

Original Article

Evaluating the micronutrient status of women of child-bearing age living in the rural disaster areas one year after Wenchuan Earthquake

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Populations with special physiological state, such as pregnant, nursing and women of child-bearing age, have been identified as nutritionally vulnerable during natural disaster. The objective of this survey was to evaluate the prevalence of anaemia and micronutrient status of women of reproductive age in April 2009 one year after the Wenchuan Earthquake. The survey recruited 58 pregnant, 66 lactating and 242 women of child-bearing age from 19 to 45 years. The concentrations of haemoglobin in whole blood and ferritin and micronutrients in serum were assayed. Among the three groups (pregnant, nursing and child-bearing women), respectively, the prevalence of anaemia was 29.1%, 25.5% and 28.8%; that of iron deficiency was 45.4%, 49.0% and 52.9%; and that of zinc deficiency was 45.4%, 23.0% and 33.5%. The sum of vitamin D deficiency and insufficiency was more than 90% in each group, and the total vitamin B₁₂ deficiency and marginal deficiency prevalence percentages were 47.3%, 17.7% and 35.7%, respectively. The prevalence of vitamin A deficiency and marginal deficiency was 1.8% and 9.1% in pregnant women, 6.1% and 15.2% in nursing women and 8.6% and 21.3% in women of child-bearing age, respectively. Our findings indicated that the micronutrient status of women of reproductive age was poor in the disaster areas. Therefore, improving the micronutrient status of these women should be an urgent priority in these areas.

Key Words: women of child-bearing age, micronutrient, women, earthquake, emergency

INTRODUCTION

The earthquake in Wenchuan occurred on 12 May 2008 in the Sichuan, Gansu and Shanxi provinces of China, severely destroying the infrastructure and social networks on which people usually depend and dramatically changed the living conditions of entire communities. The food supply systems, specifically, were severely damaged or even completely stopped, leaving families without shelter and basic necessities. The food supplies (a general food basket) provided by the local government directly after the earthquake could meet the basic energy and macronutrient requirements of most adults, with a per capita cereal supply of 500 grams per day providing about 1730 kcal/day. With the additional energy from the non-staple food consumption (vegetables, fruits and others), the general food basket could provide about 2100 kcal of energy per person per day. This meant that while basic energy and protein requirements may have been met, most of micronutrient requirements were not.¹⁻⁴

Moreover, groups in special physiological state, such as pregnant, nursing and women of child-bearing age, have been identified as nutritionally vulnerable in these

situations,^{1,2,5} and that the provided foods were unlikely to meet the unique needs of embryonic and fetal development or maintain their nutrition and health status required for breastfeeding.¹ Hence, this population affected by the earthquake was at high risk of suffering from nutritional deficiencies due to a low intake of micronutrient-rich animal-sourced foods in these areas,^{1,5,6} especially micronutrients such vitamins A and D, iron, zinc and vitamin B₁₂. It has been documented that these micronutrients are very important for the women intending to have a child and those who are pregnant or nursing because they play critical roles in placental development, embryonic

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Manuscript received 29 July 2014. Initial review completed 05 August 2014. Revision accepted 19 August 2014.

doi: 10.6133/apjcn.2014.23.4.22

growth and fetal brain development.⁷⁻⁹ There are ample data from developing countries which suggest that a micronutrient deficiency during critical periods of brain development could have long-term adverse effects on health, growth and development, morbidity and cognitive and motor development.¹⁰⁻¹²

There is some evidence that these micronutrients play specific, critical roles in women's health and nutrition.^{1, 5, 13, 14} Iron, zinc, vitamins A, B₁₂ and folic acid deficiencies are a global concern among reproductive women.^{15, 16} The primary objective of this survey was to assess the nutritional status including iron deficiency and anaemia and deficiencies in other micronutrients such as vitamins A and vitamin D, zinc, vitamin B₁₂ and folic acid in pregnant, nursing and women of child-bearing age living in rural disaster areas one year after the Wenchuan Earthquake, and to provide basic evidence supporting nutritional intervention strategies for such areas.

METHODS

All of the survey sites were located in near the seismic centre of the Wenchuan earthquake, which occurred 12 May 2008. The life and property losses suffered by local residents were very severe. The surveys including questionnaire and blood sample collection from women of child-bearing age from 19 to 45 years were conducted by according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the ethics committee of the Gansu Centre for Disease Control and Prevention (CDC), and the National Institute of Nutrition and Food Safety for the Chinese CDC. Written informed consent was obtained from all participants. In order to anonymize the participants, we have used the identification numbers only to express subject data.

Design and sampling

In April 2009 (about one year after the Earthquake), a nutritional survey, coordinated by the County and Provincial CDC organized by the National Institute of Nutrition and Food Safety for the Chinese CDC, was conducted in rural disaster areas near the Earthquake's seismic centre. A total of 344 reproductive women (19-44 years old) were sampled from 6 randomized townships near the seismic centre, including 55 women of pregnant age (19-41 years), 65 women of nursing age (19-39 years) who had breast-fed their babies within the last 12 months and 224 women of child-bearing age (19-44 years). Women were excluded if they had a serious or chronic illness. Iron deficiency and anaemia prevalence, vitamins A, D, B₁₂ and folic acid status were evaluated.

Data collection

Healthy women of reproductive age were recruited and their body weight and height were measured. A platform weighing scale (TC100KA, with 0-100 kg capacity and 10 g accuracy, Huatec Group, China) and height scale (YSC-2, 0.1 cm accuracy, Beijing Guowangxingda Weight Scale Company, China) were used to measure the body weight and height of women wearing only underwear. Before each measurement, the scales were checked using the calibrated materials. The nurses conducting the

measurements were trained and evaluated.

Blood sampling and biochemical analyses

A fasting blood sample (5 mL) was drawn from an ante-cubital vein by local clinical technicians in the morning. The blood specimens were collected in serum separation tubes and immediately wrapped with aluminium foil and kept cold for about 30-60 mins, then centrifuged at 2500-3000 rpm for 10 mins at room temperature. The serum fraction was then collected and placed in a refrigerator at -20~-30°C for up to 5 days at the field site. Once the field work has been completed, all of the serum samples were transferred, in a frozen state, to Beijing by air and stored at -80°C until they were analyzed.

Haemoglobin (Hb) concentration in whole blood was assayed using the HemoCue (HB 301, HemoCue AB, Angelholm, Sweden) at the field sites. Anaemia was defined as a Hb level of <110 g/L for pregnant women, and <120 g/L for women of nursing and child-bearing age. At sites with an altitude over 1000 meters, the anaemia prevalence was corrected using WHO recommended altitude formula.

The analyses of the micronutrients in the serum were organized and performed by the National Institute of Nutrition and Food Safety for the Chinese CDC. Serum retinol and carotenoids were assessed using a modified HPLC method (Waters 600E, US);¹⁷ serum 25-OH-D₃, vitamin B₁₂, folic acid and ferritin were determined using commercial radioimmunoassay kits (25-OH-D₃, Dria Sorin, US; vitamin B₁₂ and folic acid, MP Biomedicals, US; ferritin, Northern Institute of Biotechnology, China); serum zinc concentration was determined using flame atomic absorption spectrometry (VARIAN, US).

Iron status was defined as deficient based on a serum ferritin concentration of less than 15 µg/L. Vitamin A status was evaluated by serum retinol level, as follows: marginal deficiency, serum retinol <1.05 µmol/L; deficiency, serum retinol <0.7 µmol/L. The serum 25-OH-D₃ level was used to evaluate vitamin D status, as follows: vitamin D deficiency, serum 25-OH-D₃<48 nmol/L; vitamin D marginal deficiency, serum 25-OH-D₃ within 48-78 nmol/L. Serum zinc was used as an indicator of nutritional status: normal serum zinc level, ≥16.9 µmol/L (110 µg/dL); marginal zinc deficient level, <16.9 µmol/L (110 µg/dL); Zn deficiency, <11.0 µmol/L (72 µg/dL). A serum folic acid level of less than 16.9 nmol/L was used to indicate folate deficiency. Vitamin B₁₂ status was defined as deficient and marginally deficient based on a serum vitamin B₁₂ concentration of less than 120 ng/L or 120-160 ng/L, respectively.

Bias

Because our surveyed sites were located in high and rugged mountain areas, the participant's living places were much decentralized and inaccessible areas, the sample size at each selected site was not inconsistent by the reasons that some of women could not catch up with the survey due to the bad weather, or remote and inaccessible transportation from their living places, which could lead to the potential selection bias.

Quality control, data treatment

National, provincial and local CDCs ensured the surveillance quality from surveillance point composed of quality control networks to monitor the survey efficacy. The responsibilities and roles of all of the participants were determined and all of the investigators were trained by qualified teachers before joining the field survey.

Statistical analysis

Double entry of all data was performed using EPI-INFO 2000 statistical software. SAS software (version 9.1; SAS Institute Inc, Cary, NC) was used for the statistical analyses. Differences between groups were determined using Student's *t* test for continuous variables. Data were expressed as mean±SD and statistical significance was set at $p \leq 0.05$.

RESULTS

The cereal, roots, fat and oil intakes of women pregnant, nursing and child-bearing age living in the disaster area were almost the same as results from the 2002 National Nutrition and Health Survey. However, the intakes of animal-sourced foods such as meat and poultry were only 58.1±67.7 g/d, 76.3±219 g/d and 23.9±29.6 g/d for the three groups, respectively. The body weight, height and body mass index (BMI) of participants are shown in Table 1.

The Hb in whole blood, concentrations of ferritin and zinc in the serum of the reproductive-aged women are shown in Table 2. In the three groups (women of pregnant, nursing and child-bearing age), the anaemia prevalence was 29.1%, 25.5% and 28.8%, while the iron deficiency

was 45.4%, 49.0% and 52.9%. Zinc deficiency prevalence was 45.4%, 23.0% and 33.5%, respectively.

The concentrations of retinol, 25-OH-D₃, folic acid and vitamin B₁₂ in the serum of the reproductive-aged women are shown in Table 3. The vitamin A deficiency and marginal deficiency prevalence were 1.8% and 9.1% in pregnant women, 6.1% and 15.2% in women of nursing age, and 8.6% and 21.3% in women of child-bearing age, respectively. The vitamin D deficiency and insufficiency were 78.2% and 18.2% in women of pregnant age, 63.5% and 27.0% in women of nursing age, and 65.2% and 26.7% in women of child-bearing age. The sum of vitamin D deficiency and insufficiency was more than 90% in every group. However, 3.2% of women of child-bearing age suffered from severe vitamin D deficiency. Folic acid was almost in a sufficient state except for two women of child-bearing age who had marginal deficiency. The vitamin B₁₂ deficiency and marginal deficiency prevalence were 32.7% and 14.5% in women of pregnant age, 11.3% and 6.4% in women of nursing age and 23.8% and 11.9% in women of child-bearing age, respectively. The sum of vitamin B₁₂ deficiency and marginal deficiency was 47.3%, 17.7%, and 35.7% in women of pregnant, nursing, and child-bearing age, respectively.

The serum carotenoid concentrations of women in reproductive age are shown in Table 4. The serum β-carotene concentration was lowest in women of nursing age and highest in women of child-bearing age. However, the concentrations of α-carotene, cryptoxanthin, lutein and zeaxanthin were higher in women of pregnant age than in women of nursing and child-bearing age.

Table 1. Body weight, height and body mass index of women of child-bearing age[†]

Group	N	Age (year)	Body weight (kg)	Height (cm)	BMI [‡] (kg/m ²)
Pregnant	55	24.4±5.6	58.9±9.1 ^a	154.3±4.7	24.7±3.4 ^a
Nursing [§]	65	25.4±4.5	55.8±8.6 ^{ab}	153.9±4.1	23.6±3.6 ^{ab}
Child-bearing age	224	31.2±6.9	55.4±8.0 ^b	153.6±5.8	23.4±3.3 ^b

[†]The results are expressed as Mean±SD. Different superscript letters of a, b in the same column mean significant difference with $p < 0.05$.

[‡]BMI is body weight divided by height squared (kg/m²); [§]Women who breastfed within the 12 months before the survey.

Table 2. Hemoglobin (Hb) concentration in whole blood, serum ferritin and zinc levels of women of child-bearing age[†]

Group	N	Hb (g/L)	Ferritin (µg/L)	Zinc (µmol/L)
Pregnant	55	116.2±13.1 ^a	20.1±15.6	11.3±3.0 ^a
Nursing	65	127.0±14.5 ^b	21.0±20.7	12.6±2.7 ^b
Child-bearing age	224	128.4±14.3 ^b	19.6±27.9	12.4±3.4 ^b

[†]The results are expressed as Mean±SD. Different superscript letters of a, b in the same column mean significant difference with $p < 0.05$.

Table 3. Serum retinol, 25-OH-D₃, folic acid and vitamin B₁₂ concentrations of women of child-bearing age[†]

Group	N	Retinol (µmol/L)	25-OH-D ₃ (nmol/L)	Folic acid (nmol/L)	Vitamin B ₁₂ (ng/L)
Pregnant	55	1.40±0.04 ^{ab}	42.7±18.1	17.4±7.2	216±152 ^a
Nursing	65	1.52±0.06 ^b	49.8±27.8	18.9±13.3	314±224 ^b
Child-bearing age	224	1.34±0.05 ^a	45.8±26.0	17.0±11.3	249±185 ^c

[†]The results are expressed as Mean±SD. Different superscript letters of a, c in the same column mean significant difference with $p < 0.05$.

Table 4. Serum carotenoid concentration of women of child-bearing age (mg/L)[†]

Group	N	β -carotene	α -carotene	Cryptoxanthin	Lutein	Zeaxanthin
Pregnant	55	0.183 \pm 0.128 ^a	0.029 \pm 0.018 ^a	0.209 \pm 0.141 ^a	0.569 \pm 0.241 ^a	0.060 \pm 0.030 ^a
Nursing	65	0.178 \pm 0.107 ^b	0.019 \pm 0.011 ^b	0.118 \pm 0.072 ^b	0.446 \pm 0.235 ^b	0.046 \pm 0.028 ^b
Child-bearing age	224	0.190 \pm 0.150 ^b	0.020 \pm 0.014 ^b	0.135 \pm 0.121 ^b	0.408 \pm 0.212 ^b	0.040 \pm 0.021 ^b

[†]The results are expressed as Mean \pm SD. Different superscript letters of a, b in the same column mean significant difference with $p < 0.05$.

DISCUSSION

A recent review of dietary intake data from Asia showed that the recommended daily intakes of many essential micronutrients, such as iron, zinc, vitamins A, D and B₁₂ have not been met.¹⁸⁻²⁰ This is almost the same situation among Chinese women living in the rural disaster areas where micronutrient intake is low compared with the 2002 National Nutrition and Health Survey.²¹

Deficiencies of micronutrients such as iron, zinc, vitamins A, D and B₁₂ are highly prevalent and may occur concurrently among pregnant women, which could affect maternal nutritional and immune status.^{15,16,22,23} This study is the first to evaluate the anaemia prevalence and multi-micronutrient status of women of reproductive age in the rural disaster areas affected by the earthquake. Our findings indicated that the dietary structure has been seriously affected by the earthquake. Overall, the women's food consumption in our samples was balanced for macronutrients such as energy and protein. However, nutrients from animal sources, legumes and dairy products were relatively low and the micronutrient status was poor. Thus, these women's nutritional requirements have not been met and would be facing the risk with high prevalence of anaemia, iron, zinc, vitamins A, D and B₁₂ deficiencies in these areas. However, based on biochemical indicators, the folate status of these women is good.

Because women of reproductive age are most vulnerable due to their greater iron requirements and women in resource-constrained countries are particularly at risk, anaemia and iron deficiency have been recognized for many years as major global public-health problem.^{21,24,25} However, there has been little progress towards nutritional improvement and the global prevalence of anaemia remains unacceptably high. Severe maternal anaemia increases the risk of maternal and neonatal mortality and morbidity, while less severe anaemia and iron deficiency have been linked to sub-optimal fetal growth, premature birth and low birth weight. Based on the WHO estimate, globally, up to 500 million women of reproductive age suffer from anaemia, and the population threatened with iron deficiency could be much higher than this number. Our findings showed that anaemia prevalence in women of reproductive age was more than one fourth, with the highest prevalence among pregnant women (29.1%), followed by women of child-bearing age (28.8%) (Table 2). Prevalence of iron deficiency was close to 50% which indicated that iron deficiency in these women was very common and could be the main reason for nutritional anaemia. A significantly higher prevalence of iron deficiency and anaemia in women of reproductive age in these areas could reflect the poor food supply in their living places.^{1,26}

Zinc is an essential trace element with a key role in

numerous basic cellular functions and it is crucial to the normal functioning of the immune system and growth.²⁷⁻²⁹ Zinc deficiency has been common in women of reproductive age in developing countries, and poor maternal zinc status has been associated with negative pregnancy outcomes.³⁰⁻³³ Serum zinc is generally used to evaluate populations' nutritional statuses. Based on the low serum zinc concentration, the results of our study indicate that the prevalence of zinc deficiency was 23.0%-45.4% in women of reproductive age. Pregnant women had the highest prevalence due to the requirement increase and related to their relatively poor diet intake. Traditionally, the Chinese diet in rural areas is monotonous and cereal-based, consisting of limited amounts of food from animal sources. Cereal-based diets are high in phytate, which can inhibit zinc absorption. Meat and other animal foods are rich sources of zinc and iron, but during emergencies and poor areas, access to foods rich in bioavailable zinc and iron may be limited.

Folate and vitamin B₁₂ could play vital roles in the development of the brain, nervous system and blood-forming organs and thus are essential for optimal embryonic growth and development. Vitamin B₁₂ and folate deficiencies cause identical forms of megaloblastic anaemia and lead to a demyelinating disorder of the central nervous system in humans.³⁴⁻³⁶ Folic acid taken during the periconceptional period reduces the risk of neural tube defects (NTDs) and possibly other adverse pregnancy outcomes. Vitamin B₁₂ plays an essential role in folate metabolism and there is increasing evidence that poor maternal vitamin B₁₂ status may increase the risk of adverse pregnancy outcomes such as NTDs.³⁷ It has been reported that suboptimal vitamin B₁₂ status is common in many parts of the world.³⁸ However, the folate status of these women was good at the time of this survey (Table 3). In our present surveyed samples, the mean serum folate concentration was in a sufficient state being higher than the recommended folate deficient value (<16.9 nmol/L). The prevalence of vitamin B₁₂ deficiency and marginal deficiency was, respectively, 11.3%-32.7% and 6.4%-14.5% in women of reproductive age, pregnant women had the highest prevalence (32.7% and 14.5%), followed by women of child-bearing age (23.8% and 11.9%). The high prevalence of deficient and marginal deficiency of serum vitamin B₁₂ concentrations in these areas could be related to inadequate dietary intake resulting from their relatively poor diets. Such findings suggest that vitamin B₁₂ deficiency is likely to be prevalent in rural disaster areas with a low consumption of animal-sourced foods and susceptible populations with higher nutritional demands such as pregnancy and lactation.

Vitamin A deficiency and insufficiency have long been identified as serious public-health issues in China and

most developing countries.^{16,19-22} Vitamin A is associated with blindness and increased mortality and morbidity from severe infectious diseases. Vitamin A status was generally assessed by serum retinol level. Our results indicated that the prevalence of vitamin A deficiency and marginal deficiency was 1.8%-8.6% and 9.1%-21.3% in women of reproductive age, child-bearing age had the highest prevalence (8.6% and 21.3%) and then the nursing age (6.1% and 15.2%). The reason for the vitamin A deficiency and marginal deficiency prevalence could be due to the relatively poor diet.

Provitamin A such as β -carotene, α -carotene and β -cryptoxanthin can be converted into retinol or retinoic acid in the body, and some epidemiologic studies have found an increase in serum lutein and zeaxanthin levels to be associated with a reduced risk of developing age-related macular degeneration (AMD).³⁹ It has been reported that the six main carotenoids found in the diet, blood and tissues are β -carotene, α -carotene, β -cryptoxanthin, lutein, zeaxanthin and lycopene.⁴⁰⁻⁴² We analyzed β -carotene, α -carotene, β -cryptoxanthin, lutein and zeaxanthin levels in serum to evaluate the carotenoid status. The serum β -carotene concentration was lowest in women of nursing age and highest in women of child-bearing age (Table 4), but the concentrations of α -carotene, cryptoxanthin, lutein and zeaxanthin were higher in pregnant women than in women of nursing and child-bearing age.

In women of reproductive age, especially pregnant women, vitamin D is of particular importance given that maternal vitamin D insufficiency has been associated with gestational diabetes and short- and long-term consequences for the offspring. A more accurate assessment of an individual's vitamin D status is determined through measurement of 25-OH-D₃ in serum. Vitamin D deficiency and marginal deficiency can be diagnosed at levels of less than 48 nmol/L and within 48-78 nmol/L. Using these criteria, vitamin D deficiency has been reported to be very common in women of pregnancy, nursing, and women of child-bearing age with up to 80%-90% of individuals classified as vitamin D deficient and marginally deficient.^{43,44} Our results showed that vitamin D deficiency and insufficiency in women of reproductive age remain a serious public-health problem in China.

Limitation

The current study could have certain limitations. In surveyed areas, we could not recruit many subjects in much decentralized and inaccessible areas. It was difficult to find basic data on health and nutritional status and food supply or consumption in these areas before the earthquake, and therefore we cannot compare the micronutrient status of women in the same area before and after the earthquake, as the national or regional nutrition surveys had not reached or covered these areas in the past. For those reasons, we have used the National Data for the comparison with our present study population to show the severity of micronutrient deficiencies in these areas.

In an emergency, such as an earthquake, poor food choices and decreased accessibility to certain foods may limit the consumption of micronutrient-rich foods in the diets for reproductive women leaving them with a higher

prevalence of anaemia and micronutrient deficiencies. Therefore, improving micronutrient status of reproductive women in these areas should be an urgent priority.

ACKNOWLEDGEMENTS

We thank the field team from the local County Centre for Disease Control and Prevention, which was involved in field organization and data collection. We are indebted to the local community doctors and nurses who assisted with our field work. We thank the study families for participating the survey.

This survey was cooperated with United Nations International Children's Emergency Fund (UNICEF), which provided partly financial support.

AUTHOR DISCLOSURES

The funding sources from UNICEF had no direct influence on the design, collection, and analyses of the data or the decision to submit this manuscript for publication. None of the authors reported a conflict of interest.

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Original Article

Evaluating the micronutrient status of women of child-bearing age living in the rural disaster areas one year after Wenchuan Earthquake

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汶川地震一年后灾区育龄妇女的微量营养素营养状况评价

在突发自然灾害状况下，处于特殊生理状况的妇女，如妊娠、哺乳以及准备怀孕的妇女已经被确认为营养缺乏的易感人群。本次调查的目的是评价汶川地震一年后（2009年4月）灾区育龄妇女的贫血率和微量营养素的状况。该调查招募了年龄在19-45岁的孕妇58例、乳母66例和育龄妇女242例，测定了全血中血红蛋白、血清中铁蛋白和微量营养素的浓度。在孕妇、乳母和育龄妇女这三个人群中，贫血率分别为29.1%、25.5%和28.8%；铁缺乏率分别为45.4%、49.0%和52.9%；锌缺乏率分别为45.4%、23.0%和33.5%；各组维生素D缺乏和不足的总和均超过了90%；维生素B₁₂缺乏和边缘缺乏的合计分别为47.3%、17.7%和35.7%。维生素A缺乏和边缘缺乏率，孕妇为1.8%和9.1%，乳母为6.1%和15.2%，育龄妇女为8.6%和21.3%。本研究结果提示，灾区育龄妇女的微量营养素营养状况较差，因此改善这些地区育龄妇女的微量营养素的状况应该是优先考虑的问题。

关键词：育龄妇女、微量营养素、妇女、地震、突发事件