Original Article

Dietary survey of anaemic infants and young children in urban areas of China: a cross-sectional study

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Background and Objectives: To explore the diet characteristics of anaemic infants and young children of China, blood tests and diets surveys were conducted in five cities. **Methods and Study Design**: About 150 children aged 6-36 mo were selected in a typical community health center of each city, and the total sample was 750. Nutritional status was measured through 24h dietary recall method and HEMO Cue was used for Haemoglobin concentration testing. **Results:** The average prevalence of anaemia was 17.2% in 6-12 mo children, which was higher than in other age groups. Median intakes of 8 nutrients (protein, vitamin A, B-1 and C, calcium, iron, zinc and copper) in anaemic children were less than non-anaemic children ($p<0.05$) in 6-12 mo olds; at age 12-24 mo the intake of vitamin A in anaemic children was less than in non-anaemic children ($p<0.05$). Market complementary food was the main source of iron in both anaemic and non-anaemic children (6-12 mo olds: 2.28 and 3.69 mg; 12-24 mo olds: 2.06 and 2.09 mg, respectively). Iron intake from formula was lower in anaemic children than in non-anaemic children (6-12 mo olds: 0.88 vs 2.54 mg; 12-24 mo olds: 1.59 vs 2.87 mg). The proportion of children obtaining continued breastfeeding in anaemic children was significantly higher than in non-anaemic children aged 6-12 mo (65% vs 37%, $p<0.05$). **Conclusions:** Appropriate practices around continuing breastfeeding and complementary feeding particularly targeted to breast fed older infants and young children are needed to reduce anaemia in infants and young children.

Key Words: anaemia, infant and young child, diet nutrients, continuing breastfeeding, urban areas

INTRODUCTION

Childhood anaemia is a major public health problem worldwide and it is also a common problem in infants and young children in China, not only in rural areas, but also in urban areas.[1] Anaemia in infants and young children is associated with serious consequences, including growth retardation, lower resistance to infection, and impaired neurodevelopment. When children who have experienced early anaemia reach school age they often have impaired performance in tests of language skills, motor skills, and coordination.[2]

Anaemia may be caused by a range of shared factors, including poverty, family feeding practice, illness, and mother's status.[1,3-5] Infant and young child feeding pattern constitutes a critical role in child nutritional adequacy during early life. In order to attain data of the diet characteristics of anaemic and non-anaemic infants and young children in urban areas, dietary surveys and blood tests were conducted in children between 6 and 36 mo from four areas (north, south, east and west) of urban China.

MATERIALS AND METHODS

Child inclusion criteria were: (1) Healthy children aged 6 to 36 mo, not yet in nursery; (2) Full-term infants (gestational age greater than or equal to 37 weeks and less than 42 weeks) whose birth weight was greater than or equal to 2.5 kg and less than 4 kg; (3) Have routine medical examinations in the Department of Child Health Care of maternal nations in the Department of Child Health Care of maternal and child health institutions; (4) Guardians are familiar with food preparation processes and infant feeding; (5) Guardians agree to accept and participate in the dietary survey and visit. Child exclusion criteria were: (1) A confirmed birth defect or genetic disease; (2) History of food allergies or intolerances; (3) Suffering from cardiovascular, respiratory, endocrine, blood system, gastrointestinal tract or other systemic diseases; (4) Obvious abnormalities that affect food absorption.

Five typical cities of China were selected, including Shanghai and Nanjing located in the east of China, Beijing in the north of China, Shenzhen in the south of China, and Chengdu in the west of China. One typical maternal and child health facility in each cities was selected. About

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150 children between 6 and 36 mo of age were selected in each city by random stratified sampling. Approximately 50 children were randomly selected per one of three age groups (6-12, 12-24 and 24-36 mo). Surveys took place between June and July in 2012, and were finished within 30 days after the initial day.

Haemoglobin (Hb) concentration test equipment: HEMO Cue was selected for the study because it was fast and convenient and was suitable for use in outpatient units.[6] 24h Dietary Questionnaire: Part 1: Upon the consent of caregivers, investigators filled in the general information form, including: survey date, child name, gender and date of birth, family economic conditions and general information regarding caregivers. Part 2: the 24h Dietary recall was conducted as an interview of the caregiver who fed the child the previous day (child's mother or another caregiver). All foods and liquids the child consumed within 24 hours were recorded. Survey contents: number of meals, food name, texture and amount taken by the child in the previous day (within 24 hour). Foods included: breast milk, staple food, vegetables, legumes, fruits, meat and fish, eggs and dairy, and others. An auxiliary food atlas was used for measuring food quantity.

All surveyors were trained on the process of conducting a standardized dietary survey, the requirements and methods of auxiliary measuring atlas, as well as the process for filling in the 24h Dietary Questionnaire. After the training, the surveyors participated in practice sessions to get familiar with the survey steps and methods. Prior to the formal survey, 10 volunteers were invited for the pretest so as to evaluate the feasibility of the questionnaire and survey content and make relevant corrections.

Dietary nutrient analysis was based on data from "2009 China Food Composition" edited by the National Institute of Nutrition and Food Safety China Food Composition in 2009;[7] and breast milk nutrients analysis was based on World Health Organization (WHO) data from 1998.[8] Data input was done with Epidata 3.1; statistical analyses were performed using SAS 9.1. Statistical tests used were: chi-square test and non-parametric test.

The Ethics Committee of Capital Institute of Pediatrics (SHERLL2013005) approved the study according to the International Organizations of Medical Sciences on "Human biomedical research international guidelines" and ethical principles from "the Declaration of Helsinki". We obtained written informed consent from the next of caretakers on the behalf of the children participants involved in this study. Treatment advice for anaemia was provided to anaemic subjects free of charge.

RESULTS

In total 750 children participated in the survey. Gender distribution of the young children was slightly shifted towards more boys (392/358) and maternal education level was found to be rather high: 79% had college or university education. Maternal age distribution was: ≤25 years: 8%; 25-30 years: 44%; 30-35 years: 38%; >35 years: 10%. 86% of families had a yearly income of >100,000 RMB.

Hb concentrations below 110 g/L for children aged 0-6 years was considered as anemia.[9] Table 1 shows that the prevalence of anaemia in infants aged 6-12 mo was the highest (17.2%) and dropped to 8% and 4% for the age groups 12-24 and 24-36 mo, respectively. Total prevalence across the three age groups in our study was 9.7%.

Ten macro and micro nutrients (protein, vitamin A (vitA), vitamin B-1 (vitB-1), vitamin B-2 (vitB-2), niacin, vitamin C (vitC), calcium (Ca), iron (Fe), zinc (Zn), and copper (Cu)) were calculated from children's 24 hours food intake. Table 2 shows median intakes of nutrients in anaemic and non-anaemic children. In the 6-12 mo age group, the intakes of 8 nutrients (protein, vitA, vitB-1, vitC, Ca, Fe, Zn and Cu) in anaemic children were significantly less than in non-anaemic children (p<0.05). In the 12-24 mo age group, the intake of vitA in anaemic children was less than in non-anaemic children (p<0.05). Comparison of the median and 25th percentile values of nutrient intake with Chinese Estimated Average Requirement (EAR) or Adequate Intake (AI) levels reveals that in 6-12 mo old anaemic subject, 4 median nutrient intakes (vitA, vitB-1, vitC, Fe) were below EAR or AI, while for another 4 nutrients (protein, niacin, Ca, Cu) the 25th percentile intake values were below EAR or AI, suggesting substantial numbers of anaemic with multiple nutrient deficient intake.[10] For non-anaemic infants, the situation was clearly less severe with none of the nutrient intake levels below EAR or AI and for 6 nutrients (protein, vitA, vitB-1, niacin, vitC, Fe) 25th percentile intake levels were below EAR or AI. For the 12-24 mo old anaemic children, 4 median nutrient intakes (protein, vitA, niacin, vitC) were below EAR and for 2 nutrients (vitB-1, Ca), the 25th percentile intakes were below EAR also suggesting poor dietary intake. In the non-anaemic 12-24 mo old children, only one median nutrient intake (vitB-1) was below EAR and for 3 nutrients (niacin, vitC, Ca) 25th percentile intake was lower than EAR. These results confirm more deficient dietary intakes among the anaemic compared with the non-anaemic young children.

Figure 1 shows median iron intakes from different food sources in anaemic and non-anaemic children of 6-12 mo and 12-24 mo. In the children of 6-12 mo, the source of iron was mainly from market complementary food in both anaemic and non-anaemic children (2.28 and 3.69 mg, respectively). In the children of 12-24 mo, the major sources of iron were plant foods (2.69 and 2.20 mg, respectively), market complementary foods (2.06 and 2.09 mg, respectively) and formula in both anaemic and non-anaemic children. In both age groups, iron from formula was lower in anaemic children than in non-anaemic children (0.88 vs 2.54 mg, respectively in 6-12 mo; 1.59 vs 2.87 mg, respectively in 12-24 mo).

Figure 2 illustrates that the proportion of children obtaining continued breastfeeding in anaemic children was

Table 1. Prevalence of anaemia

Age group (month)	N	Median age (Q_1, Q_3)	Anaemia† (n (%))
6-12	250	8.7 (6.5, 10.1)	43 (17.2)
12-24	250	15.0 (12.2, 18.0)	20 (8)
24-36	250	27.9 (24.3, 30.7)	10 (4)
Total	750	15.0 (10.9, 24.2)	73 (9.7)

†Anaemia: Hb <110 g/L.

Table 2. Median (Q_1, Q_3) nutrients intakes in anaemic and non-anaemic children

	6-12 mo				12-24 mo			
	Anaemic n=43	Non-anaemic n=207	*p*	EAR or AI	Anaemic n=20	Non-anaemic n=230	*p*	EAR
Protein (g)	17.7 (11.6, 22.4)	20.9 (14.0, 28.3)	0.02	15	28.5 (17.4, 33.5)	26.3 (20.6, 33.2)	0.88	20
Vitamin A (µgRE)	286 (150, 599)	558 (240, 907)	<0.01	350	340 (202, 722)	546 (348, 900)	0.04	220
Vitamin B-1 (mg)	0.25 (0.14, 0.68)	0.47 (0.25, 0.76)	0.03	0.3	0.42 (0.30, 0.58)	0.42 (0.30, 0.67)	0.47	0.5
Vitamin B-2 (mg)	0.86 (0.57, 1.46)	1.05 (0.7, 1.83)	0.10	0.5	0.98 (0.58, 1.28)	1.01 (0.69, 1.38)	0.43	0.5
Niacin (mg)	4.43 (1.99, 6.54)	4.63 (2.87, 7.68)	0.11	3	5.81 (4.08, 7.16)	5.84 (3.88, 8.52)	0.71	5
Vitamin C (mg)	37.3 (32.8, 60.9)	54.4 (34.6, 82.9)	0.01	40	49.2 (26.5, 83.6)	58.9 (34.8, 85.7)	0.29	35
Ca (mg)	465 (239, 736)	577 (360, 862)	0.02	250	473 (274, 634)	547 (374, 754)	0.21	500
Fe (mg)	4.46 (2.29, 12.8)	8.36 (4.72, 14.1)	0.02	7	7.82 (7.03, 10.5)	8.81 (6.51, 12.5)	0.49	6
Zn (mg)	3.94 (3.04, 5.66)	5.03 (3.50, 7.05)	0.03	2.8	5.31 (4.09, 6.37)	5.33 (4.04, 6.79)	0.64	3.2
Cu (mg)	0.35 (0.23, 0.42)	0.45 (0.31, 0.68)	<0.01	0.3	0.58 (0.43, 1.1)	0.57 (0.41, 0.81)	0.45	0.25

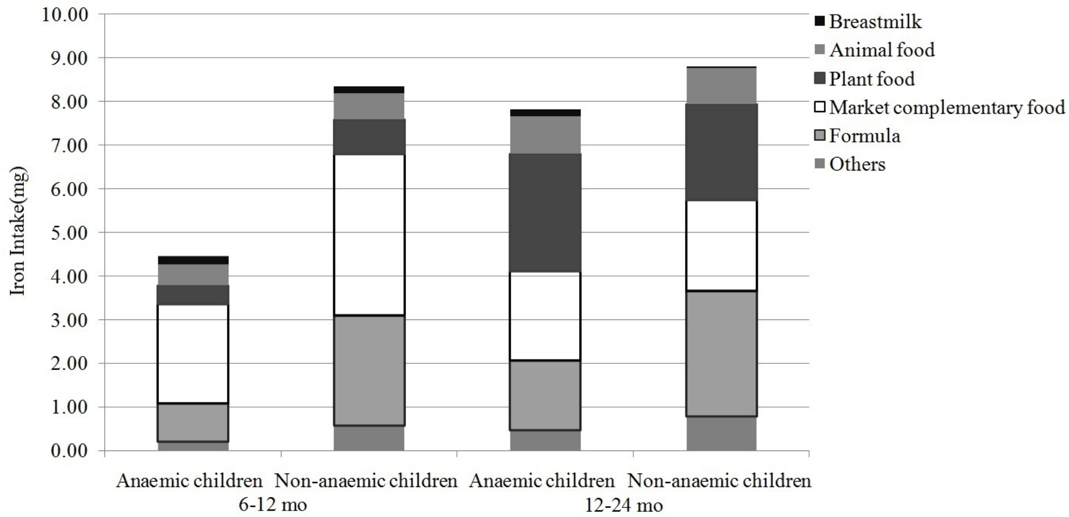

Figure 1. Iron intake from different foods in anaemic and non-anaemic children aged 6-24 mo.

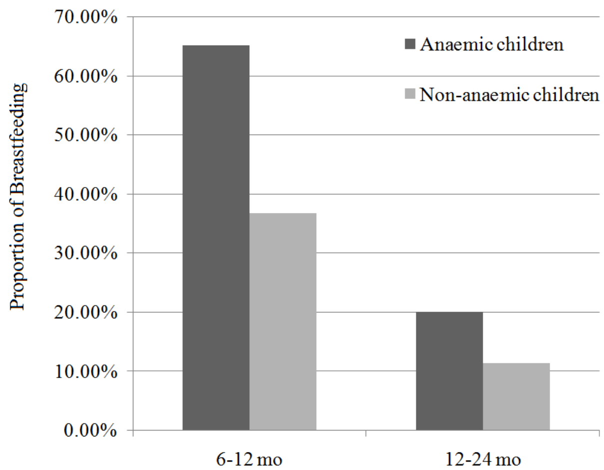

Figure 2. Proportion of breast feeding in anaemic and non-anaemic children. Chi-square test: 6-12 month: χ^2=11.82, p<0.05; 12-24 month: χ^2=1.32, p=0.25.

significantly higher than in non-anaemic children of 6-12 mo (65% vs 37%, $p<0.05$) and in 12-24 mo (20% vs 11%, $p=0.25$). In the 24-36 mo olds, the number of anaemic children was too small for a meaningful comparison (data not shown).

DISCUSSION

This study showed that the prevalence of anaemia in 6-12 mo, 12-24 mo and 24-36 mo children in our urban study population with well-educated mothers was 17.2%, 8% and 4%, respectively. As the WHO standard defines anaemia prevalence >5% to be a public health problem, therefore anaemia among young children in urban China, especially in 6-12 mo, is still a public health problem.[11] This study does no longer identify anaemia as a public health problem for 24-36 mo children across our urban China with well-educated mothers as its prevalence was lower than 5%.

In the 6-12 mo age children the median iron intake in anaemic children was only about half of the intake in non-anaemic children, although also the intakes of protein, vitB-1, C, calcium, zinc and copper were significantly lower. The difference in iron intake between the two groups can mainly be attributed to differences in iron intake from market complementary foods and milk formula, both typically fortified with fairly well-absorbable iron sources. There is consensus in the scientific arena that the prevalence of anaemia as indicator for iron deficiency is only of limited value. Lind et al[12] reported on a positive association between dietary iron intake and Hb-level in the first year of life, but not in the second. Moreover, Vendt et al[13] even determined that at Hb-cut off level of 107 g/L optimal levels for sensitivity and specificity reached 67% and 87%, respectively, for diagnosing iron deficiency in 9-12 mo old Estonian infants.

For the 12-24 mo old children, we did not find the difference in iron intake to be statistically significant, just like for the other measured nutrients except for vitamin A. This supports the conclusions from numerous other reports that the causes of anaemia are multi factorial and that iron deficiency probably overlaps only to 50% with anaemia.[12,14]

Based on the clear difference in iron intake from milk formula between anaemic and non-anaemic infants aged 6-12 mo, we investigated the effect of continued breastfeeding practice on the prevalence of anaemia and found that among the 43 anaemic 6-12 mo old infants, 28 (65%) were still being breastfed, whereas amongst the 207 non-anaemic infants, 76 (37%) were still breast fed; this difference was statistically significant. These findings agree with studies in 9-12 mo old infants from Thailand and Estonia.[15,16] Also the DINO study out of Germany points to the increased risk of breast fed infants to become anaemic between 7 and 10 mo of age.[17]

For the 12-24 mo old children, we found that among the 20 anaemic young children 4 (20%) were still being breast fed compared with 26 (11%) breast fed infants amongst the 230 non-anaemic 12-24 mo old children. This difference was not statistically significant due to the low numbers. However, the recent report on the TAR Get Kids study from Canada reports on an association between increased duration of breastfeeding and lower serum ferritin.[18] This study suggests an increasing probability of iron deficiency with longer total breastfeeding duration with an adjusted odds ratio of 1.71 (95% confidence interval: 1.05-2.79) for iron deficiency in children breastfed over 12 mo of age compared with under 12 mo of age. Our findings in the 12-24 mo olds, although statistical significance was not reached, support these results and underline the importance of continued attention for anaemia and iron deficiency after the period of infancy.

For the 6-12 mo old children, market complementary foods were the largest contributor to iron intake and next to recommending an increase in intake in hemeiron derived from animal based food. Market complementary food represents the most realistic option to increase iron intake, especially in older infants and young children who are still breastfed. Traditionally market complementary foods are fortified with micronutrients including iron as proportion of Recommended Nutrition Intakes (RNIs), occasionally taking intake from other foods including formula into account. The results from our study suggest that older infants and young children who still receive breast milk might benefit from market complementary foods designed to better fill the gap between nutrients intakes from breast milk and age specific RNIs. In this approach special attention should be paid finding the most adequate level of iron supplementation, as a study in Chili indicated negative effects on 10 years follow up developmental outcomes of a high iron milk formula (12.7 mg/L) in iron replete infants of 6-12 mo old (Hb>128 g/L), while there were positive effects in the iron depleted infants (Hb<105 g/L).[19]

This is the first population-based study to document the prevalence of anaemia and the associated infant and young child dietary habits among children of well-educated mothers in four urban areas of China. To gain more accurate data, future research should: (1) expand the period of dietary recall to 3 days, including 1 day in the weekend; (2) enlarge the survey sample size to obtain a more representative picture from children with different background characteristics, for example also study children from mothers with lower education level; (3) based on the limitations in the food composition tables of China, folic acid and vitamin B-12 could not be calculated. An update of the China food composition to incorporate folic acid and vitamin B-12 from food, next to selenium, dietary fibre and omega-3 and omega-6 fatty acids are needed.

Conclusions

Our findings showed that in the studied urban settings of China, more nutrient intakes were inadequate in anaemic children than in non-anaemic young children, especially in 6-12 mo old infants. Inadequate intake of iron was the most obvious factor associated with anaemia. Dedicated education on adequate weaning practices emphasizing diet diversity and the importance of high bioavailable iron containing foods is needed. Appropriate information about the benefits of continuing breastfeeding combined with special attention for complementary feeding are essential to reduce anaemia in infants and young children.

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AUTHOR DISCLOSURES

The authors have declared that no conflicting interests exist.

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Original Article

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中国城市贫血儿童和非贫血儿童膳食情况调查：一项横断面研究

背景与目的：调查辅食添加期间，贫血和非贫血儿童喂养和膳食情况。**方法与研究设计：**选择中国 5 个城市（北京、上海、南京、成都和深圳）6-36 月龄儿童，每个城市选择 1 个代表性的地区 150 名儿童，其中 6-12 月龄、12-24 月龄和 24-36 月龄各 50 名，共 750 例儿童。通过 24 小时回顾法调查其膳食情况，使用 HEMO Cue 检测其血红蛋白。利用食物成份数据计算分析儿童一天膳食营养情况。**结果：**总的贫血患病率为 9.7%。其中，6-12 月龄儿童最高，为 17.2%。6-12 月龄儿童中，贫血儿童一天膳食摄入的 8 种营养素（蛋白质、维生素 A、维生素 B-1、维生素 C、钙、铁、锌和铜）的中位数比非贫血儿童低（$p<0.05$）；12-24 月龄儿童中，贫血儿童一天膳食摄入的维生素 A 的中位数比非贫血儿童低（$p<0.05$）。分析铁的食物来源情况，市售辅食为贫血和非贫血儿童的铁的主要来源（6-12 月龄儿童分别为 2.28 和 3.69 mg；12-24 月龄儿童分别为 2.06 和 2.09 mg）。贫血儿童配方奶粉的铁来源低于非贫血儿童（6-12 月龄儿童分别为 0.88 和 2.54 mg；12-24 月龄儿童分别为 1.59 和 2.87 mg）。6-12 月龄贫血儿童的继续母乳喂养率显著性高于非贫血儿童（分别为 65% 和 37%，$p<0.05$）。**结论：**贫血儿童的膳食营养水平比非贫血儿童低，尤其是 6-12 月龄的婴幼儿；继续母乳喂养的儿童，尤其是大年龄母乳喂养的儿童，需要通过合理的喂养行为改善膳食营养以减少贫血。

关键词：贫血、婴幼儿、膳食营养、继续母乳喂养、城市