Original Article

Postpartum anemia is a neglected public health issue in China: a cross-sectional study

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Background and Objectives: Anemia impairs the health and wellbeing of women and increases the risk of maternal and neonatal adverse outcomes. The objectives of this study are to determine the prevalence of postpartum anemia among urban lactating women; investigate the predictors of anemia and explore the potential health effects on lactating performance. **Methods and Study Design:** Multi-stage sampling methods were used to recruit 495 lactating women from 3 cities of China. Blood and breast milk samples were collected to analyze hemoglobin levels and iron content, respectively. The intakes and sources of iron-rich food and nutrients were investigated based on Food Frequency Questionnaire and 24 h dietary recall. **Results:** The overall prevalence of postpartum anemia was 32.7%; no cases of severe anemia were encountered. Women who living in Guangzhou had a significant higher anemia prevalence. Regards to dietary intake, the amount of iron intake was generally good with a high proportion of heme iron. The animal sources ratio was 23.0%. Total iron intake and the sources of iron were not associated with anemia. Vitamin C intake was significantly higher in non-anemic women (Median (25th, 75 th) was (72.6 (38.4, 130.0) mg/d)) than anemic women (54.7 (30.7, 111.3) mg/d). Other nutrient enhancers were not associated with anemia. There were no significant differences in the iron content of breast milk between women with and without anemia (r=0.047, p=0.302). **Conclusions:** Postpartum anemia is common in urban Chinese women. A combination of interventions, including managing antenatal anemia and correcting inappropriate dietary habits will help to prevent postpartum anemia.

Key Words: postpartum anemia, lactating women, risk factors, breast milk, dietary intake

INTRODUCTION

Anemia impairs the health and wellbeing of women and increases the risk of maternal and neonatal adverse outcomes.[1] As the World Health Organization (WHO) reported, anemia affects half a billion women of reproductive age worldwide.[2] In 2011, 29% (496 million) of non-pregnant women and 38% (32.4 million) of pregnant women aged 15–49 years were anemic.[2]

The postpartum period is conventionally thought to be the time of lowest anemia risk.[3] In this period, the iron status is expected to improve because of the lower iron requirements after the birth of the infant and reduced blood loss by amenorrhea.[3] However, recent data from both developed and developing countries has indicated an alarming prevalence of postpartum anemia.[4-7] Anemia in the lactating period can be as high as 50%~80% in some areas.[8] The consequences of anemia among postpartum women include impaired physical work capacity, low work efficiency, fatigue, depressive symptoms, reduced immune function, and other diseases.[9,10] The most common cause of anemia worldwide is iron deficiency, resulting from prolonged negative iron balance caused by inadequate dietary iron intake or absorption.[11] According to Henjum's study in Nepal and our previous study in Myanmar, insufficient intake of food which is rich in iron, and other factors associated with poverty, such as lack of education and parasitic infection, might contribute to the high prevalence of postpartum anemia.[6,7] The Chinese traditional diet pattern is plant-based, which might influence the bioavailability of iron, leading to a high risk of iron deficiency anemia.[12] There are several studies performed in China that have reported a high prevalence of anemia in pregnant women; however, the prevalence of anemia and its predictors in Chinese lactating women is unknown.[13] In 2012, the 65th World Health Assembly approved an action plan and global targets for maternal, infant and child nutrition, with a commitment to reduce by 50% anemia in women of reproductive age by 2025.[2] Awareness about anemia and its consequences for health are the first steps towards its management.[11] This study was intended to 1) determine the prevalence of anemia in urban Chinese lactating women; 2) explore the predictors

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associated with anemia, especially regarding dietary intake aspects; and 3) explore the impact of anemia on breast milk iron content.

METHODS

Ethical consideration

This study was conducted in compliance with the Declaration of Helsinki and all procedures involving participants were approved by the Medical Ethics Research Board of Peking University (NO.IRB00001052-11042). Written informed consent was obtained from all participants before the study.

Participants

This study is part of the Maternal Infant Nutrition and Growth (MING) Study，the design of which, including the recruitment of participants, has been described in detail elsewhere.[14] Briefly, three Chinese cities (Beijing, Suzhou and Guangzhou) were purposively selected according to their geographic location. In each city, participants were recruited from randomly selected hospitals; a total of 580 lactating women (women who were exclusive feeding or used breast feeding as a major mode) participated in this survey. All the participants were primiparous and had given birth to singletons. According to the purpose of this study, 80 women during their first four postpartum days were not involved in analysis in order to minimize the influence of labor and hospital diet on food intake. Because in China, women were usually hospitalized for 2 or 3 days after birth and were given to the standardized diet designed by dietician. What's more, the diet of hospitalized women might be restricted if the caesarean section was performed. Other exclusion criteria included women who had preterm delivery, or diagnosed thalassemia or other genetic anemia, or who refused to have their hemoglobin tested, or had missing values in the key questions. Finally, the data of 495 women were used for the analysis.

Data collection

An interviewer-administrated questionnaire was used to collect data from lactating women on socio-demographic characteristics and anemia associated predictors. Training of the interviewers, an initial site survey, and preliminary questionnaire testing were completed prior to data collection.

We retrieved the medical records to obtain the obstetric history of participants. The Semi-quantitative Food Frequency Questionnaire (Semi-FFQ) was used to investigate the meat, eggs, fish and shrimps intake in the recent six months. A one time 24-hour dietary recall was used to obtain data concerning the 24 hours of food intake before the samples' collection. Nutrient intake and iron sources were analyzed based on the Chinese Food Composition Table together with the nutrient composition table on the food packaging.[15]

Weight and height were measured and used to calculate the body mass index (BMI). Blood samples were obtained from finger pricks of lactating women on the day of investigation and hemoglobin was measured using HemoCue (HemoCue Hb 201+ analyzer, HemoCue AB, Angelholm, Sweden). The presence and severity of anemia was diagnosed according to WHO criteria for non-pregnant women, which defines moderate anemia as Hb <12 g/dL and <7 g/dL as severe anemia.[16] Breast milk was collected and analyzed for iron content. The procedures of breast milk collection and analysis have been described in detail elsewhere.[14] Iron analysis was performed by Eurofins Technology Service (Suzhou) Co. Ltd., Suzhou, China and analyzed by inductively coupled plasma mass spectrometry (ICP-MS).

Statistical analysis

The IBM SPSS (predictive analytics software and solutions) Software version 20.0 (International Business Machines Corporation, New York, USA) was used for analysis. The normality of distribution was tested for each data set before analysis. Values were presented as mean± SD, median (25th, 75th）, or as percentages. The food intakes were compared with the recommended daily food intake based on the Chinese balanced dietary pagoda.[17] Nutrient intakes were compared with Chinese dietary reference intakes.[18] The independent t-test, non-parametric tests and chi-square analysis were used to compare socio-demographic characteristics, reproductive history, food and nutrient intakes and iron content in breast milk between women with and without anemia. After adjusting for cities, partial correlation was used to analyze the correlation of hemoglobin level with iron content in breast milk. The level of statistical significance in this study was set to $p<0.05$.

RESULTS

Prevalence of anemia

A total of 495 women qualified for and participated in this study. The mean hemoglobin level was 12.2±1.0g/dL, ranged from 8.1 to 15.0 g/dL. The overall anemia prevalence was 32.7% and no participant was diagnosed with severe anemia. The mean hemoglobin level in 162 anemic women was 11.1±0.7 g/dL and ranged from 8.1 to 11.9 g/dL. Lactating women in Guangzhou had a higher anemia rate than those living in Beijing and Suzhou. Although there is no statistic significance, there is a marginal tendency to decrease the prevalence of anemia in women with more years of schooling (p=0.092). There were no significant differences between women with and without anemia regarding maternal age, lactation stages, average monthly family income and lactation stage (Table 1).

Obstetric history and health outcomes of women

As shown in Table 2, women who had anemia in pregnancy tended to be anemic postpartum. There were no significant associations between anemia and mode of delivery, BMI, weight gain in pregnancy or weight retention postpartum.

Dietary and nutrient intakes of women

Overall, 3.4% of postpartum women took iron supplements: 3.6% of anemic women and 3.1% of non-anemic women (p=0.767). The intake of meat was high, meanwhile the fish and green vegetables intakes were low (Table 3), and there were no intake differences of meat, fish, eggs, green vegetables and fruits between women with and without anemia.

Table 1. The social-demographic characteristics of lactating women with or without anemia (N (%))

	Without anemia N=333†	With anemia N=162†	p
Areas			<0.001
Beijing	114 (76.0)	36 (24.0)	
Suzhou	128 (74.0)	45 (26.0)	
Guangzhou	91 (52.9)	81 (47.1)	
Maternal age			0.192
<35 y	299 (68.3)	139 (31.7)	
≥35 y	34 (59.6)	23 (40.4)	
Average monthly family income			0.291
<3000 rmb	79 (62.2)	48 (37.8)	
3000-6000 rmb	197 (69.9)	85 (30.1)	
>6000 rmb	48 (69.9)	21 (30.4)	
Education experience			0.092
Junior high school or under	75 (59.5)	51 (40.5)	
Senior high school and equal level	178 (68.2)	83 (31.8)	
Bachelor degree or above	74 (72.5)	28 (27.5)	
Lactation stages‡			0.879
5-11 d	57 (65.5)	30 (34.5)	
12 d -1 m	56 (65.1)	30 (34.9)	
1-2 m	57 (64.8)	31 (35.2)	
2-4 m	62 (68.9)	28 (31.1)	
4-8 m	101 (70.1)	43 (29.9)	

rmb: Renminbi, the Chinese monetary unit; d: day; m: month.
Chi-square test was used to analyze the different anemia prevalence among different characteristics.
†The missing values were exist when analyze the different anemia prevalence among different characteristics.
‡The women's lactation stages were estimated as the date of investigation minus the delivery date.

Table 2. The obstetric history and health outcomes of lactating women with or without anemia (N, (%); mean±SD or median (25th, 75 th))

	Without anemia N=333†	With anemia N=162†	p
Mode of delivery			0.155
Vaginal delivery	150 (64.1)	84 (35.9)	
Caesarean section	183 (70.1)	78 (29.9)	
Anemia in pregnancy‡			<0.001
No	262 (73.2)	96 (26.8)	
Yes	71 (51.8)	66 (48.2)	
BMI (kg/m^2)	23.3±3.2	23.3±3.1	0.779
Weight gain in pregnancy (kg)	16.0±5.9	16.2±5.8	0.778
Weight retention§ (kg)	6.0 (2.5, 10.0)	6.0 (4.0, 10.0)	0.479

Comparing of mode of delivery and anemia in pregnancy were analyzed with method of chi-square; weight gain in pregnancy was analyzed with independent-samples t test; and weight retention was analyzed with nonparametric test.
†The missing values were exist when analyze the different anemia prevalence among different characteristics.
‡The anemia in pregnancy defines as anemia occurred during the whole pregnancy according to the criteria which the hemoglobin level <11.0 g/dL.
§ Weight retention=current weight - pregestational weight.

Regarding iron intake, 50.6% of women consumed less iron than the Estimated Average Requirement (EAR, 18mg/d), and 28.9% had an iron intake higher than the Recommend Nutrients Intake level (RNI, 24 mg/d). There were no differences in these proportions between women with and without anemia (p=0.976). Table 4 shows the different sources of iron, and the women's vitamin C, vitamin B-2, folic acid and vitamin A intakes. The intake of vitamin C was significantly lower in anemic women (p=0.021). There were no significant differences between women with and without anemia regarding the sources of iron, folic acid, vitamin B-2 and vitamin A. The overall animal sources ratio (ASP) was 23.0%; the ASPs in anemic and non-anemic women were 22.0% (14.0%, 34.0%) and 24.0% (15.0%, 32.0%) respectively (p=0.547).

Association between hemoglobin and iron in breast milk

The iron level in the breast milk of anemic women was 0.77 (0.60, 1.20) mg/kg, which was significantly lower than the non-anemic women's level of 0.81 (0.64, 1.15) mg/kg, p=0.033. After adjusting for the cities, the hemoglobin level did not correlate significantly with the iron content in breast milk (r=0.047, p=0.302).

DISCUSSION

The postpartum period is generally considered as a period

Table 3. The intake of meat, eggs, fish, green vegetables and fruits by lactating women with or without anemia (N, (%))

Food Intakes†	Without anemia N=333‡	With anemia N=162‡	p
Meat			0.315
Low intake	65 (73.9)	23 (26.1)	
Appropriate intake	66 (64.1)	37 (35.9)	
High intake	202 (66.4)	102 (33.6)	
Eggs			0.987
Low intake	208 (67.5)	100 (32.5)	
Appropriate intake	26 (66.7)	13 (33.3)	
High intake	99 (66.9)	49 (33.1)	
Fish & shrimps			0.405
Low intake	145 (67.1)	71 (32.9)	
Appropriate intake	125 (70.2)	53 (29.8)	
High intake	63 (62.4)	38 (37.6)	
Green vegetables			
Low intake	151 (66.2)	77 (33.8)	0.314
Appropriate intake	114 (65.1)	61 (34.9)	
High intake	68 (73.9)	24 (26.1)	
Fruits			0.317
Low intake	84 (67.7)	40 (32.3)	
Appropriate intake	116 (63.4)	67 (26.6)	
High intake	133 (70.7)	55 (29.3)	

†In comparison of food consumptions with Chinese Balanced Dietary Pagoda 2016, low intake, appropriate intake, and high intake for meat were defined as: <40 g/d, 40-75 g/d and >75 g/d respectively; for eggs intake were defined as: <40 g/d, 40-50 g/d and >50 g/d respectively; for fish and shrimps were defined as: <40 g/d, 40-75 g/d and >75 g/d respectively; for green vegetables intake were defined as: <300 g/d, 300-500 g/d and >500 g/d respectively and for fruits intake were defined as: <200 g/d, 200-350 g/d and >350 g/d respectively.
‡The missing values were exist when analyze the different anemia prevalence among different characteristics.

Table 4. The iron from different sources, vitamin C and folic acid intake of Chinese urban women (median (25th, 75 th))

	Without anemia N=333*	With anemia N=162*	p
Iron intake from different sources(mg/d)			
Total	17.6 (13.4, 25.3)	17.9 (12.0, 25.5)	0.505
Dietary supplements	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.108
Fortified food	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.686
Plant-based food	11.9 (8.4, 17.9)	11.5 (7.7, 17.3)	0.449
Animal-based food	3.9 (2.2, 6.5)	3.9 (2.0, 6.9)	0.769
Others†	0.9 (0.6, 1.1)	1.0 (0.7, 1.2)	0.405
Nutrient enhancers			
Vitamin C (mg/d)	72.6 (38.4, 130.0)	54.7 (30.7, 111.3)	0.021
Folic acid (mg/d)	205.5 (123.5, 316.4)	203.7 (115.5, 294.8)	0.695
Vitamin B-2 (mg/d)	0.93 (0.65, 1.34)	0.85 (0.53, 1.35)	0.265
Vitamin A (μgRAE/d)	420.3 (197.6, 752.4)	495.7 (243.1, 851.0)	0.296

†The missing values were exist when analyze the different anemia prevalence among different characteristics.
‡Others included condiments and drinks.

with the lowest rates of anemia.[3] However, in the studied populations, anemia during lactation was generally high at 32.7%, which is higher than that reported in studies in Nepal and America, while lower than the reported prevalence in Myanmar, India and some of the developing countries.[4,7,19,20] There was a paucity of postpartum anemia data from China; however, it is worth pointing out that postpartum anemia was significantly higher than the overall prevalence of anemia in Chinese women of reproductive age (18.3%) and even higher than that seen in pregnant women.[21,22] This survey was conducted only in urban areas of China which have relatively higher economic levels than the rural areas, and postpartum anemia in rural areas could be expected to be higher. This current survey has extended previous findings by demonstrating that postpartum anemia is an important public health issue in China.

In this survey, we found geographic differences in the prevalence of anemia; lactating women in Guangzhou (located in southeast China) had a significantly higher prevalence rate of anemia compared to women in Beijing and Suzhou (located in north and east China). The prevalence of anemia in Southeast Asia is known to be among the highest in the world;[23] however, although this survey excluded participants with diagnosed thalassemia or other genetic anemia, the unknown genetic factors and environmental predictors cannot be ignored.

While iron deficiency is the main cause of anemia in developing countries,[24] other nutritional and environmental factors, such as certain vitamin deficiencies, being overweight, infectious diseases and parasitic infection are all reported to contribute to anemia.[25-28]

In this study, antepartum anemia was associated with a higher risk of postpartum anemia in uni-variate analysis; this finding has also been documented by several other studies.[9,20,29] The iron deficiency present during the antenatal period continues through the postpartum period, indicating that screening for and management of antepartum anemia are crucial in reducing the risk of premature delivery, low weight birth and neonatal infections, and can also help to prevent anemia in lactating women.

Regarding nutrient intake, iron deficiency is considered to be the main underlying cause of anemia in developing countries.[24] A study of Nepalese postpartum women showed a positive association between dietary and body iron.[19] However, in this present survey, the iron intake and the sources of iron were not associated with anemia. The Chinese postpartum ritual of eating more meat increases iron intake and guarantees a higher iron absorptivity from heme iron.[30] This survey demonstrated a higher meat intake and a high ASP. Nevertheless, it should be noted that there were still 50.6% women whose intake of iron was under the recommended level.

Besides iron, other nutritional factors such as vitamin A, vitamin C, folic acid and vitamin B-2 are also important, but have received considerably less attention. Interestingly, in this survey the low vitamin C intake was associated with a higher risk of anemia. The Chinese unique postpartum ritual might also explain this finding. In this ritual, women usually avoid eating fresh vegetables and fruits, which are thought to be "cold" and harmful to body recovery.[30,31] A low green vegetables intake was also observed in this study. This behavior might result in vitamin C deficiency and influence the absorption of iron. It is also worth noting that this behavior might also lead to an insufficient intake of folic acid. Although the folic acid intake was not associated with anemia, a low intake of folic acid was found in this study.

A low rate of iron supplementation was noted in both anemic and non-anemic women. Iron and folic acid supplementation has been the preferred intervention to improve iron stores and prevent anemia among pregnant women, and should also be encouraged in lactating women with inadequate dietary intake.[32]

The health effects of anemia in pregnancy have been emphasized, but very little attention has been paid to postpartum anemia. Breast milk is known to have a low iron content.[14] Infants probably take advantage of fetal iron storage during their first six months. However, several studies have revealed that severe maternal iron deficiency anemia can greatly influence the iron status of their children.[33] In this survey, there were no associations found between the iron content in breast milk and hemoglobin level. Mineral levels in breast milk appeared not to be easily affected by anemia; however, there was no case of severe anemia in this study and more investigation is needed.[14] What's more, a study of lactating women reported a reduced milk supply was associated with anemia, which contribute to the newborn not gaining enough weight.[34] In addition, a Colombian study found that, in poor areas, anemia was more prevalent in exclusively breast fed infants than in artificially fed infants.[35] Our previous study in Myanmar also found a strong association between maternal hemoglobin levels and their children's hemoglobin levels.[36] Postpartum anemia, especially severe anemia, should be taken into account as important predictors for infants' health.

Because of the cross-sectional design, the inherent limitations of this study were unavoidable. Causality between predictors and anemia in this study could not be determined. In this study, unfortunately, we did not measure indicators such as serum ferritin, transferrin saturation and erythrocyte protoporphyrin, and consequently could not distinguish the types of anemia. Since we excluded participants with diagnosed genetic anemia, we assumed most of the anemia in our sample was caused by iron deficiency, partly or exclusively. In addition, there is no data for postpartum hemorrhage or hemoglobin immediately after delivery, which is also an important predictor for postpartum anemia. We also concerned the variations on timing of data collection in different postpartum stages exist. Regarding the methodology, a three-days or seven-days dietary recall would have been better to measure the daily variance of food intake; a one time 24 hours dietary recall would not have reflected daily variations in diet. However, the food intake by Chinese lactating women is usually homogeneous because it is guided by cultural practices; a 24 hours recall was considered to generally represent the daily nutrient postpartum intake. Additionally, we used the Semi-FFQ to assess the long term dietary intake.

Conclusion

Postpartum anemia was common in China. Antepartum anemia was associated with postpartum anemia. An insufficient intake of vitamin C was associated with an increased risk of anemia. The postpartum anemia was not associated with milk iron content. As a public health issue worthy of concern, a combination of interventions including screening for anemia in both in pregnancy and postpartum, managing antepartum anemia, correcting inappropriate dietary habits in Chinese rituals, such as enhancing vitamin C intake from fresh fruits and vegetables may contribute to reducing anemia in China.

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AUTHOR DISCLOSURES

The authors declare that they have no competing interests. This study funded by Nestlé Nutrition Institute and Nestlé Research Center.

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