, except vitamin A, were significantly lower while energy intake was significantly higher for consumers of breast milk compared with non-consumers, resulting in lower micronutrient densities. Although it is recommended that breastfeeding should be continued up to age 2 years or beyond, it is important to introduce nutrient-dense foods that will fill nutrient gaps after the age of 6 months.[2]

Dairy was consumed by 67.4% of infants during the recall period. For those who consumed dairy (including formula milk), this contributed to nearly half of calcium and riboflavin intake; and, compared with non-consumers, the nutrient densities were higher for all micronutrients except for vitamin A. Inclusion of formula milk in this food group probably contributed to the higher nutrient density of micronutrients for consumers thereof. Furthermore, results of the study showed that higher consumption of dairy is associated with higher micronutrient adequacy of the diet. The substantial contribution of dairy to nutrient intake was also reported for a study in Ethiopia,[32] which showed dairy to be the main contributor of protein, vitamin A, vitamin C and calcium.

Although dairy contributed nearly half of calcium intake, the median calcium intake for the total sample was substantially lower than the AI. In a previous study in the same area, 75% of 12- to 18-month-old children had low intakes of calcium,[18] while nutrient density of the complementary diet was low for calcium for nearly all 6- to 17-month-old breastfeeding children in a study in KwaZulu-Natal.[14] Low intake of calcium intake has been

Table 5: Total energy and nutrient intake of consumers versus non-consumers of different food groups at age 6–9 months[a]

	Breast milk			Dairy		
Factor	**Consumers ($n = 97$) Median (IQR)**	**Non-consumers ($n = 47$) Median (IQR)**	***p*-value[b]**	**Consumers ($n = 97$) Median (IQR)**	**Non-consumers ($n = 47$) Median (IQR)**	***p*-value[b]**
Energy (kJ)	3 132 (2 718; 3 587)	2 642 (1 944; 3 656)	**< 0.001**	3 141 (2 636; 3 751)	2 861 (2 445; 3 296)	0.051
Protein (g)	14.1 (10.5; 17.4)	17.6 (12.8; 23.5)	**0.023**	16.7 (13.7; 22.5)	11.0 (9.7; 15.5)	**< 0.001**
Fat (g)	35.8 (32.0; 38.7)	20.5 (13.9; 29.9)	**< 0.001**	33.8 (21.4; 38.1)	32.2 (30.8; 36.1)	0.826
Carbohydrates (g)	91.0 (76.0; 115.3)	91.9 (73.8; 117.6)	0.740	96.9 (72.4; 119.2)	84.1 (65.8; 97.0)	**0.004**
Calcium (mg)	378 (312; 508)	538 (415; 846)	**< 0.001**	495 (400; 593)	310 (244; 377)	**< 0.001**
Iron (mg)	4.2 (2.1; 7.0)	10.0 (6.8; 15.0)	**< 0.001**	7.1 (4.2; 11.4)	2.9 (1.6; 5.5)	**< 0.001**
Zinc (mg)	2.7 (2.2;3.6)	5.3 (3.6; 8.2)	**< 0.001**	4.2 (3.3; 5.9)	2.2 (1.6; 2.6)	**< 0.001**
Vitamin A (µg RE)	662 (529; 854)	670 (485; 870)	0.425	693 (542; 894)	592 (498; 781)	**0.038**
Thiamine (mg)	0.4 (0.2; 0.6)	0.9 (0.6; 1.3)	**< 0.001**	0.7 (0.4; 1.1)	0.3 (0.2; 0.5)	**< 0.001**
Riboflavin (mg)	0.5 (0.4; 0.7)	1.1 (0.7; 1.5)	**< 0.001**	0.8 (0.6; 1.1)	0.4 (0.3; 0.4)	**< 0.001**
Niacin (mg)	3.2 (2.3; 4.7)	5.2 (3.5; 7.3)	**< 0.001**	4.6 (3.1; 6.4)	2.8 (1.8; 4.0)	**< 0.001**
Vitamin B6 (mg)	0.3 (0.2; 0.4)	0.6 (0.5; 0.9)	**< 0.001**	0.5 (0.3; 0.7)	0.2 (0.1; 0.4)	**< 0.001**
Folate (µg)	81.3 (60.7; 110.1)	146.7 (81.3; 210.2)	**< 0.001**	110.0 (72.2; 185.2)	71.6 (54.5; 96.6)	**< 0.001**
Vitamin B12 (µg)	0.7 (0.4; 1.8)	1.4 (0.9; 2.0)	**< 0.001**	1.2 (0.8; 1.7)	0.4 (0.3; 0.7)	**< 0.001**
Vitamin C (mg)	63.7 (48.0; 90.0)	89.3 (58.7; 121.2)	**0.006**	80.0 (55.9; 98.2)	57.7 (43.2; 77.1)	**0.004**
	Animal-source foods			**Fruits and vegetables**		
Factor	**Consumers ($n = 24$) Median (IQR)**	**Non-consumers ($n = 120$) Median (IQR)**	***p*-value[b]**	**Consumers ($n = 61$) Median (IQR)**	**Non-consumers ($n = 83$) Median (IQR)**	***p*-value[b]**
Energy (kJ)	3 517 (2 996; 4 057)	2 974 (2 437; 3 539)	**< 0.002**	3 132 (2 623; 3 814)	3 007 (2 445; 3 406)	0.077
Protein (g)	23.1 (17.5; 30.0)	14.8 (10.3; 17.4)	**< 0.001**	15.8 (11.0; 21.0)	14.6 (10.9; 19.6)	0.228
Fat (g)	39.0 (34.6; 46.1)	32.1 (28.6; 36.8)	**< 0.001**	33.7 (29.6; 37.6)	33.5 (29.5; 37.8)	0.933
Carbohydrates (g)	96.5 (77.1; 131.2)	89.5 (75.4; 116.2)	0.363	96.8 (79.6; 125.3)	86.7 (73.8; 111.9)	**0.009**
Calcium (mg)	472 (350; 559)	421 (312; 552)	0.268	455 (328; 548)	410 (310; 558)	0.444
Iron (mg)	5.8 (3.9; 9.2)	6.2 (2.4; 9.7)	0.663	6.5 (3.7; 9.7)	5.2 (2.4; 10.8)	0.520
Zinc (mg)	3.4 (2.9; 9.2)	3.3 (2.3;5.1)	0.067	3.4 (2.4; 5.0)	3.3 (2.3; 5.3)	0.829
Vitamin A (µg RE)	599 (517; 1034)	668 (520; 847)	0.911	720 (588; 1018)	594 (504; 783)	**< 0.002**
Thiamine (mg)	0.5 (0.3; 1.1)	0.5 (0.3; 0.9)	0.663	0.6 (0.3; 0.9)	0.5 (0.3; 0.8)	0.359
Riboflavin (mg)	0.8 (0.5; 1.3)	0.6 (0.4; 0.9)	**0.016**	0.7 (0.4; 1.0)	0.6 (0.4; 0.9)	0.334
Niacin (mg)	5.8 (3.4; 8.0)	3.6 (2.5; 5.3)	**0.008**	4.3 (2.8; 6.4)	3.5 (2.4; 5.3)	0.091
Vitamin B6 (mg)	0.5 (0.2; 0.9)	0.4 (0.2; 0.6)	0.058	0.5 (0.3; 0.7)	0.3 (0.2; 0.6)	**0.018**
Folate (µg)	102.4 (75.4; 152.8)	90.9 (60,9; 161.9)	0.358	108.9 (62.9; 117.8)	90.3 (63.2; 152.7)	0.450
Vitamin B12 (µg)	1.9 (1.1; 3.7)	0.8 (0.4; 1.2)	**< 0.001**	1.0 (0.5; 1.5)	0.9 (0.5; 1.4)	0.787
Vitamin C (mg)	57.2 (41.4; 95.1)	71.9 (51.2; 96.4)	0.233	81.3 (59.9; 119.2)	58.2 (43.8; 90.1)	**< 0.001**

IQR: interquartile range; g: grams; mg: milligram, µg: microgram RE: retinol equivalent.
[a]Consumers are those infants that consumed food groups on the day of recall. Non-consumers are those infants that did not consume food groups on the day of recall.
[b]$P < 0.05$ indicates significant differences and is formatted in bold type; consumers and non-consumers were compared using the Mann–Whitney *U* test.

shown to be associated with stunting in 2- to 5-year-old children,[33] and the authors contributed this association to low intake of milk.

Fruits and vegetables were consumed during the recall period by 42.4% of the infants. For consumers thereof, the contribution to total intake was low: 16.0% for vitamin B6 and 17.3% for vitamin C. In total, 13.9% of infants consumed vitamin A-rich fruits and vegetables during the recall period, contributing 23.7% of their vitamin A intake. Despite these low contributions to nutrient intake, consumers of fruits and vegetables had significantly higher intakes for vitamin A, vitamin B6 and vitamin C, and significantly higher nutrient densities for vitamin A and vitamin C, compared with non-consumers.

The early introduction of fruits and vegetables has been shown to be correlated with a higher consumption thereof throughout childhood.[34] Although the revised South African Paediatric Food-Based Dietary Guidelines recommend that from age 6–12 months children should be given dark-green leafy vegetables and orange-fleshed vegetables and fruits every day,[35] cost is a barrier for consumption of fruits and vegetables.[36] It has been suggested that promoting home-produced or wild-harvested dark-green leafy vegetables,[37] such as spinach and African leafy vegetables, and indigenous plants[38] as a complementary food is a low-cost strategy to improve micronutrient intake of children.

ASFs are nutrient-dense foods and contain multiple micronutrients (iron, zinc, vitamin A and vitamin B12) that can improve the micronutrient density of the complementary diet.[39,40] Only a small proportion of infants consumed ASFs. For consumers, ASFs contributed only 10% of energy intake, but nearly half of vitamin B12 and protein intake; and when compared with non-consumers, consumers had significantly higher intakes for both micronutrients. Although the contribution of ASFs to

Table 6: Median (interquartile range) for micronutrient density (amount per 418 kJ) between consumers and non-consumers of different food groups at age 6–9 months

	Breast milk			Dairy		
Factor	**Consumers ($n = 97$) Median (IQR)**	**Non-consumers ($n = 47$) Median (IQR)**	***p*-value[a]**	**Consumers ($n = 97$) Median (IQR)**	**Non-consumers ($n = 47$) Median (IQR)**	***p*-value[a]**
Protein (g/418 kJ)	1.80 (1.60; 2.15)	2.83 (2.44; 3.12)	< **0.001**	2.38 (1.91; 2.86)	1.70 (1.45; 1.88)	< **0.001**
Calcium (mg/418 kJ)	50.41 (43.61; 61.56)	89.21 (67.10; 107.15)	< **0.001**	66.45 (52.91; 90.38)	46.29 (40.10; 55.59)	< **0.001**
Iron (mg418 kJ)	0.50 (0.30; 0.86)	1.51 (1.13; 2.14)	< **0.001**	1.04 (0.49; 1.59)	0.49 (0.26; 0.82)	< **0.001**
Zinc (mg/ 418 kJ)	0.37 (0.31; 0.45)	0.80 (0.70; 1.05)	< **0.001**	0.59 (0.40; 0.81)	0.31 (0.27; 0.35)	< **0.001**
Vitamin A (µg RE/418 kJ)	85.04 (75.42; 104.43)	100.49 (83.36; 119.40)	< **0.001**	94.76 (78.29;114.14)	86.17 (70.10; 105.22)	0.352
Thiamine (mg/418 kJ)	0.05 (0.03; 0.07)	0.16 (0.13; 0.18)	< **0.001**	0.09 (0.06; 0.16)	0.05 (0.03; 0.06)	< **0.001**
Riboflavin (mg/418 kJ)	0.07 (0.05; 0.08)	0.17 (0.13; 0.22)	< **0.001**	0.11 (0.08; 0.17)	0.05 (0.05; 0.06)	< **0.001**
Niacin (mg/418 kJ)	0.44 (0.35; 0.57)	0.82 (0.66; 1.01)	< **0.001**	0.62 (0.45; 0.82)	0.39 (0.32; 0.51)	< **0.001**
Vitamin B6 (mg/418 kJ)	0.04 (0.03; 0.06)	0.10 (0.09; 0.12)	< **0.001**	0.07 (0.04; 0.10)	0.03 (0.03; 0.05)	< **0.001**
Folate (µg/418 kJ)	10.45 (8.49; 13.82)	20.36 (13.86; 28.24)	< **0.001**	14.56 9.96; (23.87)	9.77 (8.26; 13.06)	< **0.001**
Vitamin B12 (µg/418 kJ)	0.09 (0.06; 0.14)	0.22 (0.19;0.29)	< **0.001**	0.16 (0.12; 0.23)	0.07 (0.05; 0.09)	< **0.001**
Vitamin C (mg/418 kJ)	8.89 (6.40; 11.22)	13.42 (10.61; 16.90)	< **0.001**	10.78 (7.72; 13.88)	9.16 (6.41; 11.27)	**0.024**

	Animal-source foods			Fruits and vegetables		
Factor	**Consumers ($n = 24$) Median (IQR)**	**Non-consumers ($n = 120$) Median (IQR)**	***p*-value[a]**	**Consumers ($n = 61$) Median (IQR)**	**Non-consumers ($n = 83$) Median (IQR)**	***p*-value[a]**
Protein (g/418 kJ)	2.92 (2.38; 3.13)	1.94 (1.63; 2.43)	< **0.001**	2.04 (1.65; 2.69)	2.08 (1.76; 2.84)	0.886
Calcium (mg/418 kJ)	51.26 (43.11; 65.52)	60.84 (47.78; 79.09)	0.148	56.52 (47.97; 77.09)	58.48 (46.80; 74.96)	0.620
Iron (mg/418 kJ)	0.68 (0.46; 1.07)	0.81 (0.39; 1.50)	0.641	0.79 (0.44; 1.25)	0.77 (0.38; 1.51)	0.960
Zinc (mg/418 kJ)	0.43 (0.37; 0.61)	0.44 (0.32; 0.71)	0.513	0.40 (0.32; 0.72)	0.45 (0.35; 0.71)	0.377
Vitamin A (µg RE/418 kJ)	79.50 (59.40; 112.32)	93.99 (78.46; 112.33)	0.063	98.00 (77.87; 140.39)	87.85 (75.50; 105.04)	**0.046**
Thiamine (mg/418 kJ)	0.05 (0.04; 0.09)	0.06 (0.04; 0.14)	0.376	0.06 (0.05; 0.13)	0.06 (0.04; 0.14)	0.940
Riboflavin (mg/418 kJ)	0.09 (0.07; 0.16)	0.08 (0.06; 0.13)	0.247	0.08 (0.06; 0.15)	0.08 (0.06; 0.13)	0.950
Niacin (mg/418 kJ)	0.56 (0.47; 0.87)	0.51 (0.38; 0.75)	0.173	0.56 (0.39; 0.78)	0.51 (0.37; 0.76)	0.436
Vitamin B6 (mg/418 kJ)	0.07 (0.03; 0.09)	0.05 (0.03; 0.09)	0.664	0.06 (0.04; 0.09)	0.05 (0.03; 0.09)	0.132
Folate (µg/418 kJ)	11.74 (9.16; 21.46)	11.96 (9.13; 19.53)	0.768	11.87 (8.64; 21.23)	11.86 (9.21; 19.58)	0.720
Vitamin B12 (µg/418 kJ)	0.22 (0.13; 0.42)	0.12 (0.07;0.19)	< **0.001**	0.12 (0.07; 0.22)	0.14 (0.08; 0.20)	0.641
Vitamin C (mg/418kj)	8.04 (5.46; 10.39)	10.71 (7.43; 13.67)	< **0.004**	10.96 (8.51; 14.37)	9.51 (6.20; 12.50)	**0.007**

IQR: interquartile range; g: grams; mg: milligram, µg: microgram RE: retinol activity equivalent. [a]*P*-value < 0.05 indicates a significant difference between consumers and non-consumers.

Table 7: Association of different food group consumption with the mean adequacy ratio for those who consumed the food group on the day of recall

Association	r_s	*p*-value
Grains, roots and tubers kJ ($n = 138$) and MAR	0.518	**<0.001**
Dairy kJ ($n = 97$) and MAR	0.483	**<0.001**
ASFs kJ ($n = 24$) and MAR	0.023	0.916
Fruits and vegetable kJ ($n = 61$) and MAR	0.052	0.693

r_s = Spearman's correlation coefficient; $p < 0.05$ indicates a significant correlation.

iron intake was relatively low (19.2%) for consumers, probably because of small amounts eaten, the bioavailability of iron is high. ASFs are a rich source of highly bioavailable heme-iron,[41] and could be beneficial in increasing the availability of iron in the diet and maintaining iron stores in breastfed infants.[42] The low intake of iron in this age group is of concern, as lack of iron in the diet is one of the biggest causes of iron deficiency, which is associated with poor cognitive outcomes, infections and growth faltering.[43,44]

Furthermore, vitamin B12 is important for brain development and cognitive function.[45] ASFs, together with breast milk and dairy, are needed to meet the infant's requirements for vitamin B12, which is not found naturally in plant foods.[39] A study in India showed that little or no consumption of ASFs is associated with stunting and poor linear growth in children 6–23 months of age.[46] Consumption of ASF in LMICs, however, remains low, with cultural issues and affordability being the common driver for their low consumption.[37,39] The most affordable nutrient-dense locally available food sources of multiple key micronutrients in South Africa include beef liver, chicken liver, small fish, milk and eggs.[37]

Although this study showed that the consumption of the 'grains, roots, and tubers' group and the dairy group respectively were associated with higher micronutrient adequacy of total dietary intake, it is important to note that the consumption of different food groups is needed to improve the micronutrient adequacy and nutrient density of the complementary diet of children 6–23 months of age.[47] The consumption of different food groups is regarded as a good predictor for dietary quality and nutrient adequacy.[10,47] To achieve minimum dietary diversity, five out of the eight food groups should be consumed;[11] this was achieved for only 6.3% of the infants in the study. Identifying the most affordable food sources within each of the food groups could assist caregivers to make better food choices,[37] which may contribute to higher dietary diversity.

This study provides insight into the contribution of different food groups to nutrient intake at this young age (6–9 months), which is considered a critical time during the complementary feeding period. The study does, however, have some limitations. First, the sample size is small as recruitment had to be stopped because of COVID-19 lockdown regulations. Second, the use of a 24-hour recall does not account for day-to-day variations,[48] and quantifying breast-milk intake is challenging. Although breast-milk intake can be measured accurately using the deuterium oxide dose-to-mother technique,[49] this is not practical in a community-based research setting. Age-specific average breast-milk intake values and average nutrient content values for breast milk have been used in other studies.[50,51] It is, however, acknowledged that the nutrient content of breast milk may be influenced by factors such maternal dietary intake and maternal nutritional status.[52] It is therefore important that dietary intake data be interpreted within the context of the inherent limitations of dietary assessment.[48]

In conclusion, 'grains, roots, and tubers', dairy and breast milk were the most consumed food groups and made a substantial contribution to energy and nutrient intakes. Animal-source foods were consumed by < 20% of infants but made a substantial contribution to key nutrients for those who consumed ASF. Strategies to improve dietary diversity should encourage continued breastfeeding, aim to increase the intake of less frequently consumed food groups and promote locally available food as complementary food.

Acknowledgements – The authors would like to thank the members of the Eggcel-growth study team, parents/guardians of the infants who participated in the study and the fieldworkers who helped with data collection.

Disclosure statement – No potential conflict of interest was reported by the authors.

Funding – The study was funded by the DG Murray Trust (DGMT). The funder had no influence on the study design, data collection, analysis, or interpretation of data, writing of the manuscript or the decision to submit the manuscript for publication.

Author contributions – TM was involved in field data collection, data analysis and interpretation of results, and drafted the paper. CMS was the principal investigator of the Eggcel-growth study, provided training, gave guidance on data collection, quality control and analysis, academic input and review of the paper. HA was the project coordinator and supervised field data collection and quality control. MF provided training on dietary assessment, gave guidance on data collection, quality control and analysis, academic input and review of the paper. All authors read and approved the final manuscript.

ORCID

Tshiphiri Mukwevho http://orcid.org/0000-0003-2795-8713
Cornelius M Smuts http://orcid.org/0000-0003-4829-0054
Hannah Asare http://orcid.org/0000-0003-0656-503X
Mieke Faber http://orcid.org/0000-0002-8878-254X

References

1. Du Plessis LM, Kruger H, Sweet L. Complementary feeding: a critical window of opportunity from six months onwards. S Afr J Clin Nutr. 2013;26(Suppl 1):S129–S40. http://sajcn.co.za/index.php/SAJCN/article/view/757
2. Dewey KG. The challenge of meeting nutrient needs of infants and young children during the period of complementary feeding: an evolutionary perspective. J Nutr. 2013;143(12):2050–4. https://doi.org/10.3945/jn.113.182527
3. Gibson RS, Bailey KB, Gibbs M, et al. A review of phytate, iron, zinc, and calcium concentrations in plant-based complementary foods used in low-income countries and implications for bioavailability. Food Nutr Bull. 2010;31(2 Suppl):S134–S46. https://doi.org/10.1177/15648265100312S206
4. Vossenaar M, Hernández L, Campos R, et al. Several 'problem nutrients' are identified in complementary feeding of Guatemalan infants with continued breastfeeding using the concept of 'critical nutrient density'. Eur J Clin Nutr. 2013;67(1):108–14. https://doi.org/10.1038/ejcn.2012.170
5. Black RE, Cousens S, Johnson HL, et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet. 2010;375(9730):1969–87. https://doi.org/10.1016/S0140-6736(10)60549-1

6. Dewey KG, Mayers DR. Early child growth: how do nutrition and infection interact? Matern Child Nutr. 2011;7(Suppl 3):129–42. https://doi.org/10.1111/j.1740-8709.2011.00357.x
7. Dewey KG, Vitta BS. Strategies for ensuring adequate nutrient intake for infants and young children during the period of complementary feeding. A&T Technical Brief Issue 7, November 2013. Available from: https://www.aliveandthrive.org/sites/default/files/attachments/Insight-Issue-7_Ensuring-Adequate-Nutrition.pdf.
8. Dafursa K, Gebremedhin S. Dietary diversity among children aged 6-23 months in Aleta Wondo District, Southern Ethiopia. J Nutr Metab. 2019;2019:2869424. https://doi.org/10.1155/2019/2869424
9. Habte TY, Krawinkel M. Dietary diversity score: a measure of healthy diet. J Nutr Health Sci. 2016;3(3):303. https://doi.org/10.15744/2393-9060.3.303
10. Diop L, Becquey E, Turowska Z, et al. Standard minimum dietary diversity indicators for women or infants and young children are good predictors of adequate micronutrient intakes in 24-59-month-old children and their nonpregnant nonbreastfeeding mothers in rural Burkina Faso. J Nutr. 2021;151(2):412–22. https://doi.org/10.1093/jn/nxaa360
11. WHO (World Health Organization) / UNICEF (United Nations Children's Fund). Indicators for assessing infant and young child feeding practices: definitions and measurement methods. 2021 [Available from: https://www.who.int/publications/i/item/9789240018389.
12. Alamu EO, Gondwe T, Eyinla TE, et al. Assessment of dietary diversity of mothers and children of 6–24 months from eastern and southern provinces of Zambia. J Nutr Metab. 2019;2019(1):9. https://doi.org/10.1155/2019/1049820
13. Budree S, Goddard E, Brittain K, et al. Infant feeding practices in a South African birth cohort-A longitudinal study. Matern Child Nutr. 2017;13(3):e12371. https://doi.org/10.1111/mcn.12371
14. Faber M, Laubscher R, Berti C. Poor dietary diversity and low nutrient density of the complementary diet for 6- to 24-month-old children in urban and rural KwaZulu-Natal, South Africa. Matern Child Nutr. 2016;12(3):528–45. https://doi.org/10.1111/mcn.12146
15. Bikes GA, Tariku A, Wassie MM, et al. Factors associated with minimum dietary diversity and meal frequency among children aged 6-59 months in northwest Ethiopia: finding from the baseline survey of nutrition project. Res Square [Internet]. 2021;2021/07/20:1–17. https://doi.org/10.21203/rs.3.rs-32792/v1.
16. National Department of Health (NDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC), and ICF. South Africa Demographic and Health Survey. Key Indicators: Pretoria, South Africa, and Rockville, Maryland, USA: NDoH, Stats SA, SAMRC, and ICF; 2017; 2016. [Available from: https://dhsprogram.com/pubs/pdf/SR248/SR248.pdf.
17. South African National Health and Nutrition Examination Survey (SANHANES-1). Data analysis on infant feeding practices, and anthropometry in children under five years of age: South Africa 2012. Cape Town: HSRC Press [press release]; 2013.
18. Swanepoel E, Havemann-Nel L, Rothman M, et al. Contribution of commercial infant products and fortified staple foods to nutrient intake at ages 6, 12, and 18 months in a cohort of children from a low socio-economic community in South Africa. Matern Child Nutr. 2019;15(2):e12674. https://doi.org/10.1111/mcn.12674
19. SAFOODS. SAMRC. Food quantities manual for South Africa. 3rd ed. (ebook). Cape Town: South African Medical Research Council; 2018.
20. WHO. Complementary feeding of young children in developing countries: a review of current scientific knowledge. Geneva: World Health Organization; 1998; Available from https://apps.who.int/iris/handle/10665/65932.
21. SAFOODS. SAMRC. Food composition tables for South Africa. 5th ed. (ebook). Cape Town: South African Medical Research Council; 2017.
22. Institute of Medicine. Dietary reference intakes: the essential guide to nutrient requirements 2006. Available from: https://www.nap.edu/search/?term=DRI.
23. Institute of Medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids (macronutrients) 2005. Available from: https://www.nap.edu/search/?term=DRI.
24. Institute of Medicine. Dietary Reference Intakes: intakes for calcium and vitamin D. Institute of Medicine: Washington, *DC:* The National Academy Press 2011. Available from: https://www.nap.edu/search/?term=DRI.
25. Hatløy A, Torheim LE, Oshaug A. Food variety—a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. Eur J Clin Nutr. 1998;52(12):891–8. https://doi.org/10.1038/sj.ejcn.1600662
26. Sayed N, Schönfeldt HC. A review of complementary feeding practices in South Africa. S Afr J Clin Nutr. 2020;33(2):36–43. https://doi.org/10.1080/16070658.2018.1510251
27. National Department of Health. Regulations relating to the fortification of certain foodstuffs. (Government notice no. R504). Government Gazette, 2475, 7 Apr. 2003. Available from: http://extwprlegs1.fao.org/docs/pdf/saf90721.pdf.
28. Diana A, Mallard SR, Haszard JJ, et al. Consumption of fortified infant foods reduces dietary diversity but has a positive effect on subsequent growth in infants from Sumedang district, Indonesia. PLoS One. 2017;12(4):e0175952. https://doi.org/10.1371/journal.pone.0175952
29. WHO (World Health Organization). Complementary feeding: report of the global consultation, and summary of guiding principles for complementary feeding of the breastfed child. Geneva: World Health Organization; 2003; Available from: https://www.who.int/nutrition/publications/infantfeeding/924154614X/en/.
30. Denney L, Afeiche MC, Eldridge AL, et al. Food sources of energy and nutrients in infants, toddlers, and young children from the Mexican National Health and Nutrition Survey 2012. Nutrients. 2017;9(5):494. https://doi.org/10.3390/nu9050494
31. Wang H, Denney L, Zheng Y, et al. Food sources of energy and nutrients in the diets of infants and toddlers in urban areas of China, based on one 24-hour dietary recall. BMC Nutr. 2015;1(1):19. https://doi.org/10.1186/s40795-015-0014-x
32. Mengistu G, Moges T, Samuel A, et al. Energy and nutrient intake of infants and young children in pastoralist communities of Ethiopia. Nutr J. 2017;41:1–6. https://doi.org/10.1016/j.nut.2017.02.012.
33. Van Stuijvenberg ME, Nel J, Schoeman SE, et al. Low intake of calcium and vitamin D, but not zinc, iron or vitamin A, is associated with stunting in 2- to 5-year-old children. Nutrition. 2015;31(6):841–6. https://doi.org/10.1016/j.nut.2014.12.011
34. Hetherington M, Caton S, Ceci J, et al. Learning to like vegetables: applying learning theory to the acquisition of preferences for novel vegetables from 6-36 m. results from habeat and viva. Ann Nutr Metab. 2013;63(39):1980.
35. Du Plessis L, Daniels L, Koornhof H, et al. Overview of field-testing of the revised, draft South African Paediatric Food-Based Dietary Guidelines amongst mothers/caregivers of children aged 0–5 years in the Western Cape and Mpumalanga, South Africa. S Afr J Clin Nutr. 2021;34(4):123–31. https://doi.org/10.1080/16070658.2020.1769335
36. Faber M, Laubscher R, Laurie S. Availability of, access to and consumption of fruits and vegetables in a peri-urban area in KwaZulu-Natal, South Africa. Matern Child Nutr. 2013;9(3):409–24. https://doi.org/10.1111/j.1740-8709.2011.00372.x
37. Ryckman T, Beal T, Nordhagen S, et al. Affordability of nutritious foods for complementary feeding in Eastern and Southern Africa. Nutr Rev. 2021;79(Supplement_1):35–51. https://doi.org/10.1093/nutrit/nuaa137
38. Kuyper E, Vitta B, Dewey K. Novel and underused food sources of key nutrients for complementary feeding. A&T Tech Brief, 6, 2013. Available from https://www.aliveandthrive.org/en/resources/novel-and-underused-food-sources-of-key-nutrients-for-complementary-feeding-insight-series. (accessed 27 June 2022).
39. Iannotti LL, Lutter CK, Bunn DA, et al. Eggs: the uncracked potential for improving maternal and young child nutrition among the world's poor. Nutr Rev. 2014;72(6):355–68. https://doi.org/10.1111/nure.12107
40. Leroy JL, Frongillo EA. Can interventions to promote animal production ameliorate undernutrition? J Nutr. 2007;137(10):2311–6. https://doi.org/10.1093/jn/137.10.2311
41. Davidsson L. Approaches to improve iron bioavailability from complementary foods. J Nutr. 2003;133(5):1560S–2S. https://doi.org/10.1093/jn/133.5.1560S
42. Krebs NF, Westcott JE, Butler N, et al. Meat as a first complementary food for breastfed infants: feasibility and impact on zinc intake and status. J Pediatr Gastroenterol Nutr. 2006;42(2):207–14. https://doi.org/10.1097/01.mpg.0000189346.25172.fd

43. Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013;382(9890):427–51. https://doi.org/10.1016/S0140-6736(13)60937-X
44. Radlowski EC, Johnson RW. Perinatal iron deficiency and neurocognitive development. Front Hum Neurosci. 2013;7:585. https://doi.org/10.3389/fnhum.2013.00585
45. Venkatramanan S, Armata IE, Strupp BJ, et al. Vitamin B-12 and cognition in children. Adv Nutr. 2016;7(5):879–88. https://doi.org/10.3945/an.115.012021
46. Aguayo VM, Nair R, Badgaiyan N, et al. Determinants of stunting and poor linear growth in children under 2 years of age in India: an in-depth analysis of Maharashtra's comprehensive nutrition survey. Matern Child Nutr. 2016;12(1):121–40. https://doi.org/10.1111/mcn.12259
47. Moursi MM, Arimond M, Dewey KG, et al. Dietary diversity is a good predictor of the micronutrient density of the diet of 6-to 23-month-old children in Madagascar. J Nutr. 2008;138(12):2448–53. https://doi.org/10.3945/jn.108.093971
48. FAO. Dietary assessment: a resource guide to method selection and application in low resource settings. Rome: Food and Agriculture Organization; 2018.
49. IAEA. Stable isotope technique to assess intake of human milk in breastfed infants. Vienna: International Atomic Energy Agency; 2010; Available at https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1429_web.pdf.
50. Campbell RK, Hurley KM, Shamim AA, et al. Complementary food supplements increase dietary nutrient adequacy and do not replace home food cconsumption in children 6–18 months old in a randomized controlled trial in rural Bangladesh. J Nutr. 2018;148(9):1484–1492. https://doi.org/10.1093/jn/nxy136
51. Onifade OM, Pringle KG, Rollo ME, et al. Dietary intake of indigenous Australian infants and young children in the Gomeroi gaaynggal cohort. Nutr Diet. 2021;78(4):386–396. https://doi.org/10.1111/1747-0080.12673
52. Dror DK, Allen LH. Overview of nutrients in human milk. Adv Nutr. 2018;9:278S–294S. https://doi.org/10.1093/advances/nmy022

Received: 20-04-2022 Accepted: 24-10-2022