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RESEARCH ARTICLE

Suboptimal feeding practices and impaired growth among children in largely food insecure areas of north Wollo, Ethiopia

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Abstract

In Ethiopia, information is limited about energy and micronutrient intakes from complementary foods consumed by children in Productive Safety Net Program districts. Therefore, we assessed feeding practices and intakes of energy and selected micronutrients from complementary foods of children aged 6–23 months in a food insecure rural area of Ethiopia. Energy and micronutrient intakes were estimated from multiple-pass 24 h recall. Data were collected using a structured questionnaire. Only 1·9 % of children in the age range 6–8 months met recommended minimum dietary diversity of ≥5 food groups; this value slightly increased to 4 and 10·1 % in the older age groups (9–11 months and 12–23 months, respectively). Overwhelmingly, none of the children (9–11 months) did get the minimum acceptable diet (Children receiving minimum acceptable diet were 4 and 2·6 % in 6–8 months and 12–23 months, respectively). The overall prevalence of stunting was 34 % in younger children (6–8 months) and 51 % in older children aged 12–23 months. Median energy and selected micronutrient intakes from complementary foods were below corresponding WHO recommendations assuming average breast-milk amount and composition. The worst shortfalls were for vitamins A and C and for Ca. In contrast, median iron, protein and niacin intakes and densities were above the WHO recommendation. Caretakers and community leaders in the study setting need nutrition education on IYCF-related practices and on the importance of men's involvement in IYCF. Ensuring the accessibility and affordability of animal source foods (ASFs), fruits and vegetables, and feasible complementary foods is critical to address the quality of complementary feedings. This can be achieved through promoting nutrition-sensitive agriculture such as poultry and home gardening in this setting.

Key words: Complementary feeding: Impaired growth: Nutrient intakes: PSNP

Introduction

Optimal feeding practices of children, as per World Health Organization (WHO) guidelines, have been recommended as number one strategy to combat growth faltering and associated consequences in young children[1]. Specific recommendations and indicators of appropriate IYCF set by WHO include initiating breast-feeding within 1 h after birth, exclusively breast-feeding infants during the first 6 months as well as timely introduction of adequate and safe solid/semi-solid foods, while continuing to breast-feed until 2 years or beyond. The complementary feeding period is critical as energy and nutrient needs are high in this period for rapid physical growth and survival[1,2]. Poor complementary foods, both quality and quantity, in addition to frequent incidences of infections are linked with impaired growth and mental development as well as low productivity and earnings during later life[3]. Therefore, interventions focusing on appropriate infant and young child feeding practices (IYCF) are needed to tackle the short- and long-term consequences associated with undernutrition[4].

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Despite tremendous progress in the reduction of child undernutrition, the rate of undernutrition is still high in Ethiopia when compared with many other low-income countries. According to a recent Mini EDHS report, 37 % of children younger than 5 years were stunted, 7 % wasted and 21 % underweight[5]. In low-income countries, children frequently are fed nutrient-poor complementary foods such as watery porridges[6] deficient in iron and zinc. Like other developing countries, unrefined cereal-based complementary foods are predominant in Ethiopia. Such complementary foods are low in energy and micronutrients, particularly, growth-limiting ones, such as Fe, Zn and Ca. Even if these nutrients are present, they are poorly absorbed, in part because of high phytic acid (myoinositol hexaphosphate) concentrations, a known inhibitor of mineral absorption[7].

The Ethiopian government has been implementing the Productive Safety Net Program (PSNP since 2005, targeting food insecure households to address underlying causes of undernutrition). Since its launch, the government is on Phase 4 of the PSNP with the main objective being to increase livelihoods and resilience to shocks and to improve food security and nutrition for rural households vulnerable to food insecurity[8]. Since 2016, the PSNP has been connected with the National Nutrition Program and community nutrition programs focusing on nutrition education for lactating and pregnant women and their children. Public works participants have co-responsibilities to attend behaviour change communication sessions for pregnant and lactating women (PLW) and their young children. Health extension workers (HEWs) and volunteer community health workers (VCHWs) carry out monthly 2 h cooking demonstrations and education sessions (good food from local food, easy to cook, adding vegetables to child's gruel/porridge, feeding baby mashed foods from family food, preparing special foods like mashed meat/fish, feeding child extra meal after they recovered from illness and feeding your child mashed fruits) at a public works site for 2 h during the course of the public works implementation period[8].

However, in Ethiopia, although a few studies have evaluated IYCF practices, little evidence is available regarding nutrient intakes from complementary foods, particularly in PSNP districts. Earlier studies of nutrient intakes from complementary foods in northern and southern Ethiopian children demonstrated unrefined complementary foods were predominant and reported a high prevalence of inadequate intakes of critical growth-limiting micronutrients[9,10]. However, the earlier studies evaluated only a limited number of micronutrients in addition to energy from complementary foods and were not done in districts designated as food insecure. A study by Baye, Guyot, Icard-Vernière and Mouquet-Rivier[9] in northern Ethiopia included only an older age group (12–23 months), which does not provide the full information about complementary feeding practices of children in northern Ethiopia, particularly children from a PSNP district. Therefore, the present study was conducted to assess IYCF practices and nutrient intakes from complementary foods of the poorest segment of the population. Such quantitative data are important for designing evidence-based PSNP and other nutrition interventions aimed to improve quality of complementary diets of these households.

Methods and materials

Study site

Study area and participants. The study was conducted in 10 *kebeles* (the smallest administrative unit in Ethiopia) of Meket district, north Wollo, Ethiopia from February to March 2020. The Meket district is one of the food insecure areas in north Wollo, and a majority of the households are dependent on transfer of food aid[8]. As a result, the district is included in the Productive Safety Net Program ($PSNP_4$). Presently, 69 649 households are enrolled in the $PSNP_4$ program from Meket district. Stunting prevalence in the region (41·3 %) exceeds the national average (37 %) for children younger than 5 years[5]. There are one primary hospital, seven governmental health centres and thirty-six health posts in the district. The inhabitants of the district mainly produce maize (*Zea mays* L.), millet (*Pennisetum glaucum*), pulses and teff (*Eragrostis tef*) as staple foods. Vegetables such as kale and potato are also grown. Traditional animal rearing such as cattle is common, mainly as a source of income.

Sample size determination and sampling

As part of a larger study that investigated maternal depression and child undernutrition[11], the sample size was calculated using power analysis to detect a medium effect size (0·5 SD difference with an α of 0·05 and a power of 0·8). The final sample size was estimated to be 232, after 1·5 for design effect and approximately 15 % for non-response rate. The determined sample size and data set were sufficient to characterise the mean energy intake of the three age groups with a 95 % confidence level of approximately ±30 kcal. Of the 27 *kebeles* in the district, 10 were randomly selected. A listing of $PSNP_4$ households with infants and young children (6–23 months of age) who had lived at least 6 months in the selected *kebeles* were completed from the database that was compiled by the research team including local healthcare workers prior to actual data collection. The number of mother–child pairs to be selected was proportionally allocated to the 10 *kebeles* based on the total number of the households with 6–23-month-old children in each *kebele*. The study participants were then randomly selected from the sampling frame. In the rare cases, when several children in the same household fulfilled the inclusion criteria, one child was randomly selected. The inclusion criteria were being permanent residents for the mother–child pairs, the child being breast-fed and apparently healthy and household enrollment in $PSNP_4$. Children with physical disabilities and severe illnesses were excluded.

Data collection tool and measurements

Basic socio-demographic characteristics of study participants were collected by face-to-face interviews using a pretested questionnaire that included sex of child, age (in months), maternal age, occupation, and educational status, marital status, family size, ownership of sanitary facility, source of water, and common child illness (cough, fever, nausea/vomiting, diarrhoea or acute respiratory infection) in the 2 weeks prior to the survey. Household food insecurity was evaluated using the Household Food Insecurity Access Scale[12]. The households were categorised into four groups: food secure, mildly food insecure, moderately food insecure and severely food insecure. Finally, these were merged into two groups: food secure and food insecure (mildly, moderately and severely) households.

Maternal exposure to child feeding promotion and related activities was collected using structured questions. Men's involvement in IYCF was considered if they carried out at least one of the following supportive actions in the households: buying or providing money for the purchase of special foods for the baby (i.e. different from the usual household food); advising the mother to provide special food for the baby; keeping some milk or an egg for the baby instead of selling it in the market; preparing food for the baby; or helping the mother with some domestic duties while she cooked food or fed the baby[13].

All anthropometric measurements were conducted by a supervisor (B. S.) and the principal investigator (A. A.) to eliminate inter-examiner variation. Recumbent length was measured to the nearest millimetre as recommended by WHO[14] using a portable adult/infant length/stature measuring board (Perspective Enterprises, Portage, MI, USA) and weight via an electronic scale (Seca 770, Seca Corporation, Hanover, MD, USA) to the nearest 0·1 kg. The mean *Z*-scores for length-for-age (LAZ), weight-for-age (WAZ) and weight-for-length (WLZ) were calculated from WHO multicentre growth reference data[15] using the WHO Anthro (v. 3.2.2) computer program. Stunting, wasting and underweight were defined by *Z*-scores for LAZ, WLZ and WAZ < -2 standard deviations (SD), respectively. Age of each child was determined from their immunisation card and/or local events calendar.

Dietary intake assessment

Dietary intake was assessed using a multiple-pass interactive 24 h recall with the mother of each child in the home. The method used in this study was adapted and validated for use in developing countries[16]. Each mother was asked to recall all foods and fluids consumed by a child in the previous 24 h including time, type of meal, ingredients used, amount of total dish and amount consumed. A day before intake was assessed (2 d before the recall), plates and cups were supplied to the mothers, who were instructed not to change the dietary pattern of the child on the recall day. A demonstration was given on how weighing of food would be conducted. Portion size of foods consumed was estimated by direct weighing of salted replicas of actual foods prepared locally. In order to adjust for individual day-to-day intake variation, Intake Monitoring Assessment and Planning Program software (IMAPP) was used (More details about the program and how to access it can be found at http://www.side.stat.iastate.edu/, http://www.side.stat.iastate.edu/.), a second day dietary intake recall was collected using the same procedures from a randomly selected subsample (*n* 35) on a different day of the week as recommended by the Institute of Medicine (IOM)[17]. All days were equally represented for each age group to account for any day-of-the-week effects.

Data collection was conducted by experienced data collectors who were recruited locally and trained in a classroom setting for 5 d followed by a field practice with a group comparable to that of the actual study. The data collectors' training was mainly focused on how to ask detailed information on type, quantity and preparation method of each food consumed, including the detailed recipe. Each data collector was supplied with a digital food weighing scale (2000 g maximum weight: Model CS 2000; Ohaus Corporation, Parsippany, NJ, USA), and plates as well as cups which were distributed for mothers. For mixed dishes, the contribution of each ingredient to the total amount or volume (g or ml) consumed was estimated.

Estimation of nutrient intakes and nutrient density from complementary foods

The dietary data were entered in the 'Census and Survey Processing System' to convert food model weights to grams of food consumed and calculate individual energy and nutrient intakes (CSPro, https://www.census.gov/population/international/software). Ethiopian food composition tables (EFCTs) were used[18–20]. The vitamin A activity from complementary foods was expressed as REs for comparison with the WHO recommendations[21]. The median daily intakes for each age group were compared with the corresponding estimated energy and selected nutrient needs that should be obtained from complementary foods (any food other than breast-milk)[22–24], assuming average breast-milk amount and composition as suggested by Dewey and Brown[21] and WHO[7]. Nutrient densities (amount per 100 kcal) were compared with desired values suggested by[6]. Median dietary diversity scores were calculated based on eight food groups as described in WHO/UNICEF[2] and classified as low (1–2), medium (3–4) and high (≥5).

Data analysis

All continuous variables were checked for normality using the Kolmogorov–Smirnov test. Breast-feeding and child dietary diversity indicators (i.e. dietary diversity, minimum number of time fed solids/semi-solids; minimum number of food groups; good IYCF practices) were calculated and presented as recommended by the IYCF guidelines published by WHO/UNICEF[2]. Mean differences in anthropometric status across age group were compared using *t*-test, whereas the proportion of stunting, wasting and underweight were compared using χ^2 test. Nutrient intakes (per day) and nutrient densities (per 100 kcal) were expressed as medians and interquartile range because of non-normal distributions of some nutrients. In all comparisons, differences were considered statistically significant when $P < 0 \cdot 05$. Statistical analyses were performed using SPSS version 21.

Ethical approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Hawassa University Institutional Review Board (Ref. No. IRB/178/10). The purpose of the study was explained in a formal letter to district administration and then informed written consent was obtained from the Meket district health office. Prior to enrollment in the study, the purpose of the study was explained for mothers and written informed consent was obtained from mothers.

Results

Socio-demographic characteristics of the study participants

Socio-demographic characteristics of the participants are summarised in Table 1. A total of 232 mother–child pairs were included in the analysis. Over half (55·6 %) of the children were in the 12–23 months range and the male-to-female ratio was 1·05. Approximately one in six children (17·7 %) had symptoms of illness during the 2 weeks prior to the survey (Table 1).

The mean (SD) age of the mothers was 28·5 (±6·3) years. More than a third (33·9 %) of the mothers had primary or above education and 60·3 % reported their occupation as housewife. Most of the mothers (85·8 %) were married, and Christianity was the dominant religion. The mean (SD) household size was 4·2 (±1·2) and more than half (51·7 %) of the households had 4–5 members. Of the households, 95·1 % had sanitary facilities, and the main water source for the studied households was from a public tap (87·5 %).

Table 1. Household, maternal and child characteristics, north Wollo, Ethiopia (*n* 232)

	n (%)
Age of mother (years)	
18–27	106 (45·7)
28–37	105 (45·3)
37+	21 (9·1)
Sex of child	
Male	120 (51·2)
Female	112 (48·8)
Age of child (months)	
6–8	53 (22·8)
9–11	50 (21·6)
12–23	129 (55·6)
Educational status of mother	
Not educated	156 (67·2)
Primary+	76 (33·9)
Occupation of mother	
Housewife	140 (60·3)
Farmer	71 (30·6)
Petty trade	18 (7·8)
Others	3 (1·3)
Marital status	
Married	199 (85·8)
Divorced/separated	21 (9·1)
Others	12 (5·2)
Religion	
Muslim	24 (10·3)
Christian	208 (89·7)
Household size	
2–3	80 (34·5)
4–5	120 (51·7)
6–8	32 (13·8)
Child illness in past 2 weeks	41 (17·7)
Usual water sources	
Public tap	203 (87·5)
Others	29 (12·5)
Household owns latrine	221 (95·3)

Maternal exposure to IYCF-related information

Maternal exposure to different types of IYCF-related information is presented in Table 2. Nearly half (49·1 %) of the mothers reported discussing IYCF topics with HEWs within the 3 months prior to the survey. Similarly, in the same time frame, 40·5 and 39·2 % of the mothers participated in complementary food cooking demonstrations and discussed IYCF with community health promoters, respectively. Nearly a third (31·5 %) of the mothers were involved in income-generating activities (IGA) like raising poultry, fattening goats and sheep, and selling tella (alcoholic drink). Furthermore, 37·5 % were members of village economic and social associations (VESA) and 37·9 % heard radio broadcasts about IYCF in the 3 months prior to the survey.

Breast-feeding and complementary feeding practices

Based on maternal recall, all children were ever breast-fed and more than half (51·7 %) of the children were breast-fed within 1 h after birth (Table 3). Also, most mothers (88·4 %) reported giving colostrum to their infants. Only a few (3 %) of the children were given prelactal feeding containing plain water; likewise only 2·6 % were given prelactal feeding consisting of water + sugar, raw butter and/or honey/cow milk/fenugreek. Some of the children (3 %) were exclusively breast-feeding during the survey, although the age of the children was beyond the recommended to start complementary feeding.

Table 2. Maternal exposure to IYCF promotion and related activities north Wollo, Ethiopia (*n* 232)

Promotion activities (*n* 232)	*n* (%)
Discussed IYCF with HEW in past 3 months	114 (49·1)
Participated in cooking demonstration in past 3 months	94 (40·5)
Participated in community conversation about child feeding in past 3 months	85 (36·6)
Discussed IYCF with CHP in past 3 months	91 (39·2)
Maternal involvement in income generation activities	73 (31·5)
Member of village economic and social association (VESA)	87 (37·5)
Husband supports mother about IYCF	202 (87·1)
Ownership of nutrition card*	84 (36·2)
Heard radio broadcast about child feeding in past 3 months	88 (37·9)
Owns poultry	100 (43·1)
Household own backyard garden	79 (34·1)

* A card that promotes seven key IYCF messages and is distributed to households having children ages 0–23 months.

Table 3. Feeding practices of the study children, north Wollo, Ethiopia

	6–8 months	9–11 months	12–23 months
Started breast-feeding within 1 h after birth, *n* (%)	34 (64·2)	21 (42)	65 (50·1)
Fed colostrums, *n* (%)	45 (84·9)	44 (88)	116 (9·9)
Currently exclusively breast-feeding, *n* (%)	4 (7·5)	1 (2)	2 (1·6)
Child given prelactal feeding, *n* (%)			
Plain water	0 (0·0)	3 (6)	4 (3·1)
Water + sugar, raw butter and/or honey/cow milk/fenugreek	2 (3·8)	0 (0)	4 (3·1)
Complementary feeding rate[a]	92.5	98.0	98.4
Consumed the following foods in the past 24 h prior to survey, *n* (%)			
Breast-milk	53 (100)	50 (100)	129 (100)
Cereals, grains, roots, tubers	47 (95·9)	47 (95·5)	127 (100)
Legumes and nuts	38 (77·6)	41 (83·7)	88 (69·3)
Dairy products	9 (18·4)	8 (16·3)	26 (20·5)
Meat, poultry, fish	3 (6·1)	2 (4·1)	3 (2·4)
Eggs	6 (12·2)	7 (14·3)	16 (12·6)
Vitamin A-rich fruits and vegetables	0 (0)	2 (4·1)	14 (11)
Other fruits and vegetables	1 (2)	3 (6·1)	10 (7·9)
Number of food groups consumed (out of eight food groups), *n* (%)			
1–2 (low)	13 (24·5)	2 (4)	23 (17·8)
3–4 (medium)	39 (73·6)	46 (92)	93 (72·1)
5–8 (high)	1 (1·9)	2 (4)	13 (10·1)
Mean ± SD of food groups consumed	2·96 ± 0·89	3·20 ± 0·63	3·18 ± 0·93
Fed solid or semi-solid foods minimum number of times or more[b], *n* (%)	46 (86·8)	22 (44·8)	65 (51·2)
Fed minimum number of food groups or more[c], *n* (%)	1 (1·9)	2 (4)	13 (10·1)
Met minimum acceptable diet[d], *n* (%)	1 (4)	0 (0)	6 (2·6)
Consumed food rich in iron[e], *n* (%)	9 (18·3)	7 (14·2)	17 (13·3)

a Percent of children who received breast-milk and solid or semi-solid foods in the last 24 h[25].
b Children 6–8 months fed ≥2 times/d; children 9–23 months fed ≥3 times/d.
c Fed ≥5 food groups (out of the eight food groups) during the previous day.
d Fed solids/semi-solids minimum number of times and minimum number of food groups on the previous day.
e Includes meat (including organ meat), fish, poultry and eggs.

Almost all (98·2 %) children who received complementary food consumed foods based on cereals, grains, roots and tubers in the preceding day. About three-fourths (74·2 %) of the children received legumes or nuts, whereas very few (7·1 %) ate fruits and vegetables rich in vitamin A. A very small percentage (3·6 %) of children received meat, poultry or fish; eggs (12·9 %) or dairy products (19·1 %). More than three-fourths (76·7 %) of the studied children consumed 3–4 food groups; whereas only 16 children (6·9 %) received ≥5 food groups from eight food groups. Consequently, the mean dietary diversity score was very low. A majority of the children (93·8 %) aged 6–8 months received solid or semi-solid foods the minimum number of times or more (≥2 times/d) in addition to breast-milk. Very few (1·9 %) of the children in age range 6–8 months met recommended minimum dietary diversity of ≥5 food groups from eight; this value slightly increased to 4 and 10·1 % in the older age groups (9–11 months and 12–23 months, respectively). Overwhelmingly, very few (3·1 %) of the children were fed according to IYCF guidelines with no children aged 9–11 months achieving MAD.

Anthropometric characteristics

Anthropometric measurements of the studied children are summarised in Table 4 by age categories. The mean LAZ was negative for all age groups and was significantly worse in both older age groups than in the 6–8 months group ($P < 0·05$). The mean WAZ and WLZ scores were negative for the three age groups but were not significantly different across age categories. However, the mean WAZ was slightly lower in the two older age groups compared with the youngest group. Moreover, the prevalence of stunting was significantly higher in children aged 9–11 and 12–23 months compared with the younger ($P < 0·05$), thus the incidence of stunting became worse as the children grew older while underweight and wasting were not different by age group.

Table 4. Mean (SD) LAZ, WLZ, WAZ and prevalence of stunting, wasting and underweight by age groups of the study children, north Wollo, Ethiopia (*n* 232)

	6–8 months (*n* 53)	9–11 months (*n* 50)	12–23 months (*n* 129)	All children (*n* 232)
Length-for-age *Z*-score*	−1·29 ± 1·61	−1·79 ± 1·30	−1·85 ± 1·26	−1·70 ± 1·37
Weight-for-length *Z*-score	−0·31 ± 1·71	−0·14 ± 1·42	−0·28 ± 1·61	−0·26 ± 1·59
Weight-for-age *Z*-score	−0·71 ± 1·53	−0·83 ± 1·05	−0·83 ± 1·31	−0·80 ± 1·31
Prevalence of stunting (%)‡	18 (34)	23 (46)	66 (51·2)	107 (46·1)
Prevalence of wasting	9 (17)	5 (10)	13 (10·1)	27 (11·6)
Prevalence of underweight	14 (26·4)	15 (30)	39 (30·2)	68 (29·3)

* Significantly different by age group ($P < 0·05$, from the *t*-test, equal variances not assumed).
‡ Significantly different by age group ($P = 0·024$, Monte Carlo 1-sided significance).

Table 5. Median (Q1, Q3) energy and selected nutrient intakes from complementary foods by age group compared with estimated needs* of children aged 6–23 months in north Wollo, Ethiopia (*n* 225)

	6–8 months (*n* 49)	9–11 months (*n* 49)	12–23 months (*n* 127)
Energy (kcal)	165 (98, 207)	210 (166, 292·5)	312 (245, 409)
Estimated need	202	307	548
Protein (g)	6·7 (2·9, 11·3)	8·9 (4·6, 12·7)	12·4 (7·8, 18·9)
Estimated need	2	3·1	5
Calcium (mg)	17·8 (0·5, 113·4)	6 (2, 54·5)	17 (3, 78)
Estimated need	211	228	346
Iron (Fe; mg)	10·5 (6·7, 13·5)	11·2 (9·2, 14·3)	13·7 (10·6, 16·9)
Estimated need	18·4 (L), 9·1 (M)	18·4 (L), 9·1 (M)	11·4 (L), 5·8 (M)
Zinc (Zn; mg)	0·6 (0·1, 0·8)	0·5 (0·1, 0·6)	1·2 (0·2, 1·4)
Estimated need	7·6 (L), 3·3 (M)	7·7 (L), 3·4 (M)	7·6 (L), 3·7 (M)
Thiamine (mg)	0·09(0·06, 0·45)	0·08 (0·05 0·30)	0·12 (0·07, 0·4)
Estimated need	0·16	0·17	0·38
Riboflavin	0·03 (0·01, 0·07)	0·05 (0·03, 0·10)	0·06 (0·03, 0·11)
Estimated need	0·16	0·18	0·31
Niacin (mg)	3·40 (2·30, 4·50)	4·50 (2·90, 6·70)	6·70 (4·60, 9·60)
Estimated need	2·99	3·08	5·18
Vitamin C (mg)	0·0 (0·0, 0·2)	0·0 (0·0, 0·1)	0·0 (0·0, 0·8)
Estimated need	3·0	5·4	8·0
Vitamin A (μg RE)	0·0 (0·0, 19·5)	0·0 (0·0, 24·2)	0·0 (0·0, 22·1)
Estimated need	63	92	126

Children consuming no complementary food (*n* 7) were excluded; L, low bioavailability; M, moderate bioavailability; RE, retinol equivalent.
* Estimated needs from complementary foods are determined assuming average breast-milk intake and composition as proposed by WHO[7] and Dewey and Brown[21].

Adequacy of energy and nutrient intakes and micronutrients from complementary foods

Table 5 summarises median (Q1, Q3) energy and selected nutrient intakes from complementary foods across the three age groups with estimated needs. With the exception of median protein and niacin, intakes of energy and other micronutrients listed in Table 5 were below the estimated needs from complementary foods with the largest shortfall for vitamins C and A. Fe intakes met estimated needs only when moderate bioavailability was assumed (15 %). Under the assumption of low bioavailability (5 %) however, Fe intakes were below the estimated needs except for the children 12–23 months.

Median nutrient densities (Q1, Q3) from complementary foods were below the desired values across three age groups (Table 6). Fe met desired values for all age groups, but only when moderate bioavailability was assumed. Fe intakes from complementary foods met desired values even under the assumption of low bioavailability (5 %) for the children 12–23 months. Protein and niacin also met desired values.

Discussion

The present study findings highlight that several of the IYCF practices such as low dietary diversity and minimum meal frequency were not in accordance with the WHO recommendation[2,25] and consistent with earlier reports of children from elsewhere in Ethiopia[10,26] and Sub-Saharan Africa[27,28]. The study showed a small percentage of studied children

Table 6. Median (Q1, Q3) nutrient densities of complementary foods consumed by 6–23 months children in north Wollo, Ethiopia (*n* 225)

	6–8 months (*n* 49)	9–11 months (*n* 49)	12–23 months (*n* 127)
Protein density (g/100 kcal)	4·4 (2·2, 8·6)	4·4 (2·5, 7·3)	4·1 (3·1, 6·0)
Desired	1·4	1·2	0·9
Calcium density (mg/100 kcal)	10·7 (0·2, 78·2)	3·2 (0·8, 36·2)	5·3 (1·0, 24·5)
Desired	37	29	61
Iron density (mg/100 kcal)	6·2 (4·2, 9·7)	5·4 (3·8, 8·1)	4·5 (3·3, 5·7)
Desired	9·1(L), 4·5 (M)	6·0 (L), 3·0 (M)	2·1 (L), 1·0 (M)
Zinc density (mg/100 kcal)	0·2 (0·1, 0·6)	0·1 (0·1, 0·4)	0·2 (0·1, 0·5)
Desired	3·8(L), 1·14 (M)	2·5 (L), 0·81 (M)	1·4 (L), 0·46 (M)
Thiamine density (mg/100 kcal)	0·07 (0·04, 0·32)	0·05 (0·02, 0·12)	0·04 (0·02, 0·12)
Desired	0·08	0·05	0·07
Riboflavin density (mg/100 kcal)	0·03 (0·01, 0·06)	0·02 (0·01, 0·05)	0·02 (0·01, 0·04)
Desired	0·08	0·06	0·05
Niacin density (mg/100 kcal)	2·3 (1·5, 3·3)	2·1 (1·3, 3·4)	2·3 (1·5, 3·1)
Desired	1·5	1·0	0·9
Vitamin C density (mg/100 kcal)	0·0 (0·0, 0·14)	0·0 (0·0, 0·06)	0·0 (0·0, 0·2)
Desired	1	1	1
Vitamin A density (μg RE/100 kcal)	0·0 (0·0, 10·8)	0·0 (0·0, 11·9)	0·0 (0·0, 8·0)
Desired	25	26	19

L, low bioavailability; M, moderate bioavailability; RE, retinol equivalent; nutrient densities (amount per 100 kcal) were compared with desired values suggested by Dewey[6].

consumed nutrient-dense foods such as animal source foods (ASF)s and vitamin A-rich fruits and vegetables on the day before the survey. Many studies conducted in Ethiopia have observed that the consumption of nutrient-dense food groups is very low[9,11,13]. This is unfortunate, as poor dietary diversity in general and ASF consumption in particular are consistently associated with increased risk of stunting and micronutrient deficiencies in low- and middle-income countries (LMIC)[29,30]. Given that the present study respondents were food insecure, unavailability of food at the household, poor maternal knowledge about optimal complementary feeding practices, and unaffordability of nutrient-dense foods are among possible constraints limiting optimal complementary feeding practices[31–33].

Undernutrition expressed in stunting (46·1 %) and underweight (29·3 %) were widespread in studied children. The high prevalence of stunting and underweight found in the present study may be partly attributed to suboptimal feeding practices. Such suboptimal feeding practices are consistently associated with increased risk of stunting[29,34,35]. This situation is very concerning in the country's largest social protection PSNP and health extension program, especially in light of the other supportive IYCF work done by different NGOs for a number of years. Reexamining or strengthening the existing PSNP programs or the delivery strategies by program planners in the study area and other similar settings is critical.

It is of interest that among children aged 9–23 months, the mean WAZ was lower and the prevalence of stunting was significantly higher compared with the younger. This trend arose in part because apparently the number of 9–23-month-olds who had complementary foods three times per day was drastically lower than the number of 6–8-month-olds who met the two times per day recommendation. Infants under 2 years still have fairly small stomachs and really cannot eat enough at one time as breast-milk begins to decline. This finding implies that in the study area and other similar settings, nutrition education that improves feeding practices during this critical period of complementary feeding is important. Studies elsewhere in Ethiopia have previously reported that knowledge of caregivers about IYCF remains poor and that delivery of nutrition education through the use of the HEWs can be crucial means for improvements[13,36].

Our dietary intake data showed that, except for median total protein, Fe only when moderate bioavailability was assumed and niacin intakes, energy and selected micronutrients deficits were widespread in studied children compared with the WHO estimated needs[21]. Shortfalls of energy and growth-limiting nutrients such as Zn, Ca, riboflavin and vitamin A, when compared with their needs from complementary foods as estimated by WHO, are not unexpected, and are parallel with earlier studies from Sub-Saharan African countries[37,38]. In Ethiopia and most Sub-Saharan African countries, however, unrefined cereal or plant-based complementary foods are predominant with little consumption of nutrient-dense foods such as vitamin A-rich fruits and vegetables and ASF[26,39,40]. In the present study, a small fraction of children (6·9 %) consumed at least the minimum number of food groups, milk and milk products (19·1 %), eggs (12·9 %) and flesh foods (3·6 %). Instead, 98·2 % received starchy complementary foods including grains, roots and tubers. These suboptimal complementary feeding practices probably contributed to the low energy and micronutrients intakes as well as poor amino acid profiles. These food choices could be associated low economic status, suboptimal knowledge of caregivers about IYCF, social norms and beliefs like not feeding children ASFs during fasting for fear of contamination of cooking utensils and violation of religious fasting rules, traditional perception that certain ASFs should be served first to the father before anybody in the family and discarding of colostrums[36,41]. Our data further highlight the importance of interventions that improve feeding practices during this critical period of complementary feeding.

Deficits in growth-limiting micronutrients such as Zn, Ca and vitamins A and C from complementary foods eaten by children in the study area were very pronounced when compared with the WHO estimated needs. However, despite the reliance on plant-based diets, which are not a rich source of bioavailable iron[42], an important finding of the present study is that the median intakes or density of Fe met estimated or desired values from complementary foods when moderate bioavailability was assumed. Similarly, previous studies from elsewhere in Ethiopia and Malawi have consistently reported high Fe intakes despite reliance on plant-based diets[9,26,42,43]. Previous literature has linked this Fe to soil contamination during local processing of cereals and the iron concentration of the soil where the plants were grown and harvested[44]. In this situation if some proportion of the contaminant iron joins the body's iron pool, the effect on iron status could be important. However, it is unfortunate that none of the studies have compared the bioavailability and exchangeability of contaminant iron to that of the iron intrinsic to the foods. Thus, future study is recommended to determine the bioavailability and exchangeability of both intrinsic and extrinsic sources of iron in this and other settings.

Several limitations have to be considered when interpreting the present study findings. First, the observational nature of the study does not allow us to establish cause and effect relationships. Second, the seasonal variation of the food patterns may affect the nutrient intakes. However, some micronutrients like Fe, Zn and Ca are little affected by seasonal variation. Furthermore, because the study was conducted during the harvesting season, food shortages were less likely to be a problem in the reported intakes than they may be in other seasons. Because the study was performed in one food insecure district, the findings might not to be generalisable for the entire region. Nevertheless, our energy and selected micronutrient intake data paralleled other studies conducted elsewhere in Ethiopia. Another limitation of the present study is that breast-milk intake was not quantified but was assumed to be of average composition and amount. This assumption has potential implications for the intakes of riboflavin, thiamine, vitamins A, B12 and C considering that the breast-milk concentration of these nutrients can be reduced by poor maternal status[7]. As a result, deficits of these micronutrients could be higher than what we have estimated.

Notwithstanding the limitations mentioned above, the present study has several strengths. This study is the first quantitative study to assess energy and micronutrient intakes of infants and young children in a largely food insecure rural area in northern Ethiopia. Our dietary intake data is supplemented by 24 h dietary recall information, detailed information on maternal, household and child characteristics like anthropometric measurements, as well as maternal exposure to IYCF activities. Our findings demonstrate important factors which might contribute to poor anthropometric status of the studied children. Moreover, given the implementation of the Seqota Declaration since 2015, and inputs from PSNP in Ethiopia, our findings serve as important evidence on IYCF practices and nutrient intakes from complementary foods for nutrition programs in the region and other parts of the country.

Conclusion

Despite implementation of the PSNP program since 2005, our study highlights that suboptimal complementary feeding practices are common. Median intakes and density of total protein, Fe and niacin from complementary foods were above estimated needs. However, shortfalls of energy and growth-limiting micronutrients (Zn, Ca, riboflavin and vitamin A) from complementary foods were widespread among studied children. Also, the very high levels of stunting and high levels of underweight observed were unacceptable. These important findings have implications for the design and implementation of interventions that aim to improve complementary feeding practices and prevent undernutrition. Efforts to optimise the use of locally available foods and strengthening social and behaviour change communications are urgently needed in food insecure settings. Future research is warranted to answer the following questions: Why the ownership of nutrition cards is low and how the government distributed the cards? Who controls the money for purchase of more nutritious foods? How do fasting patterns of adult family members affect complementary foods available for children? Do women have good land for gardens? Do husbands have more education than their wives? If so, does the level of education in some way make them more receptive to information about complementary feeding, or is most of the effect through having more income?

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