Public Health Nutrition: 16(10), 1741–1750 doi:10.1017/S1368980012005277

Nutrient intakes from complementary foods consumed by young children (aged 12–23 months) from North Wollo, northern Ethiopia: the need for agro-ecologically adapted interventions

Kaleab Baye[1,2,*], Jean-Pierre Guyot[2], Christèle Icard-Vernière[2] and Claire Mouquet-Rivier[2]

[1]Center for Food Science and Nutrition, Addis Ababa University, PO Box 150201, Addis Ababa, Ethiopia: [2]IRD UMR 204 «Prévention des Malnutritions et des Pathologies Associées» (Nutripass), IRD/UM1/UM2, Montpellier, France

Submitted 14 July 2012: Final revision received 10 October 2012: Accepted 7 November 2012: First published online 13 December 2012

Abstract

Objective: To characterize current feeding practices and to evaluate the adequacy of energy and nutrient intakes of young children in subsistence farming rural households in North Wollo, Ethiopia.

Design: A cross-sectional study examining sociodemographic status, anthropometry, breast-feeding and complementary feeding practices using two in-home non-consecutive 24 h recalls.

Settings: Two rural villages in the highlands and lowlands of Gobalafto district, North Wollo.

Subjects: Seventy-six young children aged 12–23 months, thirty-nine from the lowlands and thirty-seven from the highlands.

Results: About 33 % of the children, ~46 % in the highlands and 24 % in the lowlands ($P = 0{\cdot}05$), were stunted. Complementary diets were low in animal products, fruits and vegetables. Cereals and legumes were the major sources of energy, protein, Ca, Fe, Zn and vitamin A. Legumes with potentially toxic components (grass pea, broad beans) and low nutrient-dense beverages such as tea were frequently consumed. Intakes of energy, Ca, Zn, vitamin A and vitamin C from complementary foods were below WHO recommendations assuming average breast-milk intakes. In contrast, Fe and protein intakes and densities met WHO recommendations. Although vitamin C intakes and densities were higher ($P < 0{\cdot}05$) for the lowlands, they remained far below WHO recommendations.

Conclusions: Interventions promoting the WHO guiding principles for complementary feeding practices and behaviours that take the agro-ecological contexts into account are needed here. Furthermore, specific recommendations should be formulated to discourage the consumption of grass pea, broad beans and low nutrient-dense beverages such as tea.

Keywords
Feeding practices
Micronutrients
Complementary foods
Altitude

The period of complementary feeding (6–23 months) is of particular importance as this is when infants and young children experience rapid growth and development. During this period, growth faltering and micronutrient deficiencies are highly prevalent because of children's high nutrient needs relative to their energy and micronutrient intakes[1]. Among micronutrient deficiencies, vitamin A, Fe and Zn deficiencies are the most prevalent[2]. In children, these deficiencies are associated with poor growth, impaired cognitive development and poor health status[3]. The overwhelming impact of growth faltering is usually irreversible after the age of 2 years, thereby leaving a small window of opportunity for intervention[4]. In this regard, the role of adequate complementary feeding, both in quantity and quality, is of great importance.

Despite recent improvements, child malnutrition remains a public health concern in Ethiopia. With ~44 % of children under the age of 5 years being stunted, 10 % being wasted and 29 % being underweight relative to the WHO 2006 multicentre growth reference[5,6], Ethiopia has one of the highest malnutrition rates in sub-Saharan Africa. In this region, like in many developing countries, complementary foods are largely made of unrefined cereals and legumes which may be inadequate in energy and growth-limiting micronutrients such as Fe and Zn because of poor bioavailability[7].

*Corresponding author: Email kaleabbaye@gmail.com

Studies on nutrient intakes of pregnant and lactating women in Ethiopia showed that Zn intakes but not Fe intakes were inadequate and that despite low consumption of animal-source foods (ASF), prevalence of Fe-deficiency anaemia was low for women in late pregnancy[8,9]. By 12 months of age, most young children already consume the same diet as adults. However, little is known about the adequacy of energy and nutrient intakes in children who consume an adult diet. Recently, the complementary feeding practices and energy and nutrient adequacy of complementary foods were evaluated in the southern part of Ethiopia where maize-based meals predominate[10]. However, such studies are also needed in the northern part of the country where food staples are quite different. Furthermore, in northern Ethiopia, there are considerable variations in altitude that influence the type of major food staples that can be grown and hence consumed in subsistence farming households.

There is therefore an urgent need for current quantitative data on feeding practices as well as on energy and nutrient adequacy of the diets of young children (aged 12–23 months) for the design of interventions aimed at improving the quality of complementary feeding. In the present cross-sectional study, data were generated on anthropometric indices, feeding practices and dietary intakes of young children from two agro-ecologically distinct villages (highland at altitude of ~3500 m/lowland at ~1500 m above sea level) in Gobalafto district, using a two non-consecutive 24 h recalls, to:

1. characterize the feeding practices of young children (aged 12–23 months) in Gobalafto district, North Wollo; and
2. calculate energy and nutrient intakes from complementary foods and evaluate their adequacy with respect to WHO recommendations.

Methods

Participants

The study was conducted in Gobalafto district, Amhara region, North Wollo, Ethiopia. The prevalence of stunted children (aged 6–59 months) in the Amhara region (52 %) is above the national average (44 %)[6]. The area is characterized by a rugged terrain with inhabited mountains reaching 3600 m above sea level and lowlands up to 1000 m above sea level. Two villages, Debot in the highlands (~3500 m) and Doro-gibir in the lowlands (~1500 m), were surveyed. To be selected, the villages needed to be accessible enough for the collection of perishable samples.

The subjects of the present study were 12–23-month-old children (n 76) drawn from the databases of local health centres completed by a census conducted before the survey. For the lowland sample, fifty-six children were first identified among whom forty were randomly selected; whereas for the highland, only thirty-eight were identified and all were included in the study. Selection criteria to include a child in the study were for the child to reside permanently in the study area and to be apparently healthy. In the rare cases when several children in the same household fulfilled the inclusion criteria, one child was randomly selected.

Ethical approval was obtained from the Human Ethics Committees of Addis Ababa University and the Amhara Regional Health Bureau. Verbal informed consent was obtained from the mother or guardian of each child after the purpose and methods of the study had been explained in detail to them in the presence of local health community workers and *kebele* (smallest administrative unit) administrators. All parents asked to participate in the study accepted, with the exception of those whose child was sick (n 1) or who had to leave the village temporarily for a funeral (n 1). All questionnaires were translated into Amharic before the survey.

The study was conducted from August to October 2010. Data on sociodemographic status, anthropometry, feeding practices and dietary intakes were generated on sixty-two (thirty in highlands, thirty-two in lowlands) breast-fed (BF) and fourteen (seven from each site) non-breast-fed (NBF) children.

Sociodemographic status and anthropometric measures

Sociodemographic characteristics of the participants were assessed using a pre-tested questionnaire that included questions on livelihood activities, education level of parents, health and sanitary facilities, ownership of livestock and the size of land owned.

All anthropometric measurements were made by the same person to avoid inter-examiner errors. The length and weight of the children were measured in triplicate using standardized techniques with the children wearing light clothing and no shoes. *Z*-scores for length-for-age (LAZ), weight-for-age (WAZ) and weight-for-length (WLZ) were calculated using the WHO multicentre growth reference data[5] using the software ENA 2007. None of the children had unacceptably extreme anthropometric values[11]. Stunting, underweight and wasting were defined respectively as LAZ, WAZ or WLZ <-2.

Dietary intake assessment

An interactive quantitative 24 h recall was conducted with the caregivers of the children (n 76) using the multiple-pass technique adapted and validated for use in developing countries[12]. In addition, a second day assessment was conducted (n 70). All days of the week were equally represented in the final sample. Experienced data collectors were locally recruited and trained in a classroom setting. This was followed by a pilot test on a group comparable to that of the actual study.

A day before intake was assessed (two days before the recall) plates and cups were provided to the caregivers who were instructed to not change the dietary pattern of the child on the recall day. A demonstration was given on how the amount of each food consumed would be estimated. The interview was conducted in the participants' homes.

Portions were mostly estimated by direct weighing of salted replicas of actual foods prepared locally. The salted replicas consisted of *injera* (fermented flat, pancake), *shiro* (a legume-based spicy stew) and bread. Otherwise, graduated food models and common household measures were used. In most cases, siblings living in the household helped the caregiver in the recall by also following the child on the recall day.

Collection of samples of complementary foods

The foods that were most frequently consumed by the young children were identified and their traditional preparations by women (n 10) in both highland and lowland areas were observed. Samples of *injera* made from teff–white sorghum (n 5), wheat–red sorghum (n 3) and barley–wheat (n 3) blends, *shiro* from grass pea and broad beans (n 5) and split field pea stews (n 5) were collected from households. The raw materials used were also collected for analysis. Separate samples were collected for moisture content determination and biochemical analysis. The collected samples were transferred to a deep freeze (−20°C) at a local health centre within 2 h of collection. Samples were freeze dried before further analysis.

Food composition analyses

DM content

DM contents were determined by oven drying at 105°C to constant weight.

Protein content

Protein content (N×6·25) was determined by the method of Kjeldahl[13] based on determination of N content.

Fe, Zn and Ca analyses

Fe, Zn and Ca were analysed by flame atomic absorption spectrophotometry (AA800; Perkin Elmer, Les Ulis, France) after wet mineralization using an Ethos 1 microwave digester (Milestone, Sorisole, Italy) for 15 min at 200°C and with a maximum power of 1000 W.

Accuracy and precision of the analyses were checked by analysis of certified reference materials (BCR 191: brown bread and BCR 679: white cabbage).

Compilation of local food composition database

Whenever possible (i.e. for most cereal- and legume-based foods), values for protein, Ca, Fe and Zn contents were based on results of biochemical analyses conducted in our laboratory; otherwise data were compiled from Ethiopian food composition tables[14–16] and published data[17,18]. Missing values were compiled from the US Department of Agriculture database[19], after adjustment of moisture content.

Assessment of nutrient intake adequacy from complementary foods

The median daily intakes from complementary foods of 12–23-month-old children were compared with estimated needs for energy and selected nutrients based on WHO/FAO[20–22] recommended intakes assuming average breast-milk intake and composition as proposed by WHO[23] and Dewey and Brown[24]. The mean daily nutrient intakes from breast milk, assuming an average intake of 549 g/d (~533 ml/d), were 1447 kJ energy, 5·8 g protein, 154 mg Ca, 0·2 mg Fe, 0·7 mg Zn, 275 μg RE (retinol equivalent) vitamin A and 22 mg vitamin C. Nutrient densities (per 418 kJ/100 kcal) were compared with desired values calculated by Dewey and Brown[24]. Median dietary diversity scores were calculated based on seven food groups as described in WHO[25] and classified as low (0–2), medium (3–4) and high (>4) according to Arimond and Ruel[26].

Statistical analyses

All continuous variables were checked for normality using the Kolmogorov–Smirnov test. Dietary intakes (per day) and nutrient densities (per 418 kJ/100 kcal) were expressed as medians and interquartile range because of non-normal distributions of some nutrients. Differences in the median energy and nutrient intakes between highlands and lowlands were examined using the non-parametric Mann–Whitney U test (two-tailed). For categorical variables, Fisher exact's test (one-tailed) was used. In all comparisons, differences were considered statistically significant when $P < 0·05$. Statistical analyses were performed using the SPSS statistical software package version 15.

Results

Sociodemographic characteristics and anthropometric status

The mothers surveyed had on average two or three children (Table 1). Most mothers were housewives, except for some who had some small trading activities. More mothers in the lowland village had a formal education than in the highland village ($P = 0·03$). About 79 % of the households owned private latrines. Fewer households in the highlands owned ≥1 ha of land than in the lowlands ($P = 0·001$). Thirty-four per cent of the households owned cows, and 55 % owned chickens. More households in the highlands owned chickens than in the lowlands ($P = 0·009$). More children were stunted in the highlands than in the lowlands ($P = 0·05$).

Feeding practices

Over 90 % of the children were fed complementary foods at least three times daily (Fig. 1); however, less than half

https://doi.org/10.1017/S1368980012005277 Published online by Cambridge University Press

Table 1 Sociodemographic characteristics and nutritional status: young children (*n* 76) aged 12–23 months from a highland village and a lowland village in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010

	All (*n* 76)		Highlands (*n* 32)		Lowlands (*n* 39)	
	n or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD
Sociodemographic characteristics						
Mean age of child (months)	18·3	4·4	19·2	3·7	17·4	4·8
Proportion of male children	43	57	22	60	21	54
Mean age of mother (years)	28·8	10·3	27·2	6·5	30·2	12·9
Mothers with some formal education*	26	34	10	27	16	41
Mean number of children†	2·3	1·5	2·7	1·6	2·0	1·3
Livelihood activities (housewives)	60	79	25	68	35	90
Owns a sanitary facility (latrine)*	60	79	25	68	35	90
Owns ≥1 ha of land*	27	36	5	14	22	56
Owns cows	26	34	14	38	12	36
Owns chickens*	42	55	28	76	14	36
Anthropometric indices						
Mean LAZ	−1·32	1·39	−1·59	1·45	−1·02	1·31
Mean WAZ	−1·26	1·11	−1·32	1·06	−1·19	1·15
Mean WLZ	−0·84	0·92	−0·73	0·47	−0·94	1·05
Stunted*	25	33	16	46	9	24
Underweight	21	28	11	31	10	27
Wasted	9	12	2	5	7	19

LAZ, length-for-age *Z*-score; WAZ, weight-for-age *Z*-score; WLZ, weight-for-length *Z*-score.
*Difference between highland and lowland sites was statistically significant according to Fisher's exact test (one-tailed): $P = 0{\cdot}03$ for mother's education; $P = 0{\cdot}02$ for owns a sanitary facility (latrine); $P = 0{\cdot}001$ for owns ≥1 ha of land; $P = 0{\cdot}009$ for own chickens; $P = 0{\cdot}05$ for stunted.
†Difference between highlands and lowlands was statistically significant according to Student's *t* test (two-tailed), equality of variances not assumed: $P = 0{\cdot}05$.

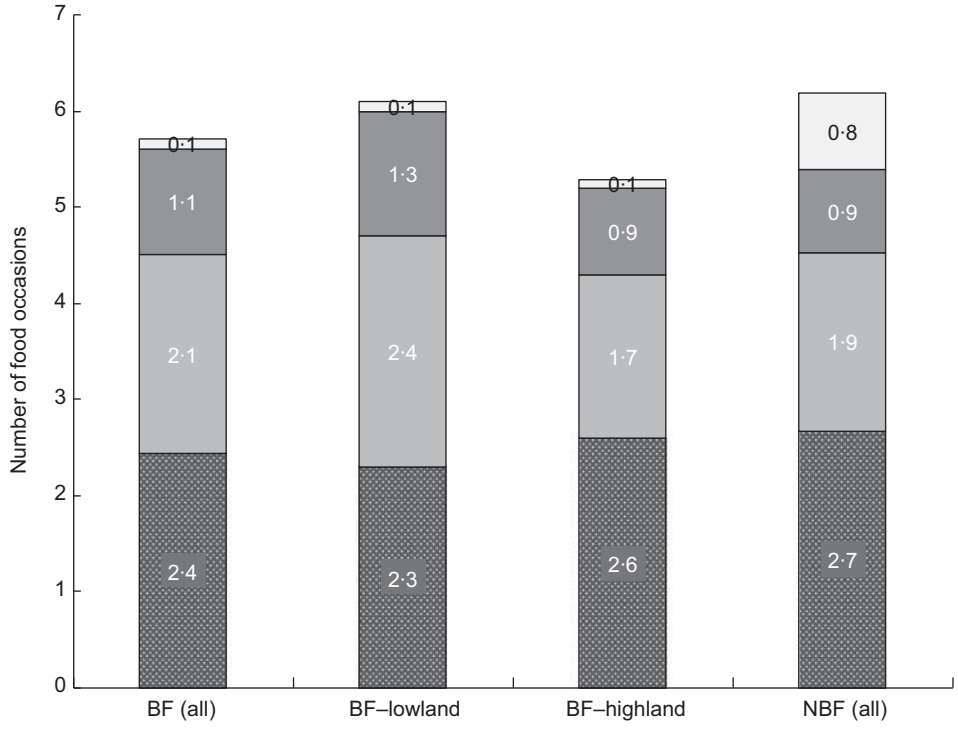

Fig. 1 Mean number of food occasions per type of food (□, gruel/porridges; ■, beverages; ▒, snacks; ▩, family foods) among breast-fed (BF) and non-breast-fed (NBF) young children (*n* 76) aged 12–23 months from a highland village (*n* 37) and a lowland village (*n* 39) in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010

met the minimum number of food groups (≥3; Table 2). Many of the children's dietary diversity scores were in the low (0–2) to medium (3–4) range.

The diets of the young children were predominantly based on cereals and legumes (Tables 2 and 3). Consumption of ASF as well as fruits and vegetables was very low, although fruit consumption was higher in the lowlands ($P = 0{\cdot}01$). Fruits were the major contributor to vitamin C intake. Only 1 % of the protein intake in the highlands *v.* 6 % in the lowlands was provided by ASF. Moreover,

https://doi.org/10.1017/S1368980012005277 Published online by Cambridge University Press

Table 2 Feeding practices according to breast-feeding status: young children (*n* 76) aged 12–23 months from a highland village and a lowland village in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010

	BF children						NBF children	
	All (*n* 62)		Highlands (*n* 30)		Lowlands (*n* 32)		All (*n* 14)	
	n or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD
Cereal products	62	100	30	100	32	100	14	100
Legumes and nuts	62	100	30	100	32	100	14	100
Animal-source foods								
Dairy	5	8	1	3	4	13	4	29
Eggs	3	5	0	0	3	8	0	0
Meat & poultry	2	3	0	0	2	5	0	0
Vitamin A-rich fruits & vegetables	11	18	3	10	8	25	0	0
Other fruits*	13	21	2	8	11	31	2	14
Tea	17	27	8	38	9	33	10	71
Coffee	2	3	2	8	0	0	1	7
Mean number of food groups (out of 7)	2·4	0·8	2·2	0·4	2·6	1·0	2·5	0·7
0–2	42	68	23	77	19	59	8	57
3–4	19	31	7	23	12	38	6	43
≥5	1	2	0	0	1	3	0	0
Fed minimum number of food groups or more†	20	32	7	23	13	41	6	43
Fed minimum number of solid/semi-solid foods‡	58	94	29	97	29	91	14	100
Fed according to IYCF practices§	20	32	7	23	13	41	4	29

BF, breast-fed; NBF, non-breast-fed; IYCF, infant and young child feeding.
*Statistically significant difference between highland and lowland sites according to Fisher's exact test (one-tailed): $P = 0{\cdot}01$.
†Minimum number of food groups: at least three daily for BF children and at least four daily for NBF children.
‡Minimum number of meals: three daily for BF children and four daily for NBF children.
§For BF children: need to be fed solids/semi-solids at least three times daily and be fed a minimum of three food groups[24]. For NBF children: need to drink at least two milk feedings and be fed at least four food groups (not including milk feeds) a minimum of four times daily[24].

Table 3 Percentage contribution (when ≥15 %) to energy and selected nutrient intakes from different food groups according to breast-feeding status: young children (*n* 76) aged 12–23 months from a highland village and a lowland village in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010

	BF children			NBF children
	All (*n* 62)	Highlands (*n* 30)	Lowlands (*n* 32)	All (*n* 14)
Energy	Cereals (75) Legumes (17)	Cereals (73) Legumes (20)	Cereals (78) Legumes (15)	Cereals (71) Legumes (18)
Protein	Cereals (57) Legumes (28)	Cereals (55) Legumes (35)	Cereals (58) Legumes (21)	Cereals (60) Legumes (26)
Ca	Cereals (37) Legumes (20)	Cereals (38) Legumes (25)	Cereals (37) Dairy products (23) Legumes (16)	Cereals (34) Legumes (18) Dairy products (28)
Vitamin A	Legumes (38) Cereals (17) Root & tubers (15) Vegetables (16)	Legumes (26) Cereals (24) Root & tubers (24) Vegetables (16)	Legumes (50) Vegetables (19)	Legumes (55) Fruits (18) Root & tubers (17)
Fe	Cereals (61) Legumes (29)	Cereals (54) Legumes (37)	Cereals (68) Legumes (21)	Cereals (67) Legumes (25)
Zn	Cereals (62) Legumes (21)	Cereals (64) Legumes (25)	Cereals (60) Legumes (17)	Cereals (61) Legumes (20)
Vitamin C	Fruits (81)	Fruits (80)	Fruits (83)	Fruits (86)

BF, breast-fed; NBF, non-breast-fed.

the contribution of ASF to Fe intake was very low: 0 % in the highlands *v.* 6 % in the lowlands (data not shown).

Most children's complementary feeding practices were not in line with the recommended infant and young child feeding (IYCF) practices[25], as only few BF children consumed three or more food groups and were fed at least three times daily. Similarly, only a few NBF children were fed according to recommended IYCF practices[25].

A high proportion of the foods consumed by the children were family foods (Figs 1 and 2). The staple (family food) in both sites (like in the rest of Ethiopia) is *injera,* a flat fermented pancake that is consumed with stews, which was consumed by all children surveyed. However, the cereals used for the preparation of *injera* differed at the two sites. A mix of teff and sorghum was most commonly used in the lowlands, whereas mixes of barley and wheat or wheat and red sorghum were used in the highlands. *Injera* is consumed at all main meals, only the types of stews vary.

Shiro was the most commonly consumed stew, with about 81 % of the children having consumed it. This consists of roast, decorticated and ground legumes mixed with spices and then cooked. The most frequently

https://doi.org/10.1017/S1368980012005277 Published online by Cambridge University Press

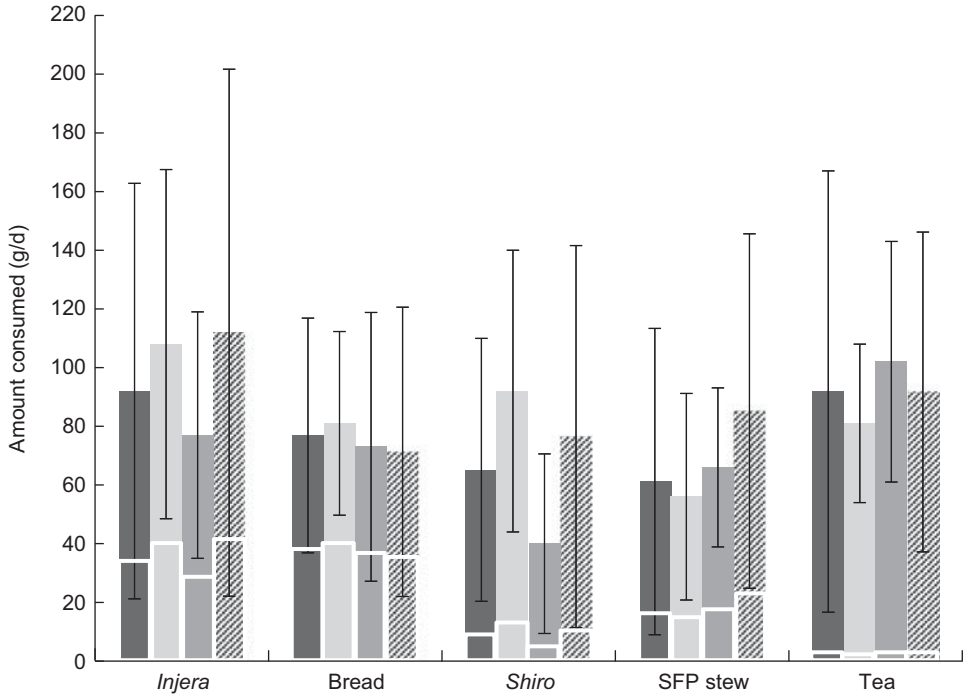

Fig. 2 Mean amounts of most frequently consumed foods per day, when eaten, among breast-fed (BF) and non-breast-fed (NBF) young children (*n* 76) aged 12–23 months from a highland village (*n* 37) and a lowland village (*n* 39) in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010. ■, BF (all); □, BF–highlands; ▒, BF–lowlands; ▨, NBF (all). Values are means with their standard deviations represented by vertical bars; the white border represents the amount consumed (g DM) on dry weight basis (SFP stew, split field pea stew)

used legumes were grass pea (*Lathyrus sativus* L.) and broad beans (*Vicia faba* L.). After *shiro*, the next most frequently consumed stew (by 42 % of children) was made from split field peas (*Pisum sativum* L.). Very few meals such as gruels/porridges were specifically prepared for the children. More gruels/porridges were consumed by NBF than BF children. Mostly aluminium but also clay pots were used for cooking the foods. Snacks consisted of leavened bread, unleavened bread (*kitta*) or fruits.

Beverages consisted of tea, coffee, milk and in some instances *tella,* a local beer. The most frequently consumed beverage was tea. The children mostly drank tea with their breakfast, which was usually wheat bread. Otherwise, almost all of the children drank water after each meal. The amounts of food consumed per day and per type of food were low (Fig. 2), and appeared even lower, in particular for tea, when taking into account only the nutritious part of the food, i.e. expressed on a dry weight basis. Thus, it clearly appears that the main sources of nutrients in the young children's diet were cereals (*injera* + bread).

Adequacy of energy and selected nutrient intakes from complementary foods

Intakes of energy, Ca, vitamin A and vitamin C from complementary foods were far below estimated needs (Table 4). Zn intakes were also below the estimated needs when low bioavailability was assumed (15 %), which is highly probable as the diet is based predominantly on cereals and legumes. On the other hand, Fe and protein intakes met estimated needs. Fe intakes from complementary foods met estimated needs even under the assumption of low bioavailability (5 %). Consumption of Fe-fortified foods was non-existent. There were no significant differences in intakes between the highland and lowland villages except for vitamin C, of which more was consumed in the lowlands ($P < 0{\cdot}001$). Diets of BF and NBF children were similar; hence, the nutrients found to be suboptimal were the same. It also appeared that NBF children ate larger quantities and as a result had higher energy and nutrient intakes. When consumed, NBF children ate two times more gruel (amount) than BF children.

Ca, vitamin A and vitamin C densities were below the desired values (Table 5). Zn met desired values, but only when moderate bioavailability was assumed, whereas Fe met desired values even under the assumption of low bioavailability. Protein densities also met desired values. When comparing the two sites, vitamin C intakes and densities were seen to be significantly higher ($P < 0{\cdot}001$) in the lowlands, whereas protein ($P = 0{\cdot}04$) and Zn ($P = 0{\cdot}02$) densities were higher in the highlands.

Discussion

The present study evaluated the feeding practices and energy and nutrient intakes from complementary foods of

https://doi.org/10.1017/S1368980012005277 Published online by Cambridge University Press

Table 4 Estimated daily median intakes (Q1, Q3) of energy and selected nutrients from non-breast-milk foods according to breast-feeding status in comparison with estimated needs: young children (*n* 76) aged 12–23 months from a highland village and a lowland village in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010

	BF children (mean age: 18·0 (SD 4·4) months)							NBF children (mean age: 19·6 (SD 4·1) months)		
	All (*n* 62)		Lowlands (*n* 32)		Highlands (*n* 30)			All (*n* 14)		
Nutrient	Median	Q1, Q3	Median	Q1, Q3	Median	Q1, Q3	Estimated needs†	Median	Q1, Q3	RNI‡
Energy (kJ)	1598	1109, 2406	1669	837, 2284	1774	1343, 2485	2293	3548	1971, 4243	3740
Protein (g)	13·8	9·5, 20·2	12·8	6·1, 20·3	16·2	11·1, 20·9	5	33·4	13·8, 36·6	10·8
Ca (mg)	102	70, 168	96	51, 191	116	84, 172	346	215	146, 327	500·0
Fe (mg)	15·0	7·6, 23·4	13·0	5·5, 25·9	17·9	10·6, 24·1		28·9	12·9, 39·1	
L							11·4			11·6
M							5·6			5·8
Zn (mg)	3·3	2·0, 4·7	2·6	1·4, 3·8	3·8	2·3, 5·1		6·7	3·9, 8·1	
L							7·6			8·3
M							3·8			4·1
Vitamin A (μg RE)	53·6	16·6, 86·3	31·5	11·3, 89·5	56·0	41·4, 87·3	126	39·4	23·2, 133·6	400
Vitamin C* (mg)	0·8	0·2, 4·1	2·3	0·7, 7·3	0·4	0·0, 2·0	8	4·6	1·0, 23·0	30·0

Q1, 1st quartile; Q3, 3rd quartile; BF, breast-fed; NBF, non-breast-fed; RNI, Recommended Nutrient Intake; L, low bioavailability; M, medium bioavailability; RE, retinol equivalent.
*Statistically significant difference between highland and lowland sites according to the Mann–Whitney *U* test: $P < 0·001$.
†For BF children, estimated needs from complementary foods are determined assuming average breast-milk intake and composition as proposed by WHO[23] and Dewey and Brown[24].
‡The RNI used are those of FAO/WHO/United Nations University[20], WHO[23] and WHO/FAO[22], for energy, protein, and vitamins and minerals, respectively.

BF and NBF young children (aged 12–23 months) in Gobalafto district, northern Ethiopia. Several feeding practices were not in accordance with WHO/Pan American Health Organization recommendations[27]. Shortfalls of Zn, Ca, vitamin C and vitamin A were observed, whereas Fe and protein intakes were adequate. Differences in the intakes and densities of certain nutrients were observed between the highlands and the lowlands.

Adequate nutrition in the first 2 years of life is critical for the child's development. In this regard, optimal breast-feeding and complementary feeding play a key role. In line with recently reported Demographic and Health Survey data, continued breast-feeding beyond the age of 1 year was practised by >80 % (62/76) of the surveyed households[6]. This is important, as breast milk is a good source of energy and essential fatty acids[28]. Although continued breast-feeding is associated with greater linear growth[29], a considerable proportion of the children studied (~33 %) were stunted.

Stunting may be due to intergenerational malnutrition, frequent infections and/or inadequate diet and feeding practices[30–32]. Although it was not possible to establish causal relationships in the present study, several features of the feeding practices of the children could be linked with poor growth.

Good sources of bioavailable nutrients like ASF were seldom consumed despite ownership of livestock. Earlier studies in Ethiopia showed that livestock is considered an asset and is therefore rarely consumed[10,33]. Dairy consumption – even in NBF children – was very low, perhaps lower than that reported for children in rural Sidama, southern Ethiopia[10]. Consumption of fruits and vegetables rich in provitamin A carotenoids also was very low despite recommendations to consume them daily[27]. This is in line with previous reports on Ethiopian complementary diets[7,10,26].

Frequent consumption of coffee and tea was observed. Such beverages contain phenolic compounds that inhibit the absorption of Ca and Fe. In addition to their appetite-suppressing effects, these beverages are of low nutrient density; thus when consumed especially with sugar, they may displace more nutritious foods[34]. This could partly explain the low energy intakes from complementary foods relative to WHO estimated needs. Nevertheless, since >90 % of the children were fed at least three times daily, better coverage of energy needs would have been expected. However, the quantity of foods consumed was small, probably due to the poor practice of responsive feeding and/or to malnutrition/infection-associated anorexia. Irrespective of the type of food consumed, the quantity did not exceed ~9 (SD 4) g/kg body weight per meal (calculation not shown), which is much lower than the theoretical gastric capacity of 30 g/kg body weight per meal.

In view of the low energy intake, the low dietary diversity and the low nutrient density of the foods consumed, the

Table 5 Median (Q1, Q3 quartile) nutrient densities of complementary foods in BF children in comparison with desired nutrient densities: young children (*n* 76) aged 12–23 months from a highland village and a lowland village in Gobalafto district, North Wollo, northern Ethiopia, August–October 2010

	All BF (*n* 62)		Lowlands (*n* 32)		Highlands (*n* 30)		
Nutrient density (per 418 kJ/100 kcal)	Median	Q1, Q3	Median	Q1, Q3	Median	Q1, Q3	Desired value†
Protein* (g)	3·4	3·1, 3·7	3·2	2·8, 3·6	3·5	3·2, 3·8	0·9
Ca (mg)	25·9	20·5, 34·2	24·9	20·3, 33·8	27·2	21·1, 34·3	63
Fe (mg)	3·8	2·6, 4·8	3·6	2·5, 4·5	3·9	2·6, 5·7	
L							2·1
M							1·0
Zn* (mg)	0·7	0·6, 0·9	0·7	0·6, 0·8	0·8	0·6, 0·9	
L							1·4
M							0·6
Vitamin A (μg RE)	12·8	6·3, 20·5	9·0	3·7, 18·3	14·6	8·0, 26·3	23
Vitamin C* (mg)	0·2	0·1, 1·4	0·5	0·2, 2·3	0·08	0·0, 0·3	1·5

Q1, 1st quartile; Q3, 3rd quartile; BF, breast-fed; L, low bioavailability; M, medium bioavailability; RE, retinol equivalent.
*Statistically significant difference between the highland and lowland sites according to the Mann–Whitney *U* test: $P = 0{\cdot}04$ for protein; $P = 0{\cdot}02$ for Zn; $P < 0{\cdot}001$ for vitamin C.
†Desired values were those calculated by Dewey and Brown[24].

high rate of stunting and the observed shortfalls of Zn, Ca, vitamin C and vitamin A are not surprising. Evidence for a close association between dietary diversity, stunting and micronutrient deficiencies in developing countries is already well documented[10,35–38]. Furthermore, considering the high proportion of stunted children, shortfalls may even be more pronounced if the children have to catch up on their growth[39].

However, a notable finding in the present study is that Fe was not a 'problem nutrient', as intakes and densities were above the estimated needs and desired values, even under the assumption of low bioavailability (5 %). Previous studies have shown that adult Fe intake in Ethiopia surpasses recommended values[8,40] and this was attributed to the high Fe contents of most cereals grown in the country[17,18]. However, a large proportion of this Fe was attributed to soil contamination[18,41]. Further investigations are required to evaluate the bioavailability of both intrinsic and contaminant Fe.

Of great concern is the wide consumption of legumes with toxic components like grass peas and broad beans. Grass pea (*Lathyrus sativus*) is associated with neurolathyrism, a neurodegenerative disorder, whereas broad bean (*V. faba* L.) is associated with favism, a haemolytic anaemia. Consumption of diets containing 30 % grass pea for 3 months or more is generally enough to trigger the onset of neurolathyrism[42]. However, consuming grass peas mixed with cereals rich in sulfur-containing amino acids can reduce the associated adverse effects[43]. So supplementing *shiro* with *injera* may help reduce the toxicity of grass pea[37], in addition to improving the quality and the content of proteins, as evidenced by the adequate protein intakes. Furthermore, processes such as soaking and roasting of grains, and the inclusion of spices with known antioxidant properties (ginger, garlic, etc.) in the preparation of *shiro*, may further reduce toxic effects[43]. However, considering the endemicity of neurolathyrism in the northern parts of Ethiopia[44], the low body weight of the children and the multiple micronutrient deficiencies these children may present, replacing grass peas and broad beans by other available legumes such as lentils, chickpeas and field peas may be preferable.

Despite the small sample of children surveyed at each site, comparison between the highlands and the lowlands revealed statistically significant differences in vitamin C intakes as well as Zn and protein densities of the diets. More stunted children were observed in the highlands ($P = 0{\cdot}05$). Possible explanations may be the harsh physical and socio-economic conditions in the highlands, the difference in staple cereals and the higher availability and thus higher consumption of fruits in the lowlands. This finding suggests that even more pronounced differences between the highlands and lowlands are likely, thus a more detailed study based on a larger sample from several highland and lowland sites is required. The small number of NBF children requires caution in interpreting the results.

The cross-sectional nature of the present study did not allow seasonal variation in food intakes to be considered. Although caregivers were instructed to not change their children's dietary pattern, this does not warrant the absence of deliberate changes. A further limitation is that breast-milk consumption was not quantified, thus values of average breast-milk intake reported in the literature were used to calculate the adequacy of energy and nutrient intakes.

Conclusions and recommendations

The present study provided an overview of the feeding pattern of young children in two rural villages (highlands/lowlands) in Gobalafto district, North Wollo, northern Ethiopia. The study provided evidence that, except for Fe and protein, energy and nutrient intakes were far below WHO recommendations.

https://doi.org/10.1017/S1368980012005277 Published online by Cambridge University Press

In both highlands and lowlands, efforts to enhance dietary diversity by including ASF, dairy, and fruits and vegetables rich in vitamin A and vitamin C are needed.

However, promotion of consumption of fruits will first need selection and cultivation of varieties adapted to the agro-climatic conditions of the highlands. In the immediate future, including available green leafy vegetables like stinging nettles (*Urtica dioica* L.) in the complementary diets of the children in the highlands may help enrich the diets with vitamin C, provitamin A carotenoids and minerals[45].

Although beverages such as tea and coffee have the advantage of usually being safer in terms of microbial contamination, in view of their negative effects on mineral absorption and the appetite of the children, their consumption should be discouraged. Caregivers should also be informed of the potential toxicities associated with consumption of grass peas and broad beans, and the consumption of other available legumes like chickpeas, lentils and field peas should be encouraged. Further research on the effect of traditional processing on the toxic component of grass pea is needed. Future nutritional interventions may need to take into account potential agro-ecological influences on feeding practices and nutrient intakes.

Acknowledgements

Sources of funding: This research was supported by a grant from the French Embassy in Ethiopia. *Conflicts of interest:* The authors declare that they have no conflicts of interest. *Author contributions:* All authors were involved in developing the study design. K.B. coordinated and supervised the field work. K.B. and C.I.-V. conducted the biochemical analysis. K.B. and C.M.-R. calculated the nutrient intakes and analysed the data. K.B., J.-P.G. and C.M.-R. participated in the interpretation of the data. All authors contributed to manuscript preparation. *Acknowledgements:* The authors thank all of the children and families who participated in this survey, and all of the dedicated data collectors who carried out the dietary recall interviews. Special thanks go to Eyerus Taddesse for her high-quality assistance during the survey.

References

1. Shrimpton R, Victora CG, de Onis M *et al.* (2001) Worldwide timing of growth faltering: implications for nutritional interventions. *Pediatrics* **107**, e75.
2. Sanghvi T, Ross J & Heymann H (2007) Why is reducing vitamin and mineral deficiencies critical for development? *Food Nutr Bull* **28**, issue 1, S167–S173.
3. Black RE, Allen LH, Bhutta ZA *et al.* (2008) Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* **371**, 243–260.
4. Martorell R, Kahn LK & Schroeder DG (1994) Reversibility of stunting: epidemiological findings in children from developing countries. *Eur J Clin Nutr* **48**, Suppl.1, S45–S57.
5. WHO Multicentre Growth Reference Study Group (2006) WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatr Suppl* **450**, 76–85.
6. Central Statistical Agency & ORC Macro (2011) *Ethiopian Demographic and Health Survey – Preliminary Report.* Addis Ababa and Calverton. MD: CSA and ORC Macro.
7. Mukuria AG, Kothari MT & Abderrahim N (2006) *Infant and Young Child Feeding Update.* Calverton, MD: ORC Macro.
8. Abebe Y, Bogale A, Hambidge KM *et al.* (2008) Inadequate intakes of dietary zinc among pregnant women from subsistence households in Sidama, Southern Ethiopia. *Public Health Nutr* **11**, 379–386.
9. Gibson RS, Abebe Y, Stabler S *et al.* (2008) Zinc, gravida, infection, and iron, but not vitamin B-12 or folate status, predict hemoglobin during pregnancy in southern Ethiopia. *J Nutr* **138**, 581–586.
10. Gibson RS, Abebe Y, Hambidge KM *et al.* (2009) Inadequate feeding practices and impaired growth among children from subsistence farming households in Sidama, southern Ethiopia. *Matern Child Nutr* **5**, 260–275.
11. World Health Organization (1995) *Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series* no. 854. Geneva: WHO.
12. Gibson RS & Ferguson EL (1999) *An Interactive 24-hr Recall for Assessing the Adequacy of Iron and Zinc Intakes in Developing Countries.* Washington, DC: International Life Sciences Institute Publishers.
13. Agence Française de Normalisation (1970) *Dosage de l'azote avec minéralisation selon la méthode de Kjeldahl. Standard NF V03-050.* Paris: AFNOR.
14. Ågren G & Gibson RS (1968) *Food Composition Table for Use in Ethiopia. Report* no. 16. Addis Ababa: Child Nutrition Unit.
15. Ethiopian Nutrition Institute (1981) *Expanded Food Composition Table for Use in Ethiopia.* Addis Ababa: ENI.
16. Ethiopia Health and Nutrition Research Unit/Food Agriculture Organization of the United Nations (1998) *Food Composition Table for Use in Ethiopia.* Addis Ababa: EHNRU/FAO.
17. Umeta M, West CE & Fufa H (2005) Content of zinc, iron, calcium and their absorption inhibitors in foods commonly consumed in Ethiopia. *J Food Compost Anal* **18**, 803–817.
18. Abebe Y, Bogale A, Hambidge KM *et al.* (2007) Phytate, zinc, iron and calcium content of selected raw and prepared foods consumed in rural Sidama, southern Ethiopia, and implications for bioavailability. *J Food Compost Anal* **20**, 161–168.
19. US Department of Agriculture (2003) National nutrient database for standard reference. http:// www.nal.usda.gov/fnic/foodcomp (accessed December 2010).
20. Food and Agriculture Organization of the United Nations/World Health Organization/United Nations University (2004) *Human Energy Requirements. Food and Nutrition Technical Report Series* no. 1. Rome: FAO/WHO/UNU.
21. Butte NF, Wong WW, Hopkinson JM *et al.* (2000) Energy requirements derived from total energy expenditure and energy deposition during the first 2 y of life. *Am J Clin Nutr* **72**, 1558–1569.
22. World Health Organization/Food and Agriculture Organization of the United Nations (2004) *Vitamin and Mineral Requirements in Human Nutrition*, 2nd ed. Geneva: WHO.
23. World Health Organization (1998) *Complementary Feeding of Young Children in Developing Countries: A Review of Current Scientific Knowledge.* Geneva: WHO.
24. Dewey K & Brown K (2003) Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Food Nutr Bull* **24**, 5–28.

25. World Health Organization (2008) *Indicators for Assessing Infant and Young Child Feeding Fractices*. Geneva: WHO.
26. Arimond M & Ruel MT (2004) Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. *J Nutr* **134**, 2579–2585.
27. Pan American Health Organization/World Health Organization (2003) *Guiding Principles for Complementary Feeding of the Breastfed Child*. Washington, DC: PAHO Division of Health Promotion and Protection, Food and Nutrition Program.
28. Onyango AW, Receveur O & Esrey SA (2002) The contribution of breast milk to toddler diets in western Kenya. *Bull World Health Organ* **80**, 292–299.
29. Simondon KB, Simondon F, Costes R *et al.* (2001) Breastfeeding is associated with improved growth in length, but not weight, in rural Senegalese toddlers. *Am J Clin Nutr* **73**, 959–967.
30. Ramakrishnan U, Martorell R, Schroeder DG *et al.* (1999) Role of intergenerational effects on linear growth. *J Nutr* **129**, 2S Suppl., 544S–549S.
31. Rosado JL (1999) Separate and joint effects of micronutrient deficiencies on linear growth. *J Nutr* **129**, 2S Suppl., 531S–533S.
32. Stephensen CB (1999) Burden of infection on growth failure. *J Nutr* **129**, 2S Suppl., 534S–538S.
33. Good S (2009) Animal source foods nutrition during early life: an evaluation of the possible link between livestock keeping, food intake and nutritional status of young children in Ethiopia. PhD Dissertation, ETH Zurich.
34. Olness KN (1985) Nutritional consequences of drugs used in pediatrics. *Clin Pediatr* **24**, 417–420.
35. Gibson RS, Ferguson EL & Lehrfeld J (1998) Complementary foods for infant feeding in developing countries: their nutrient adequacy and improvement. *Eur J Clin Nutr* **52**, 764–770.
36. Moursi MM, Arimond M, Dewey KG *et al.* (2008) Dietary diversity is a good predictor of the micronutrient density of the diet of 6–23-month old children in Madagascar. *J Nutr* **138**, 2448–2453.
37. Lander R, Enkhjargal TS, Batjargal J *et al.* (2010) Poor dietary quality of complementary foods is associated with multiple micronutrient deficiencies during early childhood in Mongolia. *Public Health Nutr* **13**, 1304–1313.
38. Rah JH, Akhter N, Semba RD *et al.* (2010) Low dietary diversity is a predictor of child stunting in rural Bangladesh. *Eur J Clin Nutr* **64**, 1393–1398.
39. Golden MH (2009) Proposed recommended nutrient densities for moderately malnourished children. *Food Nutr Bull* **30**, 3 Suppl., S267–S342.
40. Gebre-Medhin M, Killander A, Vahlquist B *et al.* (1976) Rarity of anemia in pregnancy in Ethiopia. *Scand J Haematol* **16**, 168–175.
41. Hallberg L & Bjorn-Rasmussen E (1981) Measurement of iron absorption from meals contaminated with iron. *Am J Clin Nutr* **34**, 2808–2815.
42. Tekle Haimanot R (2009) Neurological complications of malnutrition. In *Clinical Neurotoxicology – Syndromes, Substances, Environments*, pp. 614–620 [MR Dobbs, editor]. Philadelphia, PA: Elsevier.
43. Getahun H, Lambein F, Vanhoorne M *et al.* (2005) Neurolathyrism risk depends on type of grass pea preparation and on mixing with cereals and antioxidants. *Trop Med Int Health* **10**, 169–178.
44. Haimanot RT, Feleke A & Lambein F (2005) Is lathyrism still endemic in northern Ethiopia? The case of Legambo Woreda (district) in the South Wollo Zone, Amhara National Regional State. *Ethiop J Health Dev* **19**, 230–236.
45. Guil-Guerrero JL, Rebolloso-Fuentes MM & Isasa MET (2003) Fatty acids and carotenoids from stinging nettle (*Urtica dioica* L.). *J Food Compost Anal* **16**, 111–119.