Original Article

Nutritional status of breast-fed and non-exclusively breast-fed infants from birth to age 5 months in 8 Chinese cities

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This study aimed to assess the nutritional status of infants aged 0 to 5 months by different feeding approaches. A cross-sectional study on infant nutrition was performed in eight cities in China. A total of 622 infants from birth to 2 months of age and 456 infants from 3 months to 5 months of age were included in this study. Mix-fed infants received breast milk and complementary foods from birth to 2 months of age. Approximately 38.2% of mix-fed infants received excessive vitamin A, and 15.6% of infants exceeded the tolerable upper intake levels (ULs) of zinc. For artificially fed infants who received only complementary foods, approximately 20% and 12.5% infants received inadequate dietary vitamin A and zinc intakes, respectively. The vitamin A and zinc intakes of half of the infants exceeded the ULs. Results showed that the usual intake distribution of the infants from 3 months to 5 months of age were similar to that of the infants from birth to 2 months of age. The common vitamin A and zinc intakes were also severely imbalanced. In addition, higher disease prevalence and lower Z scores of length-for-age, weight-for-age, and weight-for-length were found in artificially fed infants and mix-fed infants compared with those in breast-fed infants. In conclusion, the usual nutrient intakes were adequate for the majority of Chinese infants, except for an important number of infants at risk for imbalance of vitamin A and zinc intakes.

Key Words: infant, nutritional status, dietary assessment, zinc, iron

INTRODUCTION

Nutrition is an important component of children's health. Children's physical, cognitive, and emotional growth and development largely depend on the amount and type of foods consumed and the time at which different food items are introduced.[1] In China, four national nutrition surveys were performed in 1959, 1982, 1992, and 2002.[2] In these surveys, the dietary status of the population subgroups aged more than 24 months was investigated.[2] Regional studies on the dietary status of Chinese infants and toddlers aged 0 month to 24 months have also been conducted, but small samples have been used.[3] Therefore, the dietary status of Chinese infants and toddlers aged 0 month to 24 months is less known compared with other population subgroups. At approximately six months of age, the supply of energy and nutrients from breast milk is insufficient to satisfy infants' needs. Complementary foods should be provided to achieve a well-balanced diet.[4] However, the administration of complementary foods at 4-6 months is recommended in China. Therefore, development differences in various feeding approaches in this period should be evaluated; whether or not this recommendation is appropriate should also be determined. Children aged 0 to 5 months are found at the greatest nutritional risk because of poor feeding practices with repercussions on growth and development.[5] This age group is also at increased risks of morbidity and mortality compared with other young children.[6] Therefore, the dietary status of newly born infants to five-month-old infants should be assessed.

Dietary assessment is performed to describe contemporary dietary patterns and food sources; this procedure is also conducted to estimate the adequacy of nutrient intake of population subgroups. Dietary Reference Intakes (DRIs) may be used to assess whether or not diets provide sufficient nutrients to satisfy the requirements without exceeding the recommended levels; DRIs may also be used as reference of other dietary components to promote health and reduce the risk of chronic disease.[7] To investi-

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gate the dietary status of new born infants to 36-month-old toddlers, we performed the mother, infant nutrition and growth (MING) study in eight cities in China from October 2011 to January 2012. With the cost-effectiveness and low respondent drawbacks, a 24-hour dietary recall was used in the MING study to assess the dietary requirements of this age group. In a study designed to test the validity of the 24-hour recall in young children, this tool overestimated the energy intake of 13% of infants and 29% of toddlers compared with a three-day weighed food record, accounting for 5% of the estimated energy requirement.[8]

In summary, this MING study is a rich data set that provides detailed information on food and nutrient intakes of a large sample of infants in China. Three different feeding approaches, feeding practices and patterns, and household characteristics were also investigated. This study focused on the nutrient intake of two subgroups (0 month to 2 months and 3 months to 5 months) of infants with or without breastfeeding. This study also addressed three specific research questions: 1) What are the characteristics of common nutrient intake distributions of infants by age and feeding approach? 2) Do infants have nutritionally adequate diets? 3) Are there significant differences in energy, nutrient intake, and development among the three feeding groups?

MATERIALS AND METHODS

Sampling

The MING study was designed to describe the current nutritional status of pregnant women, lactating mothers, infants, and toddlers in eight Chinese urban cities by conducting nutritional surveys. This study only presented the data of infants from birth to five months of age. A multi-stage-stratified random sampling was used in the study. Eight cities were selected, and two maternal and child care service centers from each city (one in suburban area and the other in urban area) were randomly selected. A stratified sample, including 90 infants aged 0 month to 2 months and 60 infants aged 3 months to 5 months fed by different feeding approaches (artificial feeding, mix feeding, or breastfeeding), was randomly obtained. In this study, “breastfeeding” is defined as no other food or drink, not even water, except breast milk (including milk expressed or obtained from a wet nurse) for the life, but allows the infant to receive drops and syrups (vitamins, minerals and medicines). “Artificial feeding” is defined as no breast milk (including milk expressed or obtained from a wet nurse) except complementary foods for the life of infants. “Mix feeding” is defined as both breast milk (including milk expressed or obtained from a wet nurse) and complementary foods for the life of infants. Selection criteria were healthy and full-term infants. The study was conducted according to the guidelines in the Declaration of Helsinki. All of the procedures involving human subjects were approved by the Medical Ethics Research Board of Peking University. Written informed consent was obtained from a primary caregiver of each infant participating in the study.

Anthropometric and dietary interviews

Infants were assessed in local maternal and child care service centers. Anthropometric indices (length and weight) were measured by trained research assistants following standardized procedures and using calibrated equipment. Recumbent length was measured on an infant measuring board and recorded to the nearest 0.1 cm. Weight was obtained on a digital pediatric scale and recorded to the nearest 0.1 kg. Each measurement was repeated two times, and the mean value was calculated. Other characteristics were obtained: infant information, such as age, gender, birthday, and disease status (diarrhea, respiratory system disease, and anaphylactic disease); social-economic status, such as household composition, family income, age, and employment status of the parents; and feeding information, such as feeding approach, breastfeeding duration, and introduction of foods. Dietary information was collected using a 24-hour dietary recall by a structured face-to-face interview performed by trained interviewers. The accuracy of a 24-hour dietary recall is dependent on the primary caregivers’ recollection of the types and quantities of food, beverages, and supplements consumed by infants. To address potential errors, we modified the diet assessment methodology to decrease the possibility that primary caregivers would over-report the portion sizes of certain food items in the study by measuring cups and food photographs. Nutrient intakes were then analyzed using reference values from the 2002 China Food Composition database (National Institute of Nutrition and Food Safety, China CDC). The vitamin A (retinol activity equivalents, RAE) content in the current China Food Composition Table is relatively low in human milk compared with the results from an in-house analyzed value. The figure in China Food Composition Table of Vitamin A (RAE) content is 11 μgRE/100 g, while our in-house data was 70 μgRE/100 g. Since the China CDC will change the figure in China Food Composition Table of Vitamin A to our data in the future, we calculated the vitamin A using our data. Considering that many branded baby foods are not in the nutrient database, we constructed a list of missing baby foods, obtained nutrient information, and updated the China Food Composition database. To assess the usual nutrient intake of infants, we then used the following Chinese DRIs designed by the Chinese Nutrition Society: recommended nutrition intake (RNI); adequate intake (AI); estimated average requirement (EAR); and tolerable upper intake level (UL).[9] The recommendations of Japanese DRIs in 2008 were also used because no recommendations are available for the RNI of manganese and the UL of vitamin A in China.[10]

For infants who were exclusively breastfed, 780 mL per day was administered to infants younger than seven months. For infants who were fed with both breast milk and formula, the volume of formula was subtracted from the total volume to estimate the amount of breast milk consumed. The method used to determine breast milk intake among infants was based on the assumptions used to establish calcium DRIs and has been used by other researchers.[1]

Data analysis

STATA 9.2 (Stata Corp, College Station, TX, USA) was used to calculate the Z scores of length-for-age (LAZ), weight-for-age (WAZ), and weight-for-length (WLZ). We obtained the following values: Z < 3 was 1; -3 ≤ Z < -2 was 2; -2 ≤ Z < -1 was 3; -1 ≤ Z < 0 was 4; 0 ≤ Z < 1 was 5; 1 ≤ Z < 2 was 6; 2 ≤ Z < 3 was 7; and 3 ≤ Z was 8. We then calculated the mean of Z score. One-way ANOVA was performed to assess the differences in energy intake and the Z score of LAZ, WAZ, and WLZ among the three feeding approaches. Chi-square test was performed to analyze the differences in the prevalence of stunting (Z score of LAZ was less than -2), underweight (Z score of WAZ was less than -2), wasting (Z score of WLZ was less than -2), and prevalence rate of total disease, diarrhea, respiratory system disease, and anaphylactic disease among the three feeding approaches. In addition, the differences in the Z score of LAZ, WAZ, and WLZ, the prevalence rates of stunting, underweight, and wasting, and the prevalence rates of total disease, diarrhea, respiratory system disease, and anaphylactic disease among the different nutrient intake levels of vitamin A and zinc (<EAR as inadequate, from EAR to UL as adequate, and >UL as excess) of infants were analyzed. Logistic regression analysis was performed to clarify the predictors of development and disease. *P* values were two-tailed, and *p*<0.05 was considered statistically significant. Data were presented as mean±standard deviation . Statistical analyses were performed using SPSS 20.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

A total of 622 infants from birth to 2 months of age and 456 infants from 3 months to 5 months of age were investigated. The infants from birth to 2 months of age comprised 225 mix-fed infants, 144 artificially fed infants, and 253 breast-fed infants. The infants aged 3 months to 5 months included 145 mix-fed infants, 126 artificially fed infants, and 185 breast-fed infants.

Table 1 and 2 show the intake distributions of macronutrients, vitamins, bone-related nutrients, and other micronutrients for mix-fed and artificially fed infants aged 0 month to 2 months, respectively. The mean and median intakes of macronutrients, vitamins, and bone-related nutrients and other micronutrients except energy, sodium, potassium, and selenium exceeded the AIs of mix-fed infants. EARs were available only for vitamin A and zinc. We compared the intakes of vitamin A and zinc with EARs (375 μg/d for vitamin A and 1.5 mg/d for zinc) and found that the intakes of 0.4% infants were inadequate for vitamin A and the same proportion was inadequate for zinc. ULs were available for vitamin C, vitamin A, iron, zinc, and selenium. We also compared the intakes of vitamin A and zinc with ULs (600 μg/d for vitamin A and 4 mg/d for zinc) and found that the intakes of 38.2% and 15.6% infants exceeded the ULs of vitamin A and zinc, respectively. For artificially fed infants, the mean and median intakes of the macronutrients and micronutrients exceeded the AIs. Approximately 20% and 12.5% of infants received inadequate dietary vitamin A and zinc intakes relative to the EARs, respectively. The common intakes of vitamin A and zinc from food, beverages, and supplements exceeded the ULs in half the infants fed artificially. No significant differences were found on the Z scores of LAZ, WAZ, and WLZ, the prevalence rates of stunting, underweight, and wasting, and the prevalence rates of total disease, diarrhea, respiratory system disease, and anaphylactic disease among the different nutrient intake levels of vitamin A and zinc (inadequate vs. adequate vs. excess) of infants (data not shown).

Table 3 and 4 present the estimated intake distributions of macronutrients, vitamins, bone-related nutrients, and other micronutrients of mix-fed and artificially fed infants aged 3 months to 5 months, respectively. The common intake distributions of macronutrients and micronutrients were similar to those of the infants from birth to 2 months of age. We compared the intakes of vitamin A and zinc with EARs (375 μg/d for vitamin A and 1.5 mg/d for zinc) and found that the intakes of 7.6% and 2.1% of mix-fed infants received inadequate amounts of vitamin A and zinc, respectively. Among the artificially fed infants, approximately 23.8% and 19.8% of infants received inadequate dietary vitamin A and zinc intakes, respectively, relative to EARs. We further compared the intakes of vitamin A and zinc with ULs (600 μg/d for vitamin A and 4 mg/d for zinc) and found that the intakes of approximately 51.7% of mix-fed infants and 50% of artificially fed infants exceeded the ULs of vitamin A and zinc. After comparison, we found that the prevalence rates of stunting (14.8% vs. 3.9%) and wasting (11.1% vs. 3.1%) of infants with inadequate zinc intake was significantly higher than those with adequate zinc intake (data not shown).

The mean intake of the macronutrients and micronutrients of the breast-fed infants from birth to 5 months of age was lower than that of artificially fed infants and mix-fed infants (data not shown). Table 5 shows the differences in the energy intake, prevalence rates of different diseases, and the Z scores of LAZ, WAZ, and WLZ among the three feeding approaches. The prevalence of stunting (Z score of LAZ<-2), underweight (Z score of WAZ< -2), and wasting (Z score of WLZ<-2) of all of the infants were also calculated. The mean energy intake per kilogram body weight of mix-fed infants was significantly higher than that of breast-fed infants aged 0 month to 2 months. Considering the Z score, we found that the LAZ of artificially fed infants aged 0 month to 2 months was significantly lower than that of breast-fed infants. Breast-fed infants aged 3 months to 5 months compared with breast-fed infants exhibited significantly higher WAZ than artificially fed infants. Moreover, artificially fed infants aged 3 months to 5 months exhibited a significantly increased prevalence rate of stunting compared with breast-fed infants. The prevalence rate of wasting of infants aged 0 month to 2 months was also significantly increased compared with breast-fed infants. The differences in the prevalence rate of various diseases among the three feeding approaches were also determined. We found a significantly high prevalence rate of diarrhea in mix-fed infants aged 3 months to 5 months compared with breast-fed infants. We also observed high prevalence rates of respiratory system and anaphylactic diseases in artificially fed infants from birth to 2 months of aged. After mother's education and income were adjusted, the adjusted OR's were 2.09 (95% CI = 1.09 to 4.64) and 1.96 (95% CI = 1.02 to 4.16) for wasting and anaphylactic disease in artificially fed infants compared with breast-fed infants

Table 1. One-day nutrient intake distributions from food, beverages, and supplements for mix-fed infants who received breast milk and complementary foods from birth to age 2 months (n=225)

Nutrient	Dietary Reference Intakes			Mean/median intake percentiles						% < EAR	% >UL
	RNI/AI	EAR	UL	10th	25th	Median	Mean±SE	75th	90th		
Macronutrients											
Energy (kcal/kg·d)	95			75.5	87.4	101.3	103±1.9	115	138		
Fat (g/d)				25.3	25.9	26.4	27.4±0.3	27.5	29.9		
Carbohydrate (g/d)				55.6	56.0	56.5	59.1±0.6	58.6	62.8		
Protein (g/d)	9			10.0	10.1	10.5	11.0±0.1	11.1	12.7		
Fiber (g/d)				0	0	0	0.3±0.1	0.2	1		
Cholesterol (g/d)				5.9	36	59.8	52.4±2.3	71.1	74.9		
As percentage of total energy											
Fat (%)	45-50			46.0	46.8	47.1	46.7±0.1	47.3	48.0		
Carbohydrate (%)				43.3	44.3	45.0	45.1±0.2	45.5	46.0		
Protein (%)				8.1	8.1	8.2	8.4 ± 0.1	8.5	8.8		
Vitamins											
Vitamin A (μg/d)	400	375	600†	519	524	543	662±12.8	850	987	0.4	38.2
Vitamin C (mg/d)	40		400	40.8	42.8	49.6	57.5±1.5	65.9	84.9		0
Vitamin E (mg/d)	3			0.6	0.9	1.7	2.9±0.2	4.3	6.5		
Thiamin (mg/d)	0.2			0	0.1	0.1	0.2±0.1	0.3	0.5		
Riboflavin (mg/d)	0.4			0.4	0.4	0.5	0.6±0.0	0.7	0.9		
Niacin (mg/d)	2			1.0	1.6	1.8	2.1±0.1	2.6	3.5		
Bone-related nutrients											
Calcium (mg/d)	300			241	254.3	284.1	322±7.2	356	458.4		
Phosphorus (mg/d)	150			110	119.0	134.6	158±4.1	175	240		
Magnesium (mg/d)	30			66.4	126.1	186.9	165±3.9	212	222		
Other micronutrients											
Iron (mg/d)	0.3		10	1.2	1.5	2.2	3.1±0.1	3.9	6.1		1.3
Zinc (mg/d)	1.5	1.5	4	2.3	2.4	2.7	3.1±0.1	3.4	4.5	0.4	15.6
Sodium (mg/d)	150			15.5	23.9	46.1	66.9±4.1	87.3	144		
Potassium (mg/d)	400			53.1	87.8	160.9	242±14.2	330	582		
Selenium (μg/d)	15		55	0.9	1.5	3.2	5.1±0.3	7.5	12.4		0
Copper (mg/d)	0.4			0.2	0.2	0.3	0.3±0	0.3	0.4		
Manganese (mg/d)	0.001†			0	0	0	0±0	0	0.1		

†: the recommendations of Japanese DRIs in 2008. SD: standard deviation.

Table 2. One-day nutrient intake distributions from food, beverages, and supplements for artificially fed infants who received only complementary foods from birth to age 2 months(*n*=144)

Nutrient	Dietary Reference Intakes			Mean/median intake percentiles						% <EAR	% >UL
	RNI/AI	EAR	UL	10th	25th	Median	Mean±SE	75th	90th		
Macronutrients											
Energy (kcal/kg·d)	95			26.4	59.8	95.3	99.9±4.7	136.4	165.7		
Fat (g/d)				6.6	16.3	26.5	26.8±1.2	36.1	43.4		
Carbohydrate (g/d)				17.3	32.7	58.1	57.1±2.4	77.7	90.8		
Protein (g/d)	9			3.3	7.6	11.5	12.3±0.8	16	19.4		
Fiber (g/d)				0	0	0.1	0.6±0.1	0.6	2.4		
Cholesterol (g/d)				0	0	0	6.7±3.1	0	13.2		
As percentage of total energy											
Fat (%)	45-50			38.7	46.5	47.2	45.5±0.5	48	49.3		
Carbohydrate (%)				41.8	42.3	42.7	44.2±0.5	44.9	48.3		
Protein (%)				8.3	8.4	8.7	9.8±0.5	8.8	12.4		
Vitamins											
Vitamin A (μg /d)	400	375	600†	172	399	644	627±26.8	856	1036	21.5	53.5
Vitamin C (mg/d)	40		400	18	41.8	73.5	76.1±3.6	107	136		0
Vitamin E (mg/d)	3			1.4	3	6.3	6.5±0.2	8.6	12.4		
Thiamin (mg/d)	0.2			0.1	0.3	0.5	0.5±0.01	0.7	0.8		
Riboflavin (mg/d)	0.4			0.2	0.5	0.8	0.9±0.0	1.1	1.4		
Niacin (mg/d)	2			0	0.7	2.7	2.7±0.2	4.2	5.4		
Bone-related nutrients											
Calcium (mg/d)	300		1000	140.7	235.1	390	424±21.3	559.1	728.1		0
Phosphorus (mg/d)	150			69.5	117.8	208	220±9.9	305.2	373.4		
Magnesium (mg/d)	30			14.3	27	43.1	40.9±1.6	51	62.6		
Other micronutrients											
Iron (mg/d)	0.3		10	1.6	3.4	5.9	6.4±0.4	7.8	9.9		9
Zinc (mg/d)	1.5	1.5	4	1.2	2.6	4.2	4.2±0.1	5.6	6.4	12.5	53.5
Sodium (mg/d)	150			35.7	86.4	153.6	154±7.5	206.5	254.7		
Potassium (mg/d)	400			140.8	348	554.4	553±24.9	735.8	908.9		
Selenium (μg/d)	15		55	1	5.1	12.2	11±0.6	15.2	18.5		0
Copper (mg/d)	0.4			0.1	0.2	0.3	0.3±0	0.5	0.6		
Manganese (mg/d)	0.001†			0	0	0	0.1±0	0.1	0.1		

†: the recommendations of Japanese DRIs in 2008. SD: standard deviation.

Table 3. One-day nutrient intake distributions from food, beverages, and supplements for mix-fed infants who received breast milk and complementary foods aged 3 to 5 months (n=145)

Nutrient	Dietary Reference Intakes			Mean/median intake percentiles						% < EAR	% >UL
	RNI/AI	EAR	UL	10th	25th	Median	Mean±SE	75th	90th		
Macronutrients											
Energy (kcal/kg·d)	95			44.4	60.5	71.2	79.4±3.3	82.4	126.7		
Fat (g/d)				21.2	25.9	27.1	28.3±1	29.6	35		
Carbohydrate (g/d)				55.4	56.5	59.5	75.3±4	76	106.5		
Protein (g/d)	9			9.9	10.4	11.4	14±0.6	14.5	21.7		
Fibre (g/d)				0	0	0.2	0.7±0.1	0.8	1.8		
Cholesterol (g/d)				3.4	38.3	63.6	107±11.6	78.6	301.6		
As percentage of total energy											
Fat (%)	45-50			30.3	41	46.1	42.4±0.8	47.1	47.8		
Carbohydrate (%)				42.3	44.3	45.7	49±0.8	50.9	61.4		
Protein (%)				8	8.2	8.4	9.2±0.1	9.5	11		
Vitamins											
Vitamin A (μg/d)	400	375	600†	504	524	616	709±26	905	1034	7.6	51.7
Vitamin C (mg/d)	40		400	38.7	44.1	52.7	61.5±3.4	69.3	94.2		
Vitamin E (mg/d)	3			0.9	1.6	2.8	4.3±0.5	4.8	7.8		
Thiamin (mg/d)	0.2			0.1	0.1	0.2	0.3±0.1	0.3	0.6		
Riboflavin (mg/d)	0.4			0.4	0.5	0.6	0.7±0.0	0.8	1.1		
Niacin (mg/d)	2			1.2	1.8	2.2	2.8±0.2	3.1	4.7		
Bone-related nutrients											
Calcium (mg/d)	300		1000	251	287	384	487±27.6	594	894.9		
Phosphorus (mg/d)	150			118	138	183	241±16.9	264.2	369		
Magnesium (mg/d)	30			47.6	108	169	154±5.6	207	224		
Other micronutrients											
Iron (mg/d)	0.3		10	1.5	2.1	3.4	4.8±0.4	5.6	10.3		10.3
Zinc (mg/d)	1.5	1.5	4	2.3	2.6	3.2	4.1±0.2	4.4	6.9	2.1	31.7
Sodium (mg/d)	150			23.1	41.5	74	134±16.7	129.3	274.1		
Potassium (mg/d)	400			80	115	238	340±28.9	423.8	642.1		
Selenium (μg/d)	15		55	1.2	2.4	5.1	6.9±0.6	9	12.8		
Copper (mg/d)	0.4			0.2	0.2	0.3	0.4±0.1	0.3	0.7		0
Manganese (mg/d)	0.001†			0	0	0.1	0.2±0	0.1	0.6		

†: the recommendations of Japanese DRIs in 2008. SD: standard deviation

Table 4. One-day nutrient intake distributions from food, beverages, and supplements for artificially fed infants who received only complementary foods aged 3 to 5 months (*n*=126)

Nutrient	Dietary Reference Intakes			Mean/median intake percentiles						% < EAR	% >UL
	RNI/AI	EAR	UL	10th	25th	Median	Mean±SE	75th	90th		
Macronutrients											
Energy (kcal/kg·d)	95			18.1	30.7	68.0	71.2±4.2	100.0	135.7		
Fat (g/d)				5.8	9.1	23.8	24.7±1.5	35.1	47.5		
Carbohydrate (g/d)				14	28.3	66.6	65.9±3.9	87.1	109		
Protein (g/d)	9			3.4	6.6	12.2	13.4±0.8	18.5	26.3		
Fibre (g/d)				0	0	0.2	0.8±0.1	0.8	2.1		
Cholesterol (g/d)				0	0	0	63.5±13.9	16.9	297		
As percentage of total energy											
Fat (%)	45-50			23.9	36.3	45.6	40.7±0.9	47.3	48.8		
Carbohydrate (%)				41	42.7	46.1	49.1±1	54.3	66.5		
Protein (%)				8.1	8.4	8.8	10.1±0.3	11	13.8		
Vitamins											
Vitamin A (μg/d)	400	375	600[†]	135	391.4	591	620±32.7	891	1020	23.8	50
Vitamin C (mg/d)	40		400	15.1	24.3	73.5	70.4±4.3	100.4	130		0
Vitamin E (mg/d)	3			1.2	2.1	5.9	6.3±0.4	9.5	11.9		
Thiamin (mg/d)	0.2			0.1	0.2	0.4	0.4±0.04	0.7	0.9		
Riboflavin (mg/d)	0.4			0.2	0.3	0.8	0.8±0.1	1.1	1.5		
Niacin (mg/d)	2			0	0.7	2.7	2.9± 0.3	4.4	5.9		
Bone-related nutrients											
Calcium (mg/d)	300		1000	104	227.2	413	467±29.7	624	938		7.9
Phosphorus (mg/d)	150			63	138.1	238	278±17.7	359	525		
Magnesium (mg/d)	30			9.5	23.7	39.6	44.6±2.9	60	83.7		
Other micronutrients											
Iron (mg/d)	0.3		10	1.5	2.6	6.2	6.8±0.5	9.3	12.3		19
Zinc (mg/d)	1.5	1.5	4	1.1	1.8	4.3	4.5±0.3	6.2	7.7	19.8	54.8
Sodium (mg/d)	150			37.8	68.5	142	174±11.8	241	338		
Potassium (mg/d)	400			126	242	562	567±33.6	776	1028		
Selenium (μg/d)	15		55	1.1	3.1	11.2	16.6	22.5	18.5		0
Copper (mg/d)	0.4			0.1	0.1	0.3	0.3±0	0.5	0.6		
Manganese (mg/d)	0.001[†]			0	0	0.1	0.2±0	0.2	0.4		

[#]: the recommendations of Japanese DRIs in 2008. SD: standard deviation.

Table 5. The differences on the energy intake, prevalence rate of different diseases, and the Z score of LAZ, WAZ, and WLZ among the three approaches to feeding

Indices	0-2 months			3-5 months		
	AFI	MFI	BFI	AFI	MFI	BFI
Mean energy/kg body weight	99.9	103.4*	95.5	71.2	79.4	72.8
Length for age	5.08*	5.27	5.40	5.02	5.21	5.28
Stunting prevalence	6.3	4.8	5.8	9.1*	6.1	4.4
Weight for age	5.28	5.28	5.39	5.24*	5.38	5.64
Underweight prevalence	2.8	3	4.5	2.1	2.4	2.3
Weight for height	4.98	4.79	4.79	5.15	5.13	5.37
Wasting prevalence	9.2*	5.3	5.0	2.8	4.2	3.9
Prevalence rate	26.3	24.1	19.2	51	45.6	41.6
Diarrhea	4.5	4.2	5.1	13.1	18.7*	11.4
Respiratory system disease	13.4*	10.5	8.1	37.2	26.3	29.7
Anaphylactic disease	9.5*	8.9	5.1	6.9	9.4	7

AFI: artificially fed infants who received only complementary foods; MFI: mix-fed infants who received breast milk and complementary foods; BFI: breast feeding infants who received only breast milk. *: $p<0.05$ comparing with that of breast feeding infants.

aged 0 month to 2 months (data not shown).

DISCUSSION

This study is the first to conduct a nutritional survey assessing the nutritional status, anthropometric indicators, and dietary practices of a large sample of infants aged < 5 months who live in the cities and fed by different feeding approaches. In summary, the results of the present study suggested that most of the macronutrients and micronutrients were adequate. The current feeding practices of Chinese infants provided a strong nutritional foundation for further development. However, further studies should be conducted to elucidate the high prevalence rate of infants with vitamin A and zinc intakes less than the EARs and the significant proportions of infants with intakes higher than the ULs of vitamin A and zinc, especially for artificially fed infants. The results also showed that breast feeding significantly improved infant development and prevented diseases compared with artificial feeding and mix feeding in infants aged 0 month to 5 months.

In developing countries, adequate intake of several nutrients from complementary feeding, which is commonly based on traditional and unfortified foods, is difficult to achieve in developing countries.[11] Previous studies suggested that complementary foods are limited in micronutrients, such as iron, zinc, vitamin A, and calcium.[11,5] In the present study, a significant proportion (more than 10%) of infants in both age subgroups by artificial feeding was less than the EAR for zinc. In addition, more than 20% of artificially fed infants in both age subgroups exhibited inadequate dietary vitamin A intakes relative to EAR. Zinc is ubiquitous in the body; this element is also important in protein synthesis, cellular growth, and cellular differentiation. Studies on children have demonstrated the important functions of zinc associated with immune function, growth, and development.[12] In the present study, zinc deficiency was also significantly associated with the prevalence rates of stunting (14.8%) and wasting (11.1%) in the infants with inadequate zinc intake aged 3 months to 5 months. Interventional studies have also demonstrated that growth is improved by zinc supplementation, which may directly or indirectly stimulate increased immune function and decrease the risk of infectious diseases.[13] Animal flesh, particularly oysters and shellfish, is a good source of zinc; however, fibre and phytates inhibit absorption. Thus, populations consuming a plant-based diet, such as Chinese diet, are susceptible to zinc deficiency. Furthermore, vitamin A deficiency is a common cause of preventable blindness and a risk factor of the increased severity of infectious disease and mortality. Vitamin A deficiency occurs because of inadequate vitamin A intake as a result of the following conditions: low animal food consumption; inadequate intake of non-animal sources of carotenoids converted to vitamin A; and inadequate intake of fat, which facilitates carotenoid absorption. Considering the critical function of zinc and vitamin A in normal growth and development and immune function, we thought that artificially fed and mix-fed infants whose dietary zinc and vitamin A were less than the EAR should be considered. Continued parental education with specific measures, medical professional training, and government surveillance for complementary feeding are necessary to control this nutrient deficiency. We also found that the significant proportions of infants consumed vitamin A and zinc greater than the ULs. The UL of zinc for infants was based on a study in which no adverse effects on copper metabolism have been observed in full-term infants receiving formulas with approximately 4.5 mg zinc/day.[14] However, the validity of the UL of zinc for infants and children aged 1 year to 3 years remains unclear because of insufficient data used to establish ULs and evaluate the absence of zinc toxicity with common zinc intakes in the pediatric population.[15,16] Food fortification and dietary supplements should be used to treat zinc deficiency and/or to support a positive function without adverse consequences, although no recent reports of overt zinc toxicity involving children have been published; studies have also shown that zinc homeostatic mechanisms prevent excessive zinc intakes.[17] The pediatric UL of vitamin A was based on adverse effects of intracranial pressure (bulging fontanels) and skeletal abnormalities on infants receiving high doses of vitamin A and a conservative uncertainty factor of 10. This parameter is considered because infants are more susceptible to vitamin A toxicity than older children; furthermore, chronic hypervitaminosis is usually undetected.[18,19] Dietary supplements and foods commonly consumed by infants are formulated with preformed vitamin A. However, several vitamin supplements for infants contain high amounts of preformed vitamin A exceeding the UL; as a result, infants are exposed to potential vitamin A toxicity. Therefore, all sources of preformed vitamin A in diets of young children should be considered when regulatory standards for food manufacturers are established. In addition, the method used to set the ULs of vitamin A and zinc exhibit a narrow margin between the RNI and the UL of infants (less than two times the RNI).[20] Therefore, a high proportion of infants consuming vitamin A and zinc that exceeded the ULs not only reinforces the need to avoid unwarranted supplementation but also requires sufficient data as basis of appropriate ULs for infants. In the present study, the Z scores of LAZ, WAZ, and WLZ of the artificially fed infants and mix-fed infants were significantly lower than those of breast-fed infants. In a longitudinal study, Vietnamese children aged 1 month to 4 years exhibit significantly lower Z scores of the anthropometric indices (LAZ, WAZ, and WLZ) in children who received complementary food than in children who were exclusively breast fed for at least three months.[21] We also found a high prevalence of diseases, including diarrhea, respiratory system disease, and anaphylactic disease in artificially fed and mix-fed infants compared with that in breast-fed infants. Similar results were also found by Victora et al. In a population-based case-control study performed in two urban areas in Brazil; the results showed that the type of milk in an infant's diet is an important risk factor of death from diarrhea and respiratory infections.[22] The nutritional value and protective immune properties of breast milk as well as the psychosocial benefits of breastfeeding to infants are recognized. Thus, the WHO recommends exclusive breastfeeding during the first six months. However, an early introduction of complementary food remains a common practice in China, and the inclusion of non-breast-milk foods and beverages in a child's diet before the age of 6 months increases the risk of nutrient imbalances/deficiencies and infectious diseases.[22,23] The limitations of this study should be considered. In the present study, dietary information was obtained using a 24-hour dietary recall. The validity of this dietary assessment among infants was not evaluated in China. Fisher et al reported that the use of a single, telephone-administered, multiple pass 24-hour recall may significantly overestimate the energy and nutrient intake of infants or toddlers because estimation errors are observed in terms of portion size.[8] We used measuring cups and a food photograph booklet as reference to decrease the possibility that primary caregivers would over-report the portion sizes of specific food items in the study. Moreover, only one measurement was conducted in the study. This measurement is also subjected to daily or seasonal variations. We did not measure any biomarkers to determine the vitamin/mineral status of the infants. Therefore, the results only indicated the nutrient intake status of 0 month to 5 month infants fed by different feeding approaches.

A temporal relationship between dietary practices and nutritional status cannot be established because of a cross-sectional design; however, the results of this study suggested that nutritional education and intervention programs should be established to address dietary micronutrient imbalances/deficiencies, particularly in complementary diets with high bioavailable vitamin A and zinc contents. With the detrimental consequences of early childhood malnutrition in health and development, the recommended breastfeeding period in the first six months of life should be reinforced in China.

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AUTHOR DISCLOSURES

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work influence our work.

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Original Article

Nutritional status of breast-fed and non-exclusively breast-fed infants from birth to age 5 months in 8 Chinese cities

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中国8城市0-5月母乳喂养婴儿和非纯母乳喂养婴儿营养评价研究

为了评价不同喂养方式0-5月婴儿的营养状况，我们在中国8城市实施了婴儿营养横断面调查。总共调查了622名0-2月婴儿和456名3-5月婴儿。混合喂养婴儿指同时摄入母乳和辅食的婴儿。研究结果发现0-2月婴儿中，38.2%的混合喂养婴儿摄入过量的维生素A，15.6%的混合喂养儿摄入过量的锌。对于只摄入辅食的人工喂养儿来说，大约分别有20%和12.5%的婴儿摄入维生素A和锌的量不足。而超过一半的人工喂养儿摄入过量的维生素A和锌。3-5月的婴儿营养摄入状况与0-2月婴儿的营养摄入状况大致相同，也存在严重的维生素A和锌摄入失衡状况。此外，与母乳喂养儿相比，人工喂养儿和混合喂养儿有较高的疾病发病率和较低的年龄别身高，年龄别体重和身高别体重评分。总之，对于中国城市0-5月婴儿来说，除了维生素A和锌存在不同程度的营养失衡状况之外，其他大多数的营养素均摄入充足。

关键词：婴儿、营养状况、膳食评价、锌、铁