

RESEARCH ARTICLE

Open Access



Nutrient intakes of infants and toddlers from maternal and child care centres in urban areas of China, based on one 24-hour dietary recall

Cheng Chen¹, Liya Denney^{2*}, Yingdong Zheng¹, Gerard Vinyes-Pares³, Kathleen Reidy⁴, Huan Wang¹, Peiyu Wang¹ and Yumei Zhang^{1*}

Abstract

Background: An understanding of the diet of young children from infancy to early childhood in China is limited. The objective of this study is to evaluate nutrient intakes of young children from urban areas in China.

Methods: Mothers, infants and children were recruited from maternal and child care centres as part of a cross-sectional survey of Maternal Infant Nutrition Growth (MING). One 24-h dietary recall was completed for a sample of infants and toddlers aged 6 to 35 months ($n = 1409$) via face-to-face interviews with the primary caregiver. Nutrient intakes were estimated using data from Chinese Food Composition tables and compared with the Adequate Intakes (AI) or Estimated Average Requirement (EAR) from China.

Results: Mean intakes of most nutrients met or exceeded AIs. Mean fat intakes (% energy) in all subgroups fell below the AIs (32 % vs. 40 % among infants; 31 % and 32 % vs. 35 % among younger and older toddlers). Mean intakes of vitamin B6, folate and selenium were below the AIs among infants (0.3 vs. 0.4 mg/d, 93 vs. 100 µg/d and 15.2 vs. 20 µg/d, respectively). A risk of inadequate iron intake was also observed in infants. Mean vitamin A intake exceeded the recommendations in all subgroups. Mean sodium intakes among toddlers significantly exceeded the AI.

Conclusions: Based on one day dietary intake, the diets of the infants and toddlers appear to be adequate in mean intakes of most nutrients, with a few exceptions including risk of inadequate intakes of fat, vitamin B6, folate, iron and selenium among infants and risk of inadequate intake of fat, vitamin B6 and folate as well as excessive intakes of vitamin A and sodium among toddlers.

Keywords: Nutrient intakes, Chinese infants, Chinese toddlers, Urban China

Background

Appropriate nutrition during infancy and early childhood is vital for optimal growth and development. Dietary patterns established during childhood often persist into adulthood and have implications for developing diet-related chronic diseases later in life [1–3]. Several national nutrition surveys have been conducted in China since 1982. However, in those surveys only the population groups aged 2 years and

older were studied [4]. This is also the case for regional and local studies.

Yin, Duan and colleagues studied the diet of young children aged 2 to 7 years from different cities and provinces in China using three day food records. Compared with recommendations, inadequate intakes of calcium, zinc and vitamin C and too much salt intake were found among children aged 3–6 years from urban areas [5] and inadequate intakes of energy, protein, calcium, zinc, thiamine and riboflavin were reported among young children aged 2 to 7 years from rural areas [6]. Only one study was conducted in children aged 1 to 5 years in Yunnan Province, a poor area of China, using the data

* Correspondence: liya.denney@rdls.nestle.com; zhangyumei@hsc.pku.edu.cn

²Nestlé Research Centre, Lausanne, Switzerland

¹School of Public Health, Peking University, Beijing, China

Full list of author information is available at the end of the article

from three 24-h dietary recalls. Inadequate intakes of protein, carbohydrate, fat, calcium, iron, zinc and vitamin A were identified among the children [7].

Thus, up to now, an understanding of the diet of infants and toddlers is still limited, especially how the diet evolves over this period when children are transitioning from an all milk diet onto family food. In addition, the rapid changes in economic development and demographics in China have resulted in dietary and lifestyle changes [8–11] such as the shift towards a diet higher in fat and meat and lower in carbohydrates and fibre, a rapid increase in obesity and a decline in under-nutrition [8]. The extent to which these changes have affected the food consumption and nutrient intakes of young children in China is unknown.

The objective of the present study was to describe mean nutrient intakes of a sample of young children aged 6 to 35 months from urban areas of China using data from the Maternal Infant Nutrition Growth (MING) study, in which one 24-h dietary recall was collected.

Methods

Subjects

The MING study was a cross-sectional study designed to investigate the dietary and nutritional status of pregnant women, lactating mothers and young children aged from birth up to three years living in urban areas of China conducted in 2011 and 2012. Eight cities were chosen for the MING study according to the geographical location and status of economic development defined as first or second tier cities. The 8 cities included 4 first tier cities: Beijing, Shanghai, Chengdu and Guangzhou and 4 s-tier cities: Shenyang, Lanzhou, Zhengzhou and Suzhou. In each city, two maternal and child care centres (MCCC) were randomly selected. The MCCC is the primary health care facility that provides free birth-related health services to all women and their young children in all regions of China. The care centres are located in local residence communities in different districts of the city for easy access. The main services of MCCCs are to conduct regular health checks for pregnant women and their babies, and to provide regular vaccinations to young children from birth up to school age. In MCCCs, young children aged 6 to 35 months were randomly selected based on child registration information and their parents or caregivers were approached for subject recruitment. Response rate was 66 %. Exclusion criteria were parents or caregivers with psychopathy or abnormal memory, infants with hereditary disease or disability, as well as infants suffering from respiratory diseases or digestive tract diseases during the investigation. A stratified sample of 1498 young children in three age groups of 6 to 11, 12 to 23 and 24 to 35 months was obtained. Children under 12 months of age are called infants; children 12 to 35 months of age are called toddlers.

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 (No.IRB00001052-11042). Written informed consent was obtained from the primary caregiver of each infant or toddler participating in the study.

Data collection and nutrient database

All information collected from the study was obtained through face-to-face interviews with the parent or caregiver of each child. All interviewers were trained with a standard protocol for conducting the interview. The interview covered the information of a general questionnaire, a single 24-h dietary recall, a food frequency questionnaire, a survey on dietary supplement use and consumption of commercial baby food products.

The general questionnaire provided information on family demographic and socioeconomic characteristics, such as age, birth weight, recent medical history, education and occupation of parents and monthly household income (per capita). Information about feeding practices was also collected through this questionnaire. One 24-h dietary recall was completed for all infants and toddlers. Interviewers asked the primary care-giver about all foods, beverages and supplements that the infant or toddler consumed on the previous day. A picture booklet of common foods consumed in China and measurement aids such as spoons, cups and bowls were used to estimate the amount of foods and beverages consumed. Details about food ingredients of homemade foods or meals eaten out were also asked and recorded. In addition, information on the use of dietary supplements was collected, including the name and brand of the supplement, age when supplement was first given and the amount used. A list of dietary supplements commonly used in China was used to identify the supplements reported during the interview.

All the questionnaires including the 24-h dietary recalls were reviewed by the project supervisors in each of the cities for missing foods and unrealistic quantities reported. When such issues were found, the caregiver was contacted by telephone to verify the information. Of 1498 dietary records, 89 records (6 %) could not be verified were excluded from the final data analysis. Thus, final samples sizes of the subgroups were 444 children 6 to 11 months, 476 children 12 to 23 months and 489 children 24 to 35 months.

Food records were entered and processed with a food composition database created for this study that included data from Chinese Food Composition (CFC) tables 2004 & 2009 [12, 13] and branded-products and supplements from China. CFC contains information of 1773 foods with 36 nutrients. The values for both beta-carotene

and retinol were available in the database, thus vitamin A was estimated in retinol activity equivalents using the following formula [14]: Retinol activity equivalents = $\mu\text{g retinol} + 1/2 (\mu\text{g beta-carotene equivalents}/6)$.

In the CFC, the vitamin A concentration for breast milk was $11\mu\text{gRE}/100\text{ g}$, which is significantly lower than our analysis of the breast milk samples from the MING study, $70\mu\text{gRE}/100\text{ g}$ (unpublished data). This MING value is in line with the vitamin A concentration of breast milk reported by USDA [15], therefore, this value was used to estimate vitamin A intake from breast milk. In addition, in CFC, vitamin B6 data of breast milk was not available; we also used our analysis for vitamin B6 calculated from breast milk.

Additionally, data on infant products was limited in CFC, therefore, we compiled nutrient information for 78 branded-food products, including baby food and infant formula products using nutrition information from product labels. When a specific food was reported for which there was no nutrition information available, the nutrient data for a similar product was used. Finally we also compiled nutritional information from 75 dietary supplements sold in China.

The amount of breast milk consumed was estimated, using the approach developed by Butte et.al. Data on the amount of human milk fed was not collected, but rather data was collected on the number of times the mother nursed during the day. For infants aged 6 to 11 months fed human milk as the sole milk source, the amount of human milk was assumed to be $600\text{ mL}/\text{day}$; for partially breastfed infants, the amount of human milk was estimated as $600\text{ mL}/\text{day}$ minus the amount of formula/other milks consumed. For breastfed toddlers aged 12 to 23 months, the amount of human milk was estimated as 89 mL per feeding occasion; and for toddlers aged 24–36 months, the amount of human milk was estimated as 59 mL per feeding occasion [16].

Analytic methods

All statistical analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC, USA). Nutrient adequacy was assessed by comparing nutrient intakes to the Recommended Dietary Intake from the Chinese Nutrition Society 2013 [17]. The nutrient intakes, including the nutrients from food, beverages and dietary supplements are reported for each of three age groups: infants, younger toddlers and older toddlers. Since only one day 24-h recall was available for our sample, we were not able to adjust the distribution of nutrient intake to reflect usual intake as can be done with multiple days of dietary intake. Nutrient intake assessments were done by comparing mean intakes with the Adequate Intake (AI). A population group with a mean nutrient intake at or above the AI can be assumed to have nutritionally

adequate diets and implies a low prevalence of inadequate intakes [18]. Estimated Average Requirement (EAR) is also presented for reference and discussion. The energy requirements are expressed in terms of estimated energy requirements (EER). The EER is defined as the sum of the energy intake predicted to maintain energy balance for an individual's age and weight, as well as an allowance for energy deposition to account for growth [19].

Results

Description of the sample and dietary supplement use

The characteristics of children, mothers and households are shown in Table 1. Ninety percent of the mothers were 20 to 34 years of age at the time their babies were born. Among all the mothers, nearly 79 % had an education above high school or equivalent. About half (47 %) of the families had a monthly household income (per capita) that fell at or below the RMB 2001 to 3000 category. This income category covers the average income RMB 2047 for urban households in all regions in China and the average income 2726 RMB for urban households in developed eastern regions in China [20]. About half (47 %) of the families had monthly household income higher than the RMB 2001 to 3000 category. Sixty percent of the children were cared for by mothers and 37 % by grandparents.

As reported by the child's primary caregiver, the percentage of the young children receiving dietary supplements on the day of their 24-h dietary recall was 57 %. The supplements used most frequently were fish liver oil, multiple vitamin and mineral supplements.

Nutrient intakes of infants aged 6 to 11 months

The mean nutrient intakes of infants aged 6 to 11 months are displayed in Table 2. Mean energy intake was slightly below the EER ($80\text{ kcal}/\text{kg}/\text{day}$). Both the mean and median intakes of fat as percentage of total energy (%E) were lower than the AI (40%E) recommended by the Chinese Nutrition Society recently.

Mean intakes of vitamin B6, folate and selenium were below the AIs (0.3 vs. $0.4\text{ mg}/\text{d}$, 93 vs. $100\mu\text{g}/\text{d}$ and 15.2 vs. $20\mu\text{g}/\text{d}$ respectively), suggesting that some infants could have the intakes of these nutrients below the recommendations. Although the mean iron intake was above the EAR, the median iron intake was very close to the EAR (7.3 vs. $7\text{ mg}/\text{d}$) indicating that possibly some infants were at risk for inadequate iron intake. Mean intakes of other nutrients generally met or exceeded the recommendations.

Nutrient intakes of toddlers

Among both younger and older toddlers, the mean intakes of energy and protein met recommendations but

Table 1 Characteristics of the infants and toddlers from the MING study

Characteristics	Percent	Standard error
Child's sex		
Male	54.6	1.4
Female	45.4	1.4
Child's Ethnicity		
Han	95.0	0.6
Non-Han	5.0	0.6
Age of mother at birth(y)		
< 19	0.8	0.2
20–24	22.9	1.1
25–29	44.7	1.4
30–34	22.5	1.1
35–39	7.4	0.7
≥ 40	1.7	0.4
Mother's education		
Did not attend school	0.6	0.2
Primary school	2.7	0.4
Middle school	17.9	1.0
High school/Secondary specialized school	22.1	1.1
Technical College	22.7	1.1
Bachelor's degree	25.0	1.2
Master's degree or above	9.0	0.8
Average monthly income (per family member)		
< RMB 500 (<USD 80)	1.1	0.2
RMB 501–1500 (USD 80–240)	10.4	0.6
RMB 1501–2000 (USD 240–320)	14.3	0.7
RMB 2001–3000 (USD 320–480)	20.8	0.8
RMB 3001–4000 (USD 480–640)	14.0	0.7
RMB 4001–6000 (USD 640–960)	13.8	0.7
RMB 6001–8000 (USD 960–1280)	7.6	0.5
> RMB 8000 (USD 1280)	11.3	0.7
Unspecified	4.4	0.4
The main caregiver		
Mother	60.4	1.3
Father	0.5	0.2
Grandparent(s)	36.7	1.3
Nanny	1.1	0.3
Others	1.3	0.3
Missing(not reported)	3.8	0.5

both mean and median intakes of fat (%E) were lower than the AI (Table 3). Among younger toddlers, the mean intakes of vitamin B6 and folate just met the EARs but both median intakes were below the EARs. Mean vitamin A intake was more than 3 times the EAR (805

vs. 220 $\mu\text{gRAE/d}$). In addition, it appears that sodium intakes were excessive among both younger and older toddlers as both mean intakes (2399 mg/d, 2271 mg/d) and median intakes (1981 mg/d, 1941 mg/d) of sodium were significantly above the AI (700 mg/d). Mean intakes of other nutrients generally met or exceeded the recommendations.

Discussion

We have described in detail the mean nutrient intakes of a large sample of infants and toddlers from urban areas of China. To our knowledge, this is the first study of its kind and also the first to evaluate mean nutrient intakes from food and beverages and dietary supplements among infants and young children in China. Average household income in this sample tended to be somewhat higher than the average income across urban areas in China [20]. This may reflect the fact that the MING study included three most industrialized cities, Beijing, Shanghai and Guangzhou in China. Therefore, the results of our study provide a snap shot of the diet of young children in modern urban China.

Calories from fat

Lower than recommended intakes of fat (%E) were observed in this study. There was no equivalent or recent data from urban children to compare. However, the low percent of energy from fat found in this study seems to be in line with earlier surveys in China [21], as well as data on this population group from other countries [16]. In the national nutrition survey conducted in 1992, insufficient fat intake (20 to 30 %E) was found among toddlers aged 2 to 3 years [21]. The author of this report commented that the low fat intakes were not meeting the growth needs of young children and might have contributed to the presence of underweight and stunting among young children in China in that time [21]. The results from this study indicated that low fat intakes among young children in China may still exist, even among children living in urban areas. This is typical of the transition from an all milk diet to family meals in many countries. Specific strategies for addressing this issue in the diets of Chinese children could be explored by looking into the specific food sources of energy and nutrients in this population group.

Micronutrients and sodium

Risks of inadequate mean intakes of vitamin B6 and folate were found among infants and younger toddlers. Our study was the first to report the vitamin B6 and folate intakes of young children in China. Previous studies have reported that the folate intakes of adults in China were significantly below the recommendations,

Table 2 One-day nutrient intakes from food, beverage and supplements of infants aged 6 to 11 months (*n* = 444)

Nutrient	RNI or AI	EAR	Median	Mean ± SD
Macronutrients				
Energy (EER, Kcal/d)	80		73	79 ± 46
Fat (g/d)			26	25 ± 14
Carbohydrate (g/d)	80 (AI)		85	103 ± 74
Protein (g/d)	20	15	20.8	23.8 ± 15.6
Fibre (g/d)			1.2	2.0 ± 2.8
As percentage of total energy				
Fat (%)	40 (AI)		34	32 ± 12
Carbohydrate (%)			54	56 ± 13
Protein (%)			12.4	13.1 ± 3.9
Antioxidants				
Vitamin C (mg/d)	40 (AI)		53	55 ± 45
Vitamin E (mg/d)	4 (AI)		6.0	7.3 ± 8.6
B vitamins				
Thiamine (mg/d)	0.3 (AI)		0.4	0.5 ± 0.4
Riboflavin (mg/d)	0.5 (AI)		0.7	0.8 ± 0.6
Niacin (mg/d)	3 (AI)		3.3	4.2 ± 3.5
Vitamin B6 (mg/d)	0.4 (AI)		0.3	0.3 ± 0.4
Folate (µg dietary folate equivalents/d)	100 (AI)		73	93 ± 92
Bone-related nutrients				
Calcium (mg/d)	250 (AI)		470	524 ± 424
Phosphorus (mg/d)	180 (AI)		366	431 ± 293
Magnesium (mg/d)	65 (AI)		114	120 ± 81
Other micronutrients				
Vitamin A (µgRAE/d)	350 (AI)		622	697 ± 514
Iron (mg/d)	10	7	7.3	8.5 ± 6.0
Zinc (mg/d)	3.5	2.8	4.3	4.9 ± 3.3
Sodium (mg/d)	350		307	564 ± 1005
Potassium (mg/d)	550		515	636 ± 479
Selenium (µg/d)	20 (AI)		12.3	15.2 ± 12.6

RNI Recommended Nutrient Intake, AI Adequate Intake, EAR Estimated Average Requirements, EER Estimated Energy Requirement, RAE retinol activity equivalent. A blank space in columns of RNI/AI and EAR indicates that no value has been defined by the Chinese Nutrition Society

especially for those living in northern China possibly due to a lack of fresh fruits and vegetables in cold seasons [22, 23].

Mean and median iron intakes among infants were low, suggesting that there could be a risk of inadequate iron intake in this age group. Low iron intakes, a major cause of iron deficiency anaemia among young children, have been widely documented in China and worldwide [7, 24–27]. Low intakes of iron can potentially lead to developmental delays [28]. It has been reported previously that adults and children in China obtain most of their iron from rice and wheat products, which could be problematic as iron bioavailability from these foods is generally low. The data from our further studies showed

that rice and noodles, together with vegetables, contributed about 30 to 43 % of the iron intakes among the toddlers (unpublished data). Therefore, the poor sources and bioavailability of iron could be contributing factors to iron deficiencies observed among young children and pregnant women in China [24].

In this study, very high mean vitamin A intake was found. It is known that common foods consumed in China are plant based and some vegetables commonly consumed, such as Chinese cabbage, are not naturally high in preformed vitamin A. In the past, the prevalence of vitamin A deficiency evaluated by low serum vitamin A level has been reported to be high in China, especially in rural areas [7, 29, 30]. Mothers of young children have

Table 3 One-day nutrient intakes from food, beverage and supplements of toddlers aged 12 to 35 months ($n = 965$)

Nutrient	RNI or AI	EAR	12 to 23 months		24 to 35 months	
			Median	Mean \pm SD	Median	Mean (SD)
Macronutrients						
Energy (EER, Kcal/d)	12–23 months: M 900, F 800 24–35months: M 1100, F 1000		953	1138 \pm 647	1060	1189 \pm 586
Fat (g/d)			35	41 \pm 27	36	41 \pm 24
Carbohydrate (g/d)		120	124	154 \pm 93	144	163 \pm 91
Protein (g/d)	25	20	34	41 \pm 26	40	45 \pm 24
Fibre (g/d)			3.2	4.1 \pm 4.1	4.1	5.9 \pm 6.5
As percentage of total energy						
Fat (%)	35 (AI)		33	32 \pm 11	31	31 \pm 11
Carbohydrate (%)	50 ~ 60		53	54 \pm 12	54	54 \pm 12
Protein (%)			13.7	14.5 \pm 4.3	14.8	15.6 \pm 4.2
Antioxidants						
Vitamin C (mg/d)	40	35	59	87 \pm 91	50	76 \pm 182
Vitamin E (mg/d)	6 (AI)		10	12 \pm 8	10.3	12.4 \pm 8.9
B vitamins						
Thiamine (mg/d)	0.6	0.5	0.6	0.8 \pm .07	0.6	0.8 \pm 0.8
Riboflavin (mg/d)	0.6	0.5	0.8	1.2 \pm 1.2	0.8	1.1 \pm 1.0
Niacin (mg/d)	6	5	6.2	7.5 \pm 5.5	7.2	8.8 \pm 6.2
Vitamin B6 (mg/d)	0.6	0.5	0.4	0.5 \pm 0.6	0.4	0.6 \pm 0.7
Folate (μ g dietary folate equivalents/d)	160	130	112	138 \pm 108	124	174 \pm 180
Bone-related nutrients						
Calcium (mg/d)	600	500	559	804 \pm 829	510	646 \pm 528
Phosphorus (mg/d)	300	250	606	764 \pm 577	677	762 \pm 415
Magnesium (mg/d)	140	110	129	152 \pm 95	143	160 \pm 87
Other micronutrients						
Vitamin A (μ gRAE/d)	310	220	610	805 \pm 756	445	587 \pm 503
Iron (mg/d)	9	6	10.8	13.3 \pm 9.4	11.8	15.2 \pm 13.8
Zinc (mg/d)	4	3	6.1	7.7 \pm 5.5	6.7	7.6 \pm 4.4
Sodium (mg/d)	700 (AI)		1981	2399 \pm 1757	1941	2271 \pm 2351
Potassium (mg/d)	900 (AI)		1052	1328 \pm 1022	1158	1343 \pm 820
Selenium (μ g/d)	25	20	23	27 \pm 21	27	31 \pm 17

RNI/ Recommended Nutrient Intake, AI Adequate Intake, EAR Estimated Average Requirement, EER Estimated Energy Requirements, RAE retinol activity equivalent. A blank space in columns of RNI/AI and EAR indicates that no value has been defined by the Chinese Nutrition Society

been encouraged by doctors and health professionals to give vitamin A supplements such as cod liver oil to their children. In this study, vitamin A supplements indeed contributed on average about 24 % of vitamin A intake among the children (data not shown). This could be, to certain extent, one of the factors causing the excessive intakes of vitamin A observed across all age groups. The contribution of supplements to nutrient intakes among the young children will be investigated in detail in our further studies.

We found high mean sodium intakes among the toddlers in this study. High sodium consumption is one of

several dietary factors that may be associated with increased blood pressure, a risk factor for cardiovascular disease. Eating too much salt in childhood could lead to a preference for salty foods later [31]. It is well documented that the salt intakes of adults in China are among the highest in the world, on average 14 g/day in men and 12 g/day in women, as reported by the INTERMAP study in 2003 [32]. Up to now, the information on sodium intake among young children in China was very limited. One previous study reported that the sodium intakes among preschool children aged 3 to 6 years were nearly twice the AI [5]. The average sodium intakes

(2399 to 2271 mg) among toddlers in this study were equivalent to 5.7 to 6.0 g salt per day, and far above the AI (700 mg) 1.8 g salt per day. We have also found that the high salt intakes came primarily from home-cooked foods high in salt (Wang et al. submitted together with this manuscript) as has been reported in adult population in China [33]. Our data indicate that this trend of high sodium intake begins very early in China and attention should be given to educating about potential risks of very high sodium intakes.

Limitations of the study

A major limitation of this study was that the information on food consumption among the young children was collected using a single 24-h dietary recall. Although one 24-h recall is sufficient to provide estimates of the average nutrient intakes of a large sample and to characterize the intakes to a certain extent [34], there are random errors due to day to day variation in individual diets which could lead to over or underestimation. Therefore it is not possible to accurately estimate the distribution of nutrient intakes with only one day of intake. The most appropriate way to estimate the prevalence of inadequate intakes of a population is to obtain the usual intakes of the population and use the EAR cut-point method based on the distribution of intakes to estimate [18, 35, 36]. While we have identified a few obvious issues with nutrient intakes in the diets of young Chinese children based on mean and median intakes, it was not possible to conclude with certainty that the other nutrients were consumed in adequate amounts, due to this limitation of using one day of intake. The distributions of intake for several nutrients were quite wide, which one would expect with one day of intake, but questions still remain as to whether any of the other nutrients with very wide distributions might have been issues in the diets of these children. Investigation into the food sources of energy in this sample of children revealed that a significant percent of calories among infants were being contributed by two relatively nutrient poor foods, rice and noodles (23–25 %) (Wang et al. submitted together with this manuscript). This is evidence that further investigation into the nutrient adequacy of the diets of this group of children is warranted.

The second limitation of the study was that the intakes of several important nutrients could not be assessed including saturated fat, vitamin B12, vitamin D and vitamin K, as values for these nutrients were not available from the China Food Composition tables. Therefore, these values in food composition tables need to be improved.

Finally, another possible limitation was that the bioavailability and losses of nutrients during cooking in different food categories was not considered in our current analyses, as the CFC Database provides nutrient

composition of foods before cooking. For example the contribution of vegetables, which tend to be cooked before consuming, to nutrients might have been overestimated, especially for water-soluble vitamins.

Conclusions

This was the first large-scale study evaluating the mean nutrient intakes of infants and young children from urban China. Although the diets of infants and toddlers appear to be adequate in mean intakes for most nutrients, several issues were identified. Mean intakes of fat fell below the recommendation and risks of shortfalls in the mean intakes of vitamin B6, folate, iron and selenium were observed among the infants aged 6 to 11 months. The observed high sodium intakes among toddlers indicate that the issue of high sodium intake, also seen in the adult population begins very early. Based on one day dietary intake, we could not conclude that intakes of the other nutrients assessed were adequate for all segments of the population. Further studies that collect multiple 24-h recalls to estimate the usual intake of the population are needed.

Competing interests

The author(s) declare that they have no competing interests. The study was funded by the Nestle Nutrition Institute China and the Nestle Research Centre. It was a collaborative effort between Peking University School of Public Health and Nestle.

Authors' contributions

CC contributed to the data collection, performed the statistical analyses and drafted the manuscript; LD contributed to interpretation of the data, drafting and critical revision of the manuscript; YZ contributed to data collection and statistical analyses; GVP contributed to the data interpretation and revision of the manuscript; KR contributed to the conception and design of the study, interpretation of the data and critical revision of the manuscript; HW contributed to data collection and statistical analysis; PW contributed to the conception and design of the study; YZ contributed to the conception and design of the study and data collection. All authors read and approved the final manuscript.

Acknowledgements

The authors thank the families who volunteered for this study, Laurence Li for project support and guidance, Celia Ning for project management and data collection and local project staff for recruitment and data collection.

Author details

¹School of Public Health, Peking University, Beijing, China. ²Nestlé Research Centre, Lausanne, Switzerland. ³Nestlé R&D Centre, Beijing, China. ⁴Nestlé Nutrition Global R&D, Florham Park, NJ, USA.

Received: 29 April 2015 Accepted: 30 September 2015

Published online: 28 October 2015

References

- Mikkila V, Rasanen L, Raitakari OT, Pietinen P, Viikari J. Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in Young Finns Study. *Br J Nutr*. 2005;93(6):923–31.
- Reilly JJ, Armstrong J, Dorosty AR, Emmett PM, Ness A, Rogers I, et al. Early life risk factors for obesity in childhood: cohort study. *BMJ*. 2005;330(7504):1357.
- Agostoni C, Decsi T, Fewtrell M, Goulet O, Kolacek S, Koletzko B, et al. Complementary feeding: a commentary by the ESPGHAN Committee on Nutrition. *J Pediatr Gastroenterol Nutr*. 2008;46(1):99–110.

4. Li LM, Rao KQ, Kong LZ, Yao CH, Xiang HD, Zhai FY, et al. A description on the Chinese national nutrition and health survey in 2002. *Zhonghua Liu Xing Bing Xue Za Zhi*. 2005;26(7):478–84.
5. Yin S, Su Y, Liu Q, Zhang M. Dietary status of preschool children from day-care kindergartens in six cities of China. *Wei Sheng Yan Jiu*. 2002;31(5):375–8.
6. Duan DH, Zhu MY, Luo JY, Wang Z, Gu CH, Zhang WM, et al. Investigation on dietary nutrients among rural stranded children of 2–7 year olds in china. *Zhonghua Liu Xing Bing Xue Za Zhi*. 2009;30(4):326–30.
7. Willows ND, Barbarich BN, Wang LC, Olstad DL, Clandinin MT. Dietary inadequacy is associated with anemia and suboptimal growth among preschool-aged children in Yunnan Province. *China Nutr Res*. 2011;31(2):88–96.
8. Popkin BM. Nutrition in transition: the changing global nutrition challenge. *Asia Pac J Clin Nutr*. 2001;10(Suppl):S13–8.
9. Zhai F, Wang H, Du S, He Y, Wang Z, Ge K, et al. Prospective study on nutrition transition in China. *Nutr Rev*. 2009;67 Suppl 1:S56–61.
10. Dearth-Wesley T, Gordon-Larsen P, Adair LS, Siega-Riz AM, Zhang B, Popkin BM. Less traditional diets in Chinese mothers and children are similarly linked to socioeconomic and cohort factors but vary with increasing child age. *J Nutr*. 2011;141(9):1705–11.
11. Wang Z, Zhai F, Zhang B, Popkin BM. Trends in Chinese snacking behaviors and patterns and the social-demographic role between 1991 and 2009. *Asia Pac J Clin Nutr*. 2012;21(2):253–62.
12. Center of Disease Control Institute of Nutrition and Food Hygiene. *China Food Composition*. 1st ed. Beijing: Beijing Medical University Press; 2004.
13. Center of Disease Control Institute of Nutrition and Food Hygiene. *China Food Composition*. 2nd ed. Beijing: Beijing Medical University Press; 2009.
14. Nutrition Coordinating Center University of Minnesota. Revisiting vitamin A measurements. *NDS Quarterly*. 2001;12:2.
15. USDA. National Nutrient Database for Standard Reference Release 27 Basic report 01107, Milk, human, Mature, fluid. 2014. <http://ndb.nal.usda.gov/ndb/foods/show/96>. Accessed 1 October 2014.
16. Butte NF, Fox MK, Briefel RR, Siega-Riz AM, Dwyer JT, Deming DM, et al. Nutrient intakes of US infants, toddlers, and preschoolers meet or exceed dietary reference intakes. *J Am Diet Assoc*. 2010;110(12 Suppl):S27–37.
17. Chinese Nutrition Society. *Chinese Dietary Reference Intakes Handbook 2013*. Beijing: China Standard Press; 2014.
18. Institute of Medicine. *Dietary Reference Intakes: Applications in Dietary Assessment*. Washington DC: The National Academies Press; 2000.
19. Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*. Washington DC: The National Academies Press; 2005.
20. National Bureau of Statistics of China. *China Statistical yearbook 2013*. Beijing: China Statistics Press; 2013.
21. Chunming C. Fat intake and nutritional status of children in China. *Am J Clin Nutr*. 2000;72(5 Suppl):1368S–72.
22. Meng Q, Zhang L, Liu J, Li Z, Jin L, Zhang Y et al. Dietary folate intake levels in rural women immediately before pregnancy in Northern China. *Birth Defects Res A Clin Mol Teratol*. 2014. doi:10.1002/bdra.23280
23. Hao L, Ma J, Stampfer MJ, Ren A, Tian Y, Tang Y, et al. Geographical, seasonal and gender differences in folate status among Chinese adults. *J Nutr*. 2003;133(11):3630–5.
24. Ma G, Jin Y, Li Y, Zhai F, Kok FJ, Jacobsen E, et al. Iron and zinc deficiencies in China: what is a feasible and cost-effective strategy? *Public Health Nutr*. 2008;11(6):632–8.
25. Conn JA, Davies MJ, Walker RB, Moore VM. Food and nutrient intakes of 9-month-old infants in Adelaide. *Australia Public Health Nutr*. 2009;12(12):2448–56.
26. Gibson S, Sidnell A. Nutrient adequacy and imbalance among young children aged 1–3 years in the UK. *Nutr Bull*. 2014;39:172–80.
27. Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, et al. A systematic analysis of global anemia burden from 1990 to 2010. *Blood*. 2014;123(5):615–24.
28. Berglund S, Domellof M. Meeting iron needs for infants and children. *Curr Opin Clin Nutr Metab Care*. 2014;17(3):267–72.
29. Jiang J, Toschke AM, von Kries R, Koletzko B, Lin L. Vitamin A status among children in China. *Public Health Nutr*. 2006;9(8):955–60.
30. Zhang Y, Tao F, Yin H, Zhu X, Ji G, Kong S, et al. Breast-feeding, dietary intakes and their associations with subclinical vitamin A deficiency in children in Anhui Province. *China Public Health Nutr*. 2007;10(7):733–8.
31. Campbell KJ, Hendrie G, Nowson C, Grimes CA, Riley M, Lioret S, et al. Sources and correlates of sodium consumption in the first 2 years of life. *J Acad Nutr Diet*. 2014;114(10):1525–32. e2.
32. Zhou BF, Stamler J, Dennis B, Moag-Stahlberg A, Okuda N, Robertson C, et al. Nutrient intakes of middle-aged men and women in China, Japan, United Kingdom, and United States in the late 1990s: the INTERMAP study. *J Hum Hypertens*. 2003;17(9):623–30.
33. Du S, Batis C, Wang H, Zhang B, Zhang J, Popkin BM. Understanding the patterns and trends of sodium intake, potassium intake, and sodium to potassium ratio and their effect on hypertension in China. *Am J Clin Nutr*. 2014;99(2):334–43.
34. Hebert JR, Hurley TG, Steck SE, Miller DR, Tabung FK, Peterson KE, et al. Considering the value of dietary assessment data in informing nutrition-related health policy. *Adv Nutr*. 2014;5(4):447–55.
35. Bingham SA. Limitations of the various methods for collecting dietary intake data. *Ann Nutr Metab*. 1991;35(3):117–27.
36. Murphy SP, Poos MI. Dietary reference Intakes: summary of applications in dietary assessment. *Public Health Nutr*. 2002;5(6A):843–9.

Submit your next manuscript to BioMed Central and take full advantage of:

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

