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Poor dietary quality of complementary foods is associated with multiple micronutrient deficiencies during early childhood in Mongolia

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Abstract

Objective: To assess whether persistent micronutrient deficiencies in Mongolian children identified in our earlier biochemical study are associated with inadequacies in quantity and/or quality in their complementary diets.
Design: A cross-sectional study of breast-fed children aged 6–23 months, randomly selected from four districts in Ulaanbaatar and four provincial capitals.
Subjects: Weight and length were measured, and sociodemographic status, feeding practices and nutrient adequacy of complementary foods for children aged 6–8 months (n 26), 9–11 months (n 29) and 12–23 months (n 73) were assessed via questionnaire and in-home interactive 24 h recalls.
Results: No geographic differences existed so data were combined. Adherence to WHO infant and young child feeding practices was poor: few children were exclusively breast-fed up to 6 months of age or received the recommended number of feedings containing the recommended number of food groups. Nevertheless, energy intakes from complementary diets, primarily from cereals and non-nutritious snacks, were above WHO-estimated needs; <1 % of energy was from meat and eggs or fruits and vegetables. Median intakes and densities of most nutrients (except protein, thiamin and riboflavin) failed to meet WHO recommendations for at least two age groups, assuming average breast milk intake; greatest density deficits were for Fe > vitamin C > vitamin A > Zn > Ca.
Conclusions: Complementary feeding in Mongolia is compromised by deficits in several micronutrients but not energy, in part because of frequent consumption of non-nutritious snacks. The latter may interfere with breast-feeding and should be avoided. Instead, wheat-based complementary foods should be enriched with affordable cellular animal foods and fruits rich in vitamin C to combat existing micronutrient deficits.

Keywords
Mongolia
Complementary food
Micronutrients
Infants
Iron
Zinc

In many disadvantaged countries, nutritionally adequate complementary foods that can be safely introduced after 6 months of age do not exist, especially for mothers living in resource-poor households[1]. Instead, complementary foods in these countries are frequently based almost exclusively on cereals, despite the evidence that such foods are often accompanied by major deficits in Fe, Zn, Ca and vitamin A[2–5]. Indeed, the large discrepancy between the content of these four micronutrients in complementary foods and the amount required by the breast-fed infant has led WHO[3] to define these as problem micronutrients. The mineral deficits are due in part to the high content of phytic acid (myoinositol hexaphosphate) in cereals, a potent inhibitor of mineral absorption[3,6].

Mongolia, unlike most disadvantaged countries, is distinguished by a cultural heritage of a meat-based diet. There are well-established benefits of including animal-source foods when feeding infants and young children[7–9]. Indeed, these benefits have led the Pan American Health Organization (PAHO)/WHO[1] in their complementary feeding guidelines for the breast-fed child to specify that meat, poultry, fish or eggs should be consumed daily, or as often as possible. Nevertheless, the complementary foods presently consumed throughout Mongolia rarely contain meat and instead are based almost exclusively on cereals, predominantly wheat flour and rice. Hence, it is likely that deficits in the four problem micronutrients exist in complementary diets in Mongolia and may be partly responsible for the micronutrient deficiencies which persist throughout early childhood[10,11].

Recent national surveys in Mongolia[10,12] indicate that breast-feeding is almost universal and generally practised

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up to 2 years of age. Further, few mothers practise active feeding, but instead feed their children a very restricted range of foods only when they are hungry[13]. However, the extent to which the Mongolian complementary diets are inadequate in quantity, quality, or both, is uncertain because of the paucity of quantitative data on energy and nutrient intakes from Mongolian complementary foods. Consequently, in the current cross-sectional study, our objectives were to: (i) quantify the complementary feeding practices of breast-fed Mongolian children aged 6 to 23 months; (ii) calculate the energy and nutrient intakes from complementary foods; and (iii) evaluate their adequacy by comparison with the WHO recommendations. Such information is essential for developing strategies to enhance the quality of complementary feeding in Mongolia during the vulnerable period of transition from breast-feeding to the family diet.

Subjects and methods

Subjects

The subjects of the present study were all the breast-fed children (*n* 130) aged 6 to 23·99 months who were participants of a larger cross-sectional micronutrient survey[11]. The children were recruited from four districts in Ulaanbaatar, the capital city of Mongolia, and four provincial capitals of Bulgan, Bayanhongor, Dornod and Khovd, located in the northern, southern, eastern and western parts of Mongolia. Eligible children were identified through official lists prepared by the local district governor's office in collaboration with district hospitals. Inclusion criteria were apparently healthy children aged 6 to 36 months with no evidence of infection within the previous 7 d, and whose primary caregivers were willing to allow them to participate. Eligible children were stratified by age and sex, and every fourth child randomly selected from a randomized list of each stratum. To minimize correlation between participants, only one child per family was selected. Our data and sample size allowed us to characterize the mean energy intake of each age group with a 95 % confidence interval of approximately ±588 kJ.

Written informed consent was obtained from the parents or guardians of the children, and the study protocol was approved by the Human Ethics Committee of the Mongolian Ministry of Health. The dietary data reported here were collected in November 2006, at the same time as the biochemical data[11].

Methods

Assessment of sociodemographic, health and anthropometric status

Details of the questionnaire used to assess the sociodemographic, health and breast-feeding status of the children, and the anthropometric methods, have been reported elsewhere[11]. Mean anthropometric *Z*-scores for weight-for-age (WAZ), length-for-age (LAZ), weight-for-length (WLZ) and BMI (BMIZ) were calculated for three age groups: 6 to 8·99 months (Grp-1, *n* 26), 9 to 11·99 months (Grp-2, *n* 29) and 12 to 23·99 months (Grp-3, *n* 73), based on the WHO 2007 multicentre growth reference data using the computer program WHO Anthro 2005[14]. None of the children had unacceptably extreme anthropometric values[15].

Assessment of feeding practices and food intakes from complementary foods

Trained research assistants conducted single 24 h recalls with the caregiver of each child using the interactive, multiple-pass technique validated earlier[16]; all days of the week were represented in the final sample. The assessment period lasted from the time the children awoke until they were put to bed for the night. Interviews were conducted in the participant's homes to encourage participation, improve the recall of foods consumed, and permit the calibration of family utensils. Information on breast-feeding practices and the age of introduction of other liquids (including water, water-based drinks or solids), based on self-reports by the mothers, was also collected during the recall interviews.

For actual portions of cooked foods consumed by the child, including wheat-based porridges, caregivers were requested to spoon the portions consumed by the child into the child's bowl, which was then weighed on dietary scales (Soehnle; CMS Weighing Equipment, London, UK). For composite dishes, household recipe data were collected.

From the food intake data, the mean number of times children were fed solid/semi-solid foods and mean number of food groups consumed over the 24 h recall period were calculated, from which three indicators related to optimal infant and young child feeding (IYCF) practices were compiled[1], as specified by Arimond and Ruel[17]. The indicators were: (i) percentage fed solid/semi-solid foods the recommended minimum number of times or more (i.e. ≥2 times/d for Grp-1 and ≥3 times/d for Grp-2 and Grp-3); (ii) percentage fed the minimum number of food groups (i.e. three) or more; and (iii) percentage fed according to good IYCF practices. The latter are defined as exclusive breast-feeding for the first 5 months, followed by the introduction of solids/semi-solids for the minimum number of times or more and including the minimum number of food groups, along with continued breast-feeding[1]. Median dietary diversity scores and the proportion classified with low (0–2), medium (3–4) and high (5–7) scores were also calculated for each age group[18].

Assessment of intakes and major food sources of energy and nutrients from complementary foods, and their nutrient adequacy

To calculate energy and nutrient intakes from the food intake data, a unique Mongolian nutrient composition

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database containing 141 food and beverage items was compiled by R.L. using procedures outlined in Gibson and Ferguson[16]. Nutrient values were derived from an existing Mongolian food composition table and the US Department of Agriculture (USDA) National Nutrient Database for Standard Reference[19], augmented, where necessary, with nutrient values for cooked foods, when available, from Thailand[20], Malaysia[21], the Philippines[22] and Indonesia[23]. Exceptions were the Fe, Zn, Ca and phytate values for the wheat flours used for the Mongolian porridges (*bantan*, semolina). These were based on chemical analyses of wheat flour samples purchased from vendors in the study areas in Ulaanbaatar, using methods reported earlier[24]. The nutrient composition of composite dishes was calculated from the household recipe data. When recipe data were not available from the household, data for an average recipe were substituted. Adjustments were made to all the nutrient values, where necessary, to account for differences in moisture content, and nutrient retention and yield, using factors compiled by the USDA[25] and Banjong *et al.*[26], because of the absence of Mongolian data.

Median (1st and 3rd quartile) intakes of energy and selected nutrients (per d and per 418 kJ (100 kcal)), phytate:Zn molar ratios, and sources of energy and nutrients from twelve major food groups from complementary foods, were calculated from the coded 24 h recalls for children of three age groups. To assess their adequacy, these median daily nutrient intakes (per d and per 418 kJ (100 kcal)) were compared with the estimated needs and desirable nutrient densities based on the WHO/FAO nutrient requirement estimates[27] and, for Zn, the International Zinc Nutrition Consultative Group Recommended Dietary Allowance[28], and calculated according to Dewey and Brown[29]. The energy requirements of male and female breast-fed infants of Grp-1 and Grp-2, expressed per kcal/kg per d as specified by FAO/WHO/United Nations University[30], were used to calculate the estimated energy needs from complementary foods: breast-fed infants have lower energy requirements due to their lower total energy expenditure. For the children of Grp-3, the energy requirements for males and females, expressed per kcal/kg per d and associated with moderate physical activity, were used[30]. An average breast milk intake and composition was assumed. Pooled data from low-income countries were used for both intakes and the concentration of vitamin A in breast milk, whereas for the other nutrients in breast milk, data were based on women in industrialized countries[29].

Statistical analyses

All continuous variables were checked for normality using the Kolmogorov–Smirnov test. Contingency tables of selected sociodemographic and anthropometric variables, breast-feeding and complementary feeding variables by location and/or age group were tested using the χ^2 test. Differences between sexes in the mean anthropometric *Z*-scores for each age group were examined using an independent sample *t* test (equal variances not assumed). Dietary intakes (per d and per 418 kJ (100 kcal)) of the children by the three age groups were expressed as medians (interquartile range) for consistency because of non-normal distributions for some nutrients. Differences in the median energy and nutrient intakes between Grp-1 and Grp-3 were examined using the non-parametric Kruskal–Wallis test. A P value $<0{\cdot}05$ indicated statistical significance. Statistical analyses were performed using the STATA statistical software package version 9·2 (Stata Corporation, College Station, TX, USA).

Results

Sociodemographic and anthropometric status

There were no significant differences between the breast-fed children from Ulaanbaatar and the four provincial capitals for sociodemographic status and mean anthropometric *Z*-scores. The median household size was four and the median family income was about 75 000 Mongolian Tugriks or $US 65·00 per month. More than two-thirds of the fathers and mothers had at least a high school level of education. Of the children, 80 % had received a vitamin A supplement within the past 200 d, based on self-reports by the caregivers, but very few had received an Fe supplement (Table 1).

There were no significant differences between the mean anthropometric *Z*-scores for the males and females for each age group, with the exception of the mean LAZ for Grp-1. In this age group, the mean LAZ for males was significantly lower than that for females ($-0{\cdot}55$ (SD 0·67) *v.* 0·67 (SD 1·46); $P=0{\cdot}033$). Mean WAZ and WLZ for the males and females combined for each age group were positive. Only the mean LAZ for the males and females combined in Grp-3 was negative. As a result, the prevalence of stunting and mild stunting (defined by LAZ <-2SD and LAZ <-1SD) was significantly higher for Grp-3 compared with their younger counterparts. The WLZ values of all the children were positively correlated with LAZ values ($r=0{\cdot}27$; $P=0{\cdot}002$).

Feeding practices

Feeding practices were similar for each age group of children from Ulaanbaatar and the four provincial capitals, so the data have been combined. Exclusive breast-feeding up to 6 months of age was practised by very few of the mothers with infants of Grp-1, and less than two-thirds of Grp-2 and Grp-3, based on maternal self-reports during the recall interviews (Table 2).

Very few of the children, irrespective of age group, were fed solid or semi-solid foods for the recommended minimum number of times, or received the minimum number of food groups daily in addition to breast milk. Indeed, most children consumed only 0–2 food groups,

Table 1 Selected sociodemographic data of Mongolian breast-fed children aged 6–23·99 months, and mean (SD) anthropometric *Z*-scores and prevalence of stunting and underweight by age group

	All subjects (*n* 128)	
	Median or *n*/*N*	IQR or %
Median household income ($US)	71	64, 86
Median household size	4	4, 4
Mothers educated ≥high school	86/126	68
Fathers educated ≥high school	74/99	75
Child given a vitamin A supplement within 200 d	103/128	80
Child given an Fe supplement within 200 d	3/128	2

	Grp-1 (*n* 26)		Grp-2 (*n* 29)		Grp-3 (*n* 73)	
	n or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD
Number and percentage of males	10	38·5	16	55·2	43	58·9
Mean LAZ	0·20	1·45	0·22	0·95	−0·84	1·04
Mean WAZ	0·81	0·97	0·38	0·84	0·44	1·10
Mean WLZ	1·06	0·92	0·68	0·86	0·62	1·06
Mean BMIZ	0·96	0·92	0·69	0·86	0·80	1·04
Prevalence of mild stunting*	6	23	7	24	33	45
Prevalence of stunting†	2	8	2	7	11	15
Prevalence of underweight‡	0	0	0	0	4	5

IQR, interquartile range; LAZ, length-for-age *Z*-score; WAZ, weight-for-age *Z*-score; WLZ, weight-for-length *Z*-score; BMIZ, BMI Z-score.
*Mild stunting defined as LAZ from −1·0 to −2·0. Significantly different by age group ($P = 0·042$, Pearson χ^2).
†Stunting defined as LAZ below −2·0.
‡Underweight defined as WAZ below −2·0.

Table 2 Feeding practices of Mongolian breast-fed children

	Grp-1 (*n* 26)		Grp-2 (*n* 29)		Grp-3 (*n* 73)	
	n or Mean	% or SD	*n* or Mean	% or SD	*n* or Mean	% or SD
Exclusive breast-feeding through 5·99 months	4	15	9	31	19	46
Consumed cereal in the last 24 h	24	92	20	69	51	70
Consumed dairy in the last 24 h	12	46	11	38	19	26
Consumed fruits in the last 24 h	6	23	5	17	16	22
Consumed meat/eggs in the last 24 h	1	4	4	14	9	12
Consumed vegetables in the last 24 h	4	15	3	10	11	15
Consumed 0–2 food groups	22	85	24	83	63	86
Consumed 3–4 food groups	4	15	5	17	9	12
Consumed 5 food groups	0	0	0	0	1	1
Mean number of food groups consumed	1·81	0·85	1·48	0·99	1·45	1·00
Fed solid or semi-solid foods minimum number of times or more*	4	15	2	7	10	14
Fed minimum number of food groups or more†	4	15	5	17	10	14
Fed according to IYCF practices‡	4	15	2	7	10	26
Consumed foods rich in vitamin A§	4	15	4	14	9	12
Consumed foods rich in Fe‖	1	4	4	14	9	12
Liquid tea consumption	17	65	17	59	52	71

IYCF, infant and young child feeding.
*Grp-1 infants fed ≥2 times/d; Grp-2 and Grp-3 subjects fed ≥3 times/d.
†Children fed three or more food groups.
‡Children 6–23 months: exclusively breastfed for 5 months, fed solids/semi-solids minimum number of times (two/three or more) and fed minimum number of food groups (three or more).
§Includes meat (and organ meat), fish, poultry, eggs, pumpkin, red or yellow yam or squash, carrots, red sweet potatoes, dark-green leafy vegetables, mango, papaya.
‖Includes meat (including organ meat, fish, poultry and eggs).

predominantly cereals and snacks. As a result, the mean number of food groups was low, ranging from 1·8 for the infants of Grp-1 to 1·5 for each of the two older age groups. Foods rich in vitamin A or Fe were consumed by very few children: not more than 15 % in each age group. Likewise, the proportion of children fed according to good IYCF practices itemized in Table 2 was also low, especially for the infants. Of concern was the high consumption of tea by children of all three age groups.

Major food sources and intakes of energy and selected nutrients in relation to WHO recommendations

Table 3 presents the food groups providing at least 15 % of the energy, protein, Ca, Fe, Zn and vitamin A for the

Table 3 Food groups contributing at least 15 % of energy and selected nutrients for Mongolian breast-fed children, listed in the order of importance with the percentage contribution given in parentheses

Nutrient	Grp-1 (*n* 26)	Grp-2 (*n* 29)	Grp-3 (*n* 73)
Energy	Cereals (50) Snacks & sugars (27)	Cereals (36) Snacks & sugars (35)	Snacks & sugars (40) Cereals (26) Soups (17)
Protein	Cereals (65)	Cereals (41) Soups (17) Snacks & sugars (17) Dairy products (16)	Cereals (31) Soups (28) Snacks & sugars (18)
Ca	Dairy products (42) Cereals (40)	Dairy products (38) Cereals (36)	Cereals (29) Dairy products (26) Snacks & sugars (25)
Fe	Cereals (66) Snacks & sugars (17)	Cereals (49) Snacks & sugars (19)	Cereals (44) Snacks & sugars (21) Soup (20)
Zn	Cereals (66) Dairy products (16)	Cereals (39) Soups (24)	Soups (39) Cereals (31)
Vitamin A	Cereals (39) Dairy products (23) Snacks & sugars (22)	Meat & eggs (29) Cereals (21) Dairy products (17) Snacks & sugars (15)	Meat & eggs (38) Snacks & sugars (16)
Riboflavin	Cereals (44) Dairy products (36)	Cereals (29) Dairy products (24)	Cereals (27) Snacks & sugars (21)

three age groups. For the two younger age groups, the major sources of energy were cereals, closely followed by snacks and sugars, whereas for the older children, snacks and sugars followed by cereals were the major energy sources. Cereals were also the major source of five nutrients (protein, Fe, Zn, vitamin A and riboflavin) for the youngest age group, four nutrients (protein, Fe, Zn and riboflavin) for infants of Grp-2, and four nutrients (protein, Ca, Fe and riboflavin) for the children of Grp-3. Dairy products were the major source of Ca for the two younger age groups, and the secondary source of Zn, vitamin A and riboflavin for the youngest age group, of riboflavin for children of Grp-2, and of Ca for the oldest age group. Meat and eggs were the major source of only one nutrient (vitamin A) for the two older groups. Snacks and sugars were the secondary source of Fe for all three age groups.

As expected, median intakes of energy and most nutrients (protein, Fe, Zn, thiamin, niacin, fat) were significantly higher ($P < 0{\cdot}05$) for Grp-3 than for Grp-1. Median intakes of energy, protein and riboflavin met the estimated needs[27,30] for all three age groups, but shortfalls existed for Ca, Fe, Zn, vitamin A, vitamin C, thiamin and niacin for at least one of the age groups (Table 4). Median intakes of fat were 19, 18 and 31 g/d, providing 30 %, 26 % and 34 % of energy from fat in complementary foods for Grp-1, Grp-2 and Grp-3, respectively. Median phytate:Zn molar ratios of the complementary foods were very low, ranging from 2 for Grp-1 to 4 for Grp-2 and 3 for Grp-3.

In general, median nutrient densities (per 418 kJ (100 kcal)) of the complementary foods were similar across all three age groups (Table 5), including the densities of the three problem micronutrients: Fe, vitamin A and Zn. However, the nutrient density for Ca was markedly higher for the infants of Grp-1 compared with the other two age groups (ANOVA, $P = 0{\cdot}018$). Median densities for Fe, Zn, Ca, thiamin, niacin, and vitamins C and A were all less than 80 % of desired levels for at least two age groups; the greatest deficits were for Fe (assuming low bioavailability) and vitamin C density for all three age groups, followed by Zn, Ca and vitamin A for two age groups.

Discussion

To our knowledge, this is the first study to quantify the feeding practices and energy and nutrient intakes from complementary foods for breast-fed children in Mongolia. Our results highlight the poor compliance with the PAHO/WHO complementary feeding guidelines and the existence of deficits in the four problem micronutrients from the Mongolian complementary diets, as noted in other disadvantaged countries[4,5,31–35]. In contrast, unlike other countries in South/South-East Asia[4,5,31,32], energy intakes from these Mongolian complementary diets appeared adequate, but vitamin C intakes were low.

Feeding practices

In Mongolia breast-feeding rates are very high. In the most recent national survey, about 94 % and 75 % of the children were still being breast-fed at 6–11 months and 12–23 months[10], respectively, compared with 96 % and 76 % among the children of our cross-sectional survey[11]. However, breast milk may be displaced by the very early

Table 4 Median (IQR) intakes of energy and selected nutrients from complementary diets for breast-fed Mongolian children, and estimated need and percentage of estimated need*

	Grp-1 (*n* 26)		Grp-2 (*n* 29)		Grp-3 (*n* 73)	
	Median or estimated need	IQR or % of estimated need	Median or estimated need	IQR or % of estimated need	Median or estimated need	IQR or % of estimated need
Energy (kJ)	2360	1833, 2841	2582	1766, 3201	3464	3096, 3966
Estimated need†	1038	227	1481	174	2222	156
Protein (g)	17·4	9·8, 28·1	16·8	12·7, 25·6	28·2	18·0, 34·9
Estimated need	2·0	870	3·1	542	5·1	553
Ca (mg)	190	47, 337	136	58, 232	142	77, 227
Estimated need	111	171	228	60	346	41
Fe (mg)	1·6	0·9, 2·9	1·9	1·2, 2·8	3·2	2·4, 4·4
Estimated need‡	18·4	9	18·4	10	11·4	28
Zn (mg)	2·5	1·3, 3·7	2·7	1·8, 3·1	4·0	2·7, 5·3
Estimated need§	3·2 M	78	3·2 M	84	2·4 M	167
	4·2 L	60	4·2 L	64	2·4 L	167
Thiamin (mg)	0·2	0·1, 0·3	0·2	0·1, 0·3	0·3	0·2, 0·4
Estimated need	0·2	100	0·2	100	0·4	75
Riboflavin (mg)	0·4	0·2, 0·6	0·4	0·3, 0·7	0·4	0·3, 0·6
Estimated need	0·2	200	0·2	200	0·3	133
Niacin (mg)	2·6	1·5, 5·2	3·8	1·8, 4·6	4·8	3·5, 6·6
Estimated need	3·0	87	3·1	123	5·2	92
Ascorbic acid (mg)	2·1	1·0, 3·4	1·6	0·7, 5·3	2·7	1·3, 5·7
Estimated need	3·0	70	5·4	30	8·0	34
Vitamin A (μg RE)	78·0	22·5, 109·4	61·4	22·8, 108·4	58·3	20·7, 136·0
Estimated need	63·0	124	92·0	67	125·0	47
Fat (g)	19	12, 28	18	13, 26	31	19, 42
% energy from fat‖	30		26		34	
Recommended % energy from fat	0¶; 34** (MB)		5¶; 38** (MB)		17¶; 42** (MB)	

IQR, interquartile range; RE, retinol equivalents.
*Estimated needs from complementary foods assuming average breast milk intake and nutrient content as determined by WHO[3].
†Based on FAO/WHO/United Nations University (UNU)[30] energy requirements of male and female infants expressed per kcal/kg per d, specified for breast-fed infants. For Grp-3 children based on energy requirements for males and females, expressed per kcal/kg per d and associated with moderate physical activity (FAO/WHO/UNU[30]).
‡Assuming low Fe bioavailability.
§Based on International Zinc Nutrition Consultative Group Recommended Dietary Allowance for Zn[28] assuming a refined (M) and unrefined cereal-based (L) diet.
‖Percentage of energy from fat in complementary foods.
¶,**Percentage of energy from fat in complementary foods needed to achieve 30 %¶ and 45 %** of total energy (breast milk and complementary foods) as lipid, assuming medium level of breast milk energy intake (MB).

Table 5 Median (IQR) nutrient densities* of the complementary diets of breast-fed Mongolian children, and desired density and percentage of desired density

	Grp-1 (*n* 26)		Grp-2 (*n* 29)		Grp-3 (*n* 73)	
	Median or desired density	IQR or % of desired density	Median or desired density	IQR or % of desired density	Median or desired density	IQR or % of desired density
Protein (g/418 kJ)	3·0	2·8, 4·5	3·0	2·5, 3·6	3·2	2·7, 3·7
Desired density†	0·8	375	0·9	333	1·0	320
Ca (mg/418 kJ)	44·4	20·0, 59·1	24·7	13·3, 32·5	16·4	11·3, 22·1
Desired density	45	99	64	39	65	25
Fe (mg/418 kJ)	0·3	0·2, 0·4	0·3	0·3, 0·5	0·4	0·3, 0·5
Desired density‡	7·4	4	5·2	6	2·2	18
Zn (mg/418 kJ)	0·5	0·3, 0·7	0·4	0·3, 0·5	0·5	0·3, 0·6
Desired density§	1·38 M	36	0·90 M	44	0·45 M	111
	1·82 L	27	1·19 L	34	0·45 L	111
Thiamin (mg/418 kJ)	0·03	0·03, 0·04	0·03	0·03, 0·04	0·04	0·03, 0·05
Desired density	0·08	38	0·06	50	0·08	50
Riboflavin (mg/418 kJ)	0·09	0·05, 0·10	0·06	0·04, 0·09	0·05	0·04, 0·06
Desired density	0·08	113	0·06	100	0·06	83
Niacin (mg/418 kJ)	0·6	0·4, 0·7	0·6	0·3, 0·7	0·6	0·5, 0·8
Desired density	1·2	50	0·9	67	1·0	60
Ascorbic acid (mg/418 kJ)	0·3	0·2, 0·6	0·3	0·1, 0·5	0·4	0·2, 0·6
Desired density	1·2	25	1·5	20	1·5	27
Vitamin A (μg RE/418 kJ)	13·9	5·9, 20·6	9·2	4·2, 15·6	7·7	2·8, 12·7
Desired density	25	56	26	35	24	32

IQR, interquartile range; RE, retinol equivalents.
*Nutrient density = amount/418 kJ (100 kcal).
†Desired nutrient densities assuming average breast milk intake and nutrient content, as determined by WHO[3]. Desired levels were calculated by dividing the estimated energy needs by the estimated needs for energy intake for each age group.
‡Percentage desired Fe density assuming low bioavailability.
§Based on International Zinc Nutrition Consultative Group Recommended Dietary Allowance for Zn[28] assuming a refined (M) and unrefined cereal-based (L) diet.

introduction of complementary foods, as noted here and by others[5,13,36,37]. The most recent WHO[38] recommendation is for exclusive breast feeding up to 6 months of age. The first complementary foods introduced in the current study were wheat-based porridges with very low energy densities (1·42 kJ/g (0·34 kcal/g) for semolina and 1·76 kJ/g (0·42 kcal/g) for *bantan*)[39], which were rarely enriched with cellular animal foods, dark-green vegetables or yellow-orange fruits, as emphasized by the very small proportion of children consuming any Fe- or vitamin-A-rich foods (Table 2). Hence, very few of our Mongolian infants or children received complementary foods containing the minimum number of food groups per day, a shortfall that tended to be more marked among the Grp-2 and Grp-3 children than among the infants aged 6 to 8 months. This trend may have arisen because of the failure to practise active feeding, particularly as caregivers tend to leave children to feed themselves once they start to eat independently[13]. Consequently, dietary diversity, based on the mean number of food groups consumed[18], was much lower for these Mongolian children than has been reported in the Demographic and Health Surveys of young children from other countries in South/South-East Asia and Central Asia[40].

The Mongolian children were also not receiving the recommended number of feedings per day. Instead, a relatively large proportion of the energy was contributed by non-nutritious snacks and sweets (Table 3), as reported for Cambodian children[5]. The Mongolian snacks were mainly doughnuts and biscuits, whereas in Cambodia, they were crisps, biscuits and sponge cake; all energy-dense but with a very low micronutrient density. This is of concern because frequent consumption of such energy-dense snacks by young breast-fed children has the potential to displace breast milk[4,41].

The consumption of tea was also a frequent practice among children in both Mongolia and Cambodia[5]. Polyphenols in tea are likely to have a marked adverse effect on non-haem Fe absorption, particularly in Mongolian complementary diets[42] because of their low content of ascorbic acid and cellular animal protein, two enhancers of non-haem Fe absorption[43]. On average, ≤1 % of the energy intake from complementary foods was from meat and eggs or fruits and vegetables, with many children not consuming these foods.

Adequacy of energy and nutrient intakes

In view of the poor feeding practices discussed above, it is not surprising that large deficits in the four problem micronutrients[3] – Ca, Fe, Zn and vitamin A, as well as vitamin C – were a notable feature of these Mongolian complementary diets for at least two age groups (Tables 4 and 5) and irrespective of setting. These findings parallel those for young breast-fed children living in other disadvantaged countries in South/South-East Asia[4,5,31,32] and sub-Saharan Africa[33–35], where cereal-based complementary diets containing little micronutrient-dense cellular animal foods, dark-green vegetables or yellow-orange fruits predominate.

It is of interest that the deficits in micronutrient intakes occurred even though the median energy intakes derived from complementary foods and energy-dense snacks for each age group exceeded our estimated energy needs (Table 4), and each was accompanied by a positive mean WLZ (Table 1). Nevertheless, it is possible that our calculated energy needs from complementary foods alone were underestimated, especially for the breast-fed infants aged 6 to 8 months, because we used data for breast milk intakes compiled from other low-income countries[3] rather than from direct measurements of breast milk volume for Mongolian children. Indeed, elsewhere in South/South-East Asia[4,5,31,32], marked deficits in intakes of energy and micronutrients from complementary foods, accompanied by negative WLZ indicative of wasting, have been reported.

Despite the positive mean WLZ for each age group, the mean LAZ for the oldest group (i.e. aged 12 to 23 months) was negative (Table 1). Such a trend is well recognized in children of this age from longitudinal studies both in Asia[44] and sub-Saharan Africa[45], and reflects a progressive deterioration in their nutritional status as breast milk becomes increasingly replaced with the traditional complementary foods of low micronutrient quality.

Calculations (not shown) indicate that even if the Mongolian caregivers fed the wheat-based complementary foods for the recommended minimum number of times per day, intakes of the four problem micronutrients and vitamin C would still be suboptimal because of the low micronutrient density of these porridges. Similar findings have been reported elsewhere in the region[4,5,32].

Detailed biochemical data[11] on these same children, collected at the same time as the current dietary data, corroborate the evidence presented here that intakes from complementary foods of three of the problem micronutrients – Fe, Zn and vitamin A – are inadequate. Indeed, of these breast-fed children, 24 % had Fe-deficiency anaemia while 77 % and 40 % had low serum Zn and retinol concentrations, respectively. No biochemical assessment of Ca or vitamin C status was undertaken.

The discrepancy between the high prevalence of low serum Zn concentrations and the relatively modest levels of stunting among these breast-fed Mongolian children has been discussed earlier[11]. An unusual feature of these complementary diets is the frequent consumption of cow's milk products, some of which are fermented. As a result, the Ca intakes and densities of the complementary diets, especially for Grp-1, were markedly higher than many reported elsewhere[4,33–36]. Significantly, there is some evidence that cow's milk has a positive effect on linear growth[46], associated, at least in part, with the stimulating effect of cow's milk on insulin-like growth factors (IGF-I). Products prepared from fermented milk, such as yoghurt, also contain growth-promoting factors[47]. Hence, perhaps the increases in circulating levels of IGF-I stimulated by cow's milk and

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fermented yoghurt were sufficient to overcome, at least in part, the reduction in IGF-I levels induced by suboptimal Zn status in these Mongolian children[48].

We recognize that our results are not based on a nationally representative sample of breast-fed Mongolian children, and that the number of children in each age group was small. Hence caution must be used when interpreting our results. Nevertheless, the sampling in each of the provincial capitals and in the four districts of Ulaanbaatar was random, and several nutritional status variables for these Mongolian children, including the overall prevalence of stunting, anaemia, use of vitamin A supplements and breast-feeding practices, were comparable to those reported in the most recent national survey[10] and in a smaller study[49] in Mongolia. Other methodological limitations include the collection of data on exclusive breast-feeding based on self-reports by the mothers during the recalls rather than direct observations; our estimate of breast milk volume based on data compiled from low-income countries other than Mongolia, and not by direct measurements; and the use of a single 24 h recall to assess intakes of complementary foods. As a result, we could not calculate the usual nutrient intakes derived from both breast milk and complementary food for each child, and thus could not apply the estimated average requirement cut-point method to compare the prevalence of inadequate intakes for each age group[50]. Instead, we compared the median intakes from complementary food alone for the three age groups with the corresponding WHO estimated needs[3,29].

Conclusions and recommendations

The present study has highlighted the poor dietary quality of the complementary diets of breast-fed children in Mongolia. With the exception of vitamin A, the shortfalls in Ca, Fe, Zn and probably vitamin C cannot be rectified by improving the levels in breast milk, because they are independent of maternal nutritional status[3]. Enhancing maternal Fe status could, however, have a positive impact on the Fe status of these children through its effect on placental transfer[51,52]. Clearly, efforts should be made to educate caregivers to enhance the dietary quality of the complementary foods fed to children by enriching the cereal-based porridges with affordable cellular animal foods and vitamin-C-rich seasonal fruits, and restricting the intake of tea and inappropriate snacks of low micronutrient density. Our findings also emphasize the importance of educating the health-care providers in these settings to ensure that they are familiar with the PAHO/WHO (2003)[1] guiding principles for complementary feeding practices and behaviours.

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