ISSN 2096-7071
CN 10-1629/R1

CHINA CDC WEEKLY

Vol. 3 No. 11 Mar. 12, 2021

CCDC weekly

中国疾病预防控制中心周报

Preplanned Studies

ISSN 2096-7071

Cover photo: Local CDC staff conducting physical examinations for the Nutrition and Health Surveillance of Children and Lactating Women at a community healthcare center in Kashi City, Xinjiang Uygur Autonomous Region in August 2018 (photographer: Hongyun Fang, National Institue for Nutrition and Health, China CDC).

Preplanned Studies

Iron Status Among Children Aged 6−17 Years by Serum Ferritin — China, 2016−2017

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Summary

What is already known on this topic?

Iron deficiency (ID) is the most widespread micronutrient deficiency and have several adverse effects on health. Consequences of ID among children include delayed psychomotor development and impaired cognitive performance, which makes it important to monitor the iron status of children.

What is added by this report?

In this study, the serum ferritin (SF) level was 56.6 (95% CI: 56.0–57.2) ng/mL in 65,293 children aged 6–17 years old in the National Nutrition and Health Surveillance in China in 2016–2017. ID prevalence varied significantly in children stratified by sex, age, and regions ranging from 1.0% to 28.1% judged by the standard of SF<15 ng/mL and SF<25 ng/mL. ID prevalence in females aged 12–17 years was the highest among children aged 6–17 years.

What are the implications for public health practice?

Understanding iron status of school children could provide evidence and data for developing policies and strategies for ID and iron deficiency anemia (IDA) control and prevention. Females aged 12–17 years showed high ID prevalence, and iron-rich food interventions are strongly recommended.

Iron deficiency (ID) is the most prevalent micronutrient deficiency worldwide, resulting in adverse health outcomes including anemia, impaired muscle function, poor immune function, delayed psychomotor development, and impaired cognitive performance in children in the short and long term (*1–2*).

ID has three progressive stages which include depletion of iron stores (ID), iron deficient erythropoiesis (IDE), and iron deficiency anemia (IDA). Available indicators in different stages contain serum ferritin (SF), soluble transferrin receptor (sTfR), zinc protoporphyrin, transferrin saturation, body iron stores, hemoglobin, reticulocyte hemoglobin, and hepcidin, etc. Each indicator has their own strengths and limitations. SF is the most recommended indicator for determining ID because it reflects a state of iron store in the body and researchers have established a cutoff for iron depletion by using SF (*3–4*).

In 2015–2017, China completed its fifth National Nutrition and Health Surveillance and monitored the iron status with large-scale samples. The primary objective of this study was to analyze the prevalence of ID among children aged 6–17 years in China in 2016–2017 to provide guidance to the development of appropriate intervention strategies.

Sampling of participants was based on the protocol for China Nutrition and Health Surveillance of Children and Lactating Women (2016–2017). The details were described in the introduction of China Nutrition and Health Surveys (1982–2017) (*5*). The blood samples in the serum separator tube were promptly centrifuged at 3,000 ×*g* for 15 minutes after venous blood collection and coagulation at room temperature, divided into aliquots of serum, and frozen at −80 ℃ for subsequent assays: SF and high-sensitivity C-reactive protein (hsCRP). SF was measured by electrochemiluminescence immunoassay on Roche Modular e601 automated analyzer; and hsCRP by Roche Tina-quant immunoturbidimetric assay on Hitachi 7600 automatic biochemical analyzer.

All analyses were conducted with SPSS (version 23.0, IBM Corp, Armonk, NY, USA). We log transformed SF to normalize the distribution because SF concentrations were positively skewed. SF distribution was described as geometric means ($\bar{x}_G$) and 95% confidence interval (95% CI) as well as selected percentiles by age and sex subgroups. Concentrations of hsCRP higher than 5 mg/L was considered as the presence of a possible infection or inflammation. ID was defined by the World Health Organization (WHO) recommended standard as SF<15 ng/mL and the National Hygienic Standard WS/T 465-2015 in China as SF<25 ng/mL; both standards were set in the absence of signs of inflammation (*3,6*). Independent *t*-tests and chi-squared tests were conducted on continuous variables and categorical variables between subgroups, respectively. Means, percentiles, ID prevalence, and differences between subgroups were analyzed from the method of complex sampling survey. The level of statistical significance was set at $P<0.05$.

In total, 65,293 participants were included after exclusion of hsCRP>5 mg/L, with 32,503 (50.0%) being male and 32,790 (50.0%) being female. The age of all children ranged from 6 to <18 years old with a median age of 11.3 years. The study population distribution was presented in Table 1.

As presented in Table 1, geometric mean SF concentrations were 57.9 (95% CI: 57.0–58.8) ng/mL and 55.5 (95% CI: 54.7–56.2) ng/mL for children aged 6–17 years in urban and rural areas, respectively. The SF concentrations were significantly higher in urban than those in rural areas, while males had a higher levels than that of females ($P<0.05$). The ferritin concentration in female subgroup aged 12–17 years was the lowest among all the subgroups ($P<0.05$).

Table 2 described the percentile distribution of SF concentrations in age and sex subgroups, which were widely arranged and varied among subgroups.

The prevalence of ID for children was shown in Table 3. Overall, the prevalence of ID in children aged 6–17 years, as defined by SF<25 ng/mL and SF<15 ng/mL, was 11.2% and 4.9% in this weighted population, respectively. According to ID judged by the cut-off value of 25 or 15 ng/mL for SF concentration, the prevalence of ID was significantly different in the subgroups by age, sex, or regions ($P<0.05$). Children aged 12–17 years had a higher incidence of ID than children aged 6–11 years ($P<0.05$). Males had a lower ID prevalence than females ($P<0.05$). The prevalence of ID in urban areas was significantly different with that in rural areas ($P<0.05$).

DISCUSSION

This study explored the status of SF and ID based on SF among children aged 6–17 years in China. This is the first survey on iron status among a large, nationally representative children samples in China.

SF is the best indicator to reflect the body iron store and could be measured by standardized laboratory assays as well as established cut-offs, but SF is considered as an acute-phase protein. Inflammation, infection, and liver disease could impact SF levels and bring deviations for iron status of the body. The WHO recommends using one or two acute phase proteins to reflect the state of inflammation in the body. CRP is a sensitive indicator that rises rapidly in the early stages of infection (*3*). In the study, hsCRP was used to screen children for the presence of infection or inflammation. Children with elevated hsCRP concentrations (>5 mg/L) were excluded from the analysis. The geometric mean concentrations of SF

TABLE 1. Serum ferritin levels for children aged 6–17 years — China, 2016–2017 (ng/mL).

Age group (years)	Total			Urban			Rural		
	n	$\bar{x}_G$	95% CI	*n*	$\bar{x}_G$	95% CI	*n*	$\bar{x}_G$	95% CI
6–17									
Total	65,293	56.6	56.0–57.2	30,960	57.9	57.0–58.8	34,333	55.5§	54.7–56.2
Male	32,503	66.4	65.5–67.2	15,404	69.4	68.0–70.7	17,099	63.8§	62.8–64.9
Female	32,790	47.3*	46.5–48.0	15,556	47.2*	46.1–48.4	17,234	47.3*	46.3–48.2
6–11									
Subtotal	36,596	60.4	59.8–61.1	17,423	62.0	60.9–63.1	19,173	59.3§	58.5–60.2
Male	18,223	60.5	59.6–61.5	8,665	62.2	60.7–63.8	9,558	59.3§	58.1–60.6
Female	18,373	60.3	59.4–61.3	8,758	61.7	60.2–63.3	9,615	59.3§	58.2–60.5
12–17									
Subtotal	28,697	53.1	52.2–54.0	13,537	54.8	53.5–56.2	15,160	51.3§	50.2–52.5
Male	14,280	72.7†	71.3–74.2	6,739	75.8†	73.7–78.1	7,541	69.6†§	67.8–71.4
Female	14,417	37.6*†	36.7–38.6	6,798	38.5*†	37.2–40.0	7,619	36.7*b§	35.5–37.9

Abbreviation: CI=Confidence Interval; $\bar{x}_G$=geometric means.

* *P*-value <0.05 for differences between male and female at same age group.

† *P*-value <0.05 for differences between children 6–11 years and 12–17 years.

§ *P*-value <0.05 for differences between urban and rural areas.

TABLE 2. Median and selected percentiles of serum ferritin concentrations for children aged 6–17 years in China in 2016–2017 (ng/mL).

Age group (years)	$P_{2.5}$	P_5	P_{10}	P_{25}	P_{50}	P_{75}	P_{90}	P_{95}	$P_{97.5}$
Total									
6–17									
Total	9.8	15.2	23.4	38.7	59.9	89.6	131.8	166.3	203.9
Male	17.9	23.1	30.3	45.0	66.5	100.3	147.7	188.3	225.7
Female	7.0	10.3	16.9	32.2	52.5	79.2	112.4	137.3	165.4
6–11									
Subtotal	19.1	24.0	30.5	43.1	61.4	86.1	119.3	146.1	179.4
Male	19.3	24.1	30.5	43.3	61.2	84.9	119.7	148.2	187.8
Female	18.8	23.9	30.4	43.0	61.7	87.2	118.7	142.6	171.0
12–17									
Subtotal	7.2	10.7	17.1	33.4	58.0	93.9	144.1	181.2	221.8
Male	16.7	21.8	30.1	47.6	75.1	118.2	171.5	212.7	251.8
Female	5.2	7.3	11.0	22.7	42.7	68.9	102.7	131.2	160.6
Urban									
6–17									
Total	9.2	14.5	22.5	38.3	61.4	95.5	141.0	181.0	220.7
Male	17.6	22.8	30.3	45.6	69.5	108.2	159.1	206.1	246.3
Female	6.5	9.7	15.6	31.2	52.7	81.4	118.6	146.2	177.8
6–11									
Subtotal	18.2	23.4	30.0	43.3	63.1	90.8	125.9	158.7	197.5
Male	18.5	23.5	30.5	43.3	62.4	91.0	127.6	168.7	206.1
Female	17.8	23.3	29.6	43.2	63.6	90.8	125.0	153.3	189.1
12–17									
Subtotal	7.0	10.7	17.2	33.7	59.6	100.1	152.3	193.5	236.1
Male	16.8	22.3	30.3	48.5	79.6	124.8	181.0	224.7	262.5
Female	5.2	7.1	11.2	22.9	43.5	71.4	111.6	142.0	170.4
Rural									
6–17									
Total	10.5	16.0	24.0	39.1	58.9	85.1	122.6	153.0	184.4
Male	18.1	23.4	30.3	44.4	64.3	93.1	138.3	172.9	205.2
Female	7.4	10.8	17.9	33.2	52.4	76.9	105.9	129.0	152.5
6–11									
Subtotal	19.9	24.5	30.8	43.0	60.1	83.5	113.8	138.6	166.7
Male	20.1	24.5	30.5	43.3	60.1	81.9	114.4	140.5	168.9
Female	19.7	24.5	31.1	42.7	60.1	85.0	113.6	136.8	161.4
12–17									
Subtotal	7.4	10.7	17.1	33.2	56.4	88.1	134.5	171.6	206.1
Male	16.3	21.4	29.8	46.7	71.6	109.6	161.1	198.4	231.6
Female	5.2	7.4	10.8	22.4	41.9	66.3	95.4	118.0	141.5

were 57.9 (57.0–58.8) ng/mL and 55.5 (54.7–56.2) ng/mL for children aged 6–17 years in urban and rural areas, respectively. Males aged 12–17 years had a higher level of SF than those aged 6–11 years. The results are in line with the findings from a previous study (*7*). Since their dietary iron absorption is

TABLE 3. Iron deficiency prevalence for children aged 6–17 years — China, 2016–2017 [% (95% CI)].

Age group (years)	SF<25 ng/mL			SF<15 ng/mL		
	Total	Urban	Rural	Total	Urban	Rural
6–17						
Total	11.2(10.8, 11.6)	11.8(11.2, 12.4)	10.6(10.1, 11.2)§	4.9(4.6, 5.2)	5.4(4.9, 5.8)	4.5(4.1, 4.9)§
Male	6.1(5.7, 6.6)	6.3(5.7, 7.0)	5.9(5.4, 6.6)	1.6(1.4, 1.9)	1.8(1.5, 2.2)	1.4(1.2, 1.8)
Female	16.9(16.2, 17.6)*	18.0(16.9, 19.0) *	16.0(15.0, 17.0)*§	8.6(8.1, 9.2)*	9.3(8.5, 10.2)*	7.9(7.3, 8.7)*§
6–11						
Subtotal	5.5(5.1, 5.9)	6.0(5.4, 6.6)	5.2(4.6, 5.8)	1.3(1.1, 1.5)	1.5(1.3, 1.9)	1.1(0.8,1.4)
Male	5.5(5.0, 6.1)	6.0(5.3, 6.8)	5.2(4.4, 6.1)	1.2(0.9, 1.5)	1.5(1.1, 2.0)	1.0(0.6, 1.5)
Female	5.5(4.9, 6.2)	6.0(5.1, 7.0)	5.2(4.4, 6.1)	1.4(1.1, 1.7)	1.6(1.2, 2.2)	1.2(0.9, 1.6)
12–17						
Subtotal	16.7(16.0, 17.4)	16.4(15.5, 17.4)	16.9(16.0, 17.9)	8.4(7.9, 8.9)	8.4(7.7, 9.1)	8.4(7.7, 9.2)
Male	6.7(6.1, 7.4)†	6.6(5.7, 7.6)	6.9(6.0, 7.8)†	2.0(1.7, 2.4)†	2.0(1.6, 2.7)	2.0(1.6, 2.6)†
Female	27.6(26.4, 28.8)*†	27.1(25.4, 28.8) *†	28.1(26.4, 29.8)*†	15.4(14.4, 16.4)*†	15.2(13.9, 16.7)*†	15.5(14.1, 17.0)*†

Abbreviation: SF=serum ferritin.

* Chi-squared test *P*-value <0.05 for differences between male and female at same age group;

† Chi-squared test *P*-value <0.05 for differences between children 6–11 years and 12–17 years.

§ Chi-squared test *P*-value <0.05 for differences between urban and rural areas.

increasing during body growth, young men may increase levels of stored iron and result in increased SF until reaching normal level. The study also found that SF levels in males were higher than that in females.

SF threshold of 15 ng/mL ensures the specificity of the diagnostic ID, but the sensitivity was relatively low. Yu D et al. conducted a meta-analysis of the threshold value of SF for ID determination, and the conclusion was that the diagnostic accuracy and comprehensive efficiency of SF were increased if the threshold value of SF was 25 or 30 ng/mL (*8*). The findings were supported by other studies (*9*). In this study, the prevalence of ID among children aged 6–17 years was estimated to be 4.9% in China according to WHO recommendation. When ID was defined as SF< 25 ng/mL, which might be more sensitive in detecting early depletion of body iron stores, the percentage increased from 4.9% to 11.2%. According to the results in the 2010–2012 National Nutrition and Health survey, based on cutoffs of 25 ng/mL and 15 ng/mL for SF, the results showed that ID prevalence among 472 children aged 6–11 years in big cities were 2.3% and 0.6%, respectively; among 543 children aged 6–11 years in poverty rural areas were 6.1% and 1.5%, respectively; among 450 children aged 12–17 years in big cities were 9.1% and 3.6%, respectively; and among 602 children aged 12–17 years in poverty rural areas were 10.3% and 4.3%, respectively (*10*). In the survey, resampling for measuring iron indicator was conducted based on the samples from the big cities and poverty rural areas, respectively, and the sample size was small, in addition, the method used for SF was an immunoturbidimetry assay. In the present study, a representative large-scale sample was involved and the method for SF determination was electrochemiluminescence immunoassay with the advantages of high sensitivity and stability. Therefore, the results and trends were not compared between 2010–2012 and 2016–2017.

ID results from long-term imbalance caused by inadequate dietary iron intake, poor iron absorption or utilization, increased iron requirements, or chronic blood loss. Lin XM et al. analyzed the iron nutrition status of 1,012 school-age children aged 7–13 years in Beijing's mountainous areas and found that 26.5% school-age children had SF below 30 ng/mL (*11*). In the present study, except for girls aged 12–17 years, ID prevalence of other children was low. In China, socioeconomic conditions were improving and many nutrition intervention programs targeting poor children were implemented in recent years (*12–13*). In 2011, the Nutrition Improvement Program for Rural Compulsory Education Students (NIPRCES) was launched by the State Council (*12*). In rural boarding schools, NaFeEDTA-fortified soy sauce has been used to improve the iron deficiency and anemia status for students in some rural areas (*13*). As a result, children in rural areas have improved iron intake because of education, dietary diversification, and iron-fortified food consumption. The level of iron stores was lower in female aged 12–17 years, which may be related to the high iron requirements in this period. In addition, the iron loss in menstruation and bad dietary habits for keeping slim could also contribute.

This study was subject to some limitations. First, α1-acid glycoproteins (AGP) was a marker to reflect the state of inflammation in the body, which responds to inflammation later, but duration longer than CRP. In chronic or subclinical infections, AGP may be more appropriate for determining the inflammatory status of the body. In our study, AGP was not included. Second, sTfR and hemoglobin are good indicators for determining IDE and IDA. In the future, more studies including SF, sTfR, and Hb should be conducted to comprehensively assess the iron status of children.

In conclusion, understanding iron status of school children could provide evidence and data for developing policies and strategies for ID and IDA control and prevention. The prevalence of ID varies significantly in children by sex, age, and regions ranging from 1.0% to 28.1% based on SF below 15 ng/mL and 25 ng/mL. Females aged 12–17 years showed high ID prevalence, and iron-rich food interventions are strongly recommended.

Acknowledgements: Team members and participants of the National Nutrition and Health Surveillance 2016–2017 as supported by the National Health Commission of China.

doi: 10.46234/ccdcw2021.063

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Submitted: January 18, 2021; Accepted: March 10, 2021

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Preplanned Studies

Folic Acid Status and Associated Factors for Pregnant Chinese Women — China, 2015

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Summary

What is already known on this topic?

Low folate status in pregnancy has been associated with multiple adverse pregnancy outcomes, including neural tube defects, congenital heart defects, fetal growth restriction, low birth weight, and preterm delivery. Low folate status is common in China, especially in northern areas.

What is added by this report?

Folate status remains suboptimal among pregnant Chinese women in 2015. Folate concentration was in the widespread in rural area (9.88ng/mL) and especially in the northern of China (9.10ng/mL). Pregnant women in the last trimester had the lowest folic acid concentration (9.18 ng/mL). Taking folic acid supplements every day would achieve adequate serum folate concentrations (10.87 ng/mL *vs.* 10.11 ng/mL *vs.* 9.38 ng/mL, $P<0.001$).

What are the implications for public health practice?

Folic acid interventions should be strengthened, especially for pregnant women in rural areas and in northern China, those with junior school or below education, those pregnant during spring and winter, or those with late pregnancy.

Folate is an essential element for DNA replication and normal cell formation and growth, and it is particularly critical during the early stages of human embryo development. Low folate levels during pregnancy is associated with multiple adverse pregnancy outcomes including neural tube defects (NTD). Low folate status is common in China, especially in northern China. However, most studies on folate status focused on specific regions and women of childbearing age, and few studies have been conducted on the folate status of pregnant women in China. Several studies found that living in northern areas, living in rural areas, and being in early lactating periods were risk factors associated with folic acid deficiency in lactating women, where folic acid interventions should be considered as a priority. The Ministry of Health of China (now the National Health Commission; NHC) launched a nationwide program to increase folic acid intake in rural reproductive-aged women starting in 2009. This program provided folic acid supplements (0.4 mg folic acid per tablet) for free to women with rural household registrations and who intended to get pregnant. Significant developments have occurred in pregnant women's dietary habits, economic status, and educational level. This study aimed to observe the folic acid status and associated factors of Pregnant Chinese women in 2015.

The data of pregnant women were extracted from the China Nutrition and Health Surveillance (2015–2017). By using a multistage stratified cluster random sampling method, 30 pregnant women were sampled from each of 302 sites in 31 provincial-level administrative divisions (PLADs) of the mainland of China. After excluding those without adequate blood specimens, data of birth, or gestational weeks, 7,985 pregnant women were included in the analysis. This project has been approved by the Ethics Review Committee of the Institute of Nutrition and Health of China CDC (Number: 201519-A). All respondents have signed informed consent before the investigation.

A standard questionnaire was used to obtain general information, history of pregnancy, and folic acid supplements. A 4 mL fasting blood sample was collected from each individual and stored in a −80 °C freezer. Serum folate concentration was measured by the electro-chemiluminescence immunoassay method (Elecsys Folate III, Cobas 601 Roche). A high and a low-quality control material (Elecsys Precicontrol Varia, Roche) were entered on each run and the target value (Mean±3SD) was (2.87±1.29) ng/mL and (11.1±3.0) ng/mL, respectively. The results of the test quality material were expressed as the following means: High 11.70 (SD 1.36) ng/mL and Low 3.17 (SD 0.39) ng/mL; the coefficient of variation (CV) of high and low-quality control material was 12.2% and

11.6%, respectively.

Multiple linear regressions were utilized to examine the relationship between serum folate concentration and various variables. The stepwise selection was applied to select independent variables [e.g., education, gestation, season, body mass index (BMI), age, and folic acid supplementation], adjusting for regions as well as for potential sociodemographic characteristics that were associated with serum folate. The F test and coefficient of determination R^2 were used to identify the optimal model. Folic acid deficiency was defined as a serum folic acid level <2 ng/mL (4.53 nmol/L) recommended by US CDC (*1*). Statistical significance was established at *P*<0.05 for all analysis. All data cleaning and statistical analyses were performed using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA).

A total of 7,985 pregnant women were included in the study, and the mean age of subjects was 27.9±4.6 years old. More than half of the pregnant women were living in cities (56.4%) and completed high school or above education level (63.0%), 88.5% were Han nationality, and 37.1% were unemployed or stayed at home (Table 1).

TABLE 1. Association between characteristics and serum folate concentrations (ng/mL) of pregnant women — China, 2015.

Variable	N	Serum folate (ng/mL) P_{50} (P_{25}–P_{75})	χ^2	*P*
Age (years)			56.73	<0.001
<25	2,137	7.14 (4.28–11.82)		
25–34	5,229	8.36 (4.93–13.01)		
≥35	619	8.62 (4.96–13.75)		
Nationality			28.35	<0.001
Han	6,945	8.27 (4.93–13.00)		
Minority	902	6.44 (3.54–10.87)		
Missing	138			
Gestational weeks			359.12	<0.001
<12	2,217	10.40 (6.27–14.65)		
13–27	3,001	8.01 (4.87–12.50)		
≥28	2,654	6.56 (4.04–10.83)		
Missing	113			
BMI			183.11	<0.001
≤18.5	406	10.55 (6.16–14.42)		
18.5–23.9	3,579	9.00 (5.28–13.52)		
24.0–27.9	2,557	7.24 (4.40–12.06)		
≥28.0	1,325	6.72 (4.03–11.04)		
Missing	118			
Education			229.74	<0.001
Junior high and below	2,953	6.91 (4.10–11.30)		
Senior high/college	3,561	8.36 (4.85–12.98)		
University and above	1,471	10.22 (5.93–14.46)		
Occupation			252.45	<0.001
Agriculture, forestry, animal husbandry, fishery	907	5.72 (3.14–9.37)		
Production and transportation equipment operators, commercial service personnel	1,043	8.63 (5.06–12.97)		
State organs, party-mass organizations, enterprises and public institutions, working, personnel	1,013	9.72 (5.55–14.03)		
Professionals	1,465	8.99 (5.41–13.68)		
Other workers	532	8.35 (5.30–12.63)		
Students and unemployed	2,923	7.79 (4.62–12.41)		
Missing	102			

TABLE 1. (Continued)

Variable	N	Serum folate (ng/mL) P_{50} (P_{25}–P_{75})	χ^2	*P*
Area type			85.56	<0.001
Urban	4,450	8.62 (5.36–13.25)		
Rural	3,446	7.41 (4.15–12.29)		
Missing	89			
Region			398.41	<0.001
Northern region	3,785	6.52 (3.73–11.44)		
Southern region	4,200	9.28 (5.86–13.72)		
Tine since last pregnancy (years)			14.38	<0.01
<1	4,017	8.19 (4.92–13.17)		
1–5	602	7.88 (4.39–12.36)		
>5	3,366	7.86 (4.57–12.41)		
Folic acid supplementation			185.65	<0.001
Yes	6,861	8.43 (4.98–13.18)		
No	1,021	5.84 (3.48–9.63)		
Missing	103			
Timing of folic acid supplementation			9.47	0.002
After pregnancy	3,476	8.18 (4.95–12.80)		
Before pregnancy	3,393	8.77 (5.01–13.54)		
Missing	1,116			
Supplementation frequency in the past week (days)			317.43	<0.001
≤3	3,283	7.14 (4.37–11.28)		
3–6	686	8.93 (5.42–13.56)		
7	2,892	10.35 (6.01–14.73)		
Missing	1,124			
Season			52.17	<0.001
Spring	977	6.73 (3.33–12.15)		
Summer	33	12.17 (6.14–15.17)		
Autumn	1,251	8.47 (5.36–12.78)		
Winter	5,185	8.02 (4.73–12.79)		
Missing	450			

Abbreviation: BMI=body mass index.

The median (25th and 75th percentiles) serum folate concentrations were 8.02 (4.73–12.79) ng/mL. Overall, 6.12% of pregnant women were folate deficient. As presented in Table 2, compared with those living in the rural, pregnant women living in urban had a significantly higher serum concentration (9.88 ng/mL *vs.* 10.37 ng/mL, *P*<0.001). Compared with those living in the northern region, pregnant women living in the southern region had a higher serum folate concentration (9.10 ng/mL *vs.* 11.14 ng/mL, *P*<0.001). Pregnant women in the first trimester and second trimester had higher folic acid concentration than those in the last trimester (11.13 ng/mL and 10.05 ng/mL *vs.* 9.18 ng/mL, *P*<0.001). Serum folate status in summer and autumn were higher than the other 2 seasons (12.07 ng/mL and 10.01 ng/mL *vs.* 8.76 ng/mL and 9.63 ng/mL, *P*<0.001). Pregnant women who took folic acid supplements every day had highest serum folate concentration than those who did not (10.87 ng/mL *vs.* 10.11 ng/mL *vs.* 9.38 ng/mL, *P*<0.001). Compared with normal weight pregnant women, obese pregnant women have lower levels of folate status (9.66 ng/mL *vs.* 10.04 ng/mL, *P*<0.001). The older (>25 years) pregnant women and with higher levels of education have the higher serum folate concentration (10.16 ng/mL *vs.* 10.54 ng/mL *vs.*

TABLE 2. Factors are associated with serum folate of pregnant women — China, 2015.

Risk factors	LSMEAN (ng/mL)	SE	Pr>|t|
Residence			
Urban	10.37	0.27	
Rural	9.88	0.28	<0.001
Region			
Northern region	9.10	0.27	
Southern region	11.14	0.28	<0.001
Supplementation frequency in the past week (days)			
≤3	9.38	0.28	
3–6	10.11	0.32	<0.001
7	10.87	0.27	<0.001
Gestational weeks			
<12	11.13	0.29	
13–27	10.05	0.28	<0.001
≥28	9.18	0.28	<0.001
Season			
Spring	8.76	0.20	
Summer	12.07	0.97	<0.001
Autumn	10.01	0.18	<0.001
Winter	9.63	0.13	<0.001
BMI			
≤18.5	10.99	0.39	0.002
18.5–23.9	10.04	0.27	
24.0–27.9	9.78	0.28	<0.074
≥28.0	9.66	0.30	<0.041
Age (years)			
<25	9.56	0.28	
25–34	10.16	0.26	<0.001
≥35	10.54	0.33	<0.001
Education*			
Junior high and below	9.44	0.28	
Senior high/college	10.01	0.28	<0.001
University and above	10.91	0.29	<0.001

Abbreviation: BMI=body mass index; LSMEAN=least squares means; SE=standard error.

*Junior high and below: include that do not receive formal school education; do not graduate from primary school; graduate from primary school; graduate from junior high school. Senior high/college: include high school; technical secondary school; technical school; graduate from college. University and above: include that graduated from the university, get a master degree, or above.

9.56 ng/mL, *P*<0.001), (10.01 ng/mL *vs.* 10.91 ng/mL *vs.* 9.44 ng/mL, *P*<0.001).

DISCUSSION

In this study, the prevalence of folic acid deficiency was 6.12% for pregnant women in China. A study conducted in Shanxi Province found that the median folic acid level was 7.6 ng/mL (*2*), which was close to our results. Furthermore, in more developed countries such as the United States (14.9 ng/mL) and New Zealand (21.4 ng/mL), the mean serum folic acid levels were higher than the results demonstrated in this study (*3–4*).

The serum folate level of pregnant women was higher in urban areas than in rural areas in this study.

Despite the implementation of the free folic acid supplementation programs in rural area, the status of serum folic was still significantly lower than that of urban areas. On the other hand, a study conducted by Zhu L, et al. (*5*) showed that 32%–35% of women had low plasma folate (5.2 ng/mL). In this study, pregnant women living in northern regions still had a lower folate concentration.

Maternal age, education levels, and gestation were associated with folate concentrations in pregnancy. Pregnant women of older ages (>25 years) and higher levels of education have the higher serum folate concentration. This suggested that pregnant women of older ages (>25 years) and higher education may pay more attention to prepare for pregnancy and achieve adequate nutritional status during gestation.

It has been previously observed that folic acid supplementation had a strong impact on serum folate concentrations (FA). Liu J et al. (*6*) found that earlier supplementation, increase in supplementation frequency, and more total days of supplementation were associated with higher plasma folate concentrations. The results also revealed that pregnant women who took folic acid supplements every day had the highest serum folate concentration than other pregnant women. Studies on later pregnancies showed the importance of continued FA supplementation (0.4 mg/d) in the second and third trimesters (*7*). Taking FA supplement may prevent declines in serum and erythrocyte folate concentrations and increase plasma homocysteine concentration, which occurs as pregnancy progresses. Therefore, the nationwide program should further emphasize the timing and frequency of supplementation.

The usage, number, and type of supplements changed throughout pregnancy. Looman M et al. (*8*) found that plasma folate levels significantly increased from preconception to 12 gestational weeks and were significantly lower in 24 gestational weeks. This drop is most likely related to the intake of folic acid supplements until week 12 of gestation. The drop in supplemental folate intake from week 12 to 24 of pregnancy has also been observed in numerous studies (*9*). The study further demonstrated that serum folate levels in the second and the third trimester was significantly lower than the first trimester.

According to the study in Anhui Province, folate concentration in summer and autumn was higher than in other seasons (*10*), equally this study showed that the serum folate status of pregnant women in the summer and autumn were higher than in other seasons. The main resource of folate is provided by the consumption of dark-green leafy vegetables (e.g., lettuce, spinach, and broccoli) since people seldom fortify food with folic acid in China. However, compared with other seasons, dark-green leafy vegetables were less available in spring and winter.

Similar to the study of Cheng TL et al. (*11*), a significantly lower folate level was found in obese groups compared with other BMI groups. This indicated that obesity might influence folate metabolism and ideal folate levels should be measured before conception so that personalized advice can be provided.

This study was subject to some limitations. First, the sample size used in the study was small in each study site, and participants were recruited from prenatal care clinics, which may not represent the whole country. Women who sought prenatal care (and thus were recruited into the study) may differ from others in terms of socioeconomic and demographic status, which might affect the generalization of the current results. Second, serum folic acid is heavily affected by recent folate intake including dietary folic acid and supplementary folate intake. If red blood cell folate levels were measured, we could have a better understanding of overall folate status.

Funding: National Health and Family Planning Commission (former Ministry of Health of the People's Republic of China) Medical Reform Major Program: Chinese Nutrition and Health Surveillance (2015).

doi: 10.46234/ccdcw2021.065

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Submitted: January 18, 2021; Accepted: March 10, 2021

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Preplanned Studies

Trends of Underweight Malnutrition Among Chinese Residents Aged 60 Years and Above — China, 1992–2015

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Summary

What is already known about this topic?

The prevalence of underweight malnutrition largely decreased in Chinese adults in recent thirty years while obesity became increasingly concerning. However, underweight malnutrition still affected elderly populations and increased risk of anemia, infection diseases, some non-communicable chronic diseases and disability.

What is added by this report?

In this study, data from 4 national surveys from 1992 to 2015 were analyzed to study underweight malnutrition. There was an 80.5% reduction for underweight malnutrition nationally, including a 67.5% reduction in rural areas and 67.4% in urban areas, and 76.2% in males and 79.4% in females.

What are the implications for public health practice?

Underweight malnutrition seriously affects the health and quality of life for older people and will lead to heavy burdens for families and society overall. Therefore, efforts should be maintained to screen, treat, and safeguard elderly populations with underweight malnutrition using nutritional improvement strategies, especially for the oldest elderly individuals in rural areas.

With rapid socioeconomic development, the nutritional status of the Chinese population has been greatly improved, but overweight and obesity are becoming more and more concerning. In addition, underweight malnutrition in the elderly population is largely ignored and even considered as a normal phenomenon of aging (*1*). Underweight malnutrition can increase the risk of anemia, nutrition-deficient neuropathy, and infection and can cause several other diseases in older people (*2*), which can ultimately result in a substantial socioeconomic burden (*3*–*4*). A study in the Netherlands in 2011 reported that the extra cost of managing diseases related to underweight malnutrition was about $1.9 billion, accounting for 2.1% of the Dutch national health expenditure (*5*). To analyze this problem in China, data of four national representative surveys was analyzed to evaluate trends of underweight malnutrition during these decades, and the results from this study helped provide a scientific basis for further formulation of accurate prevention and intervention strategies of underweight malnutrition in the elderly population.

Data was extracted from four nationally representative surveys, which were the National Nutrition Survey in 1992 (NNS 1992) (*6*), the China National Nutrition and Health Survey in 2002 (CNNHS 2002) (*7*), the China Nutrition and Health Surveillance in 2010–2013 (CNHS 2010–2013) (*8*), and the China Adult Chronic Disease and Nutrition Surveillance 2015 (CACDNS 2015) (*9*). Each of these surveys were stratified multistage cluster random sampling in nationwide. Of the four surveys, in person interviews using uniform questionnaires were conducted at a local site for respondents to collect demographic and socioeconomic information such as age, gender, and other characteristics by trained staff. Anthropological measurement of height and weight were measured using uniform measurement instruments with strict quality control by trained staff at local community health service centers. Weight of participants wearing no shoes and light clothing was measured to the nearest 0.1 kg and height was determined to the nearest 0.1 cm with no shoes. Body mass index (BMI) was calculated by the formula of weight in kilograms divided by height squared in meters. BMI lower than 18.5 kg/m^2 was diagnosed to be underweight malnutrition according to the criteria of adult weight determination (*10*). These four surveys were all organized by National Institute for Nutrition and Health of China CDC and were approved by the Ethics Committee of China CDC (Former Chinese Academy of Preventive Medicine). All respondents signed informed consent forms and those aged 60 and above in the four surveys were included in this study.

SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA) was applied for statistical analysis and

Student's *t*-tests, ANOVA, and chi-squared tests were used to compare differences between participants among subgroups. As the age and gender distribution of the surveyed population was different between these four surveys, we calculated standard values using PROC SURVEYFREQ procedures in SAS for prevalence of underweight malnutrition based on the 2010 national census data (*11*). Bilateral $P<0.05$ was considered as statistically significant.

The general characteristics of participants in the 4 surveys were shown in Table 1. There were 6,714 (2,687 in urban areas and 4,027 in rural) elderly participants in 1992 survey, and those aged 75 years and above accounted for 13.7% of this population in urban areas and 13.5% in rural areas. Female accounted for 49.1% in the urban areas and 48.6% in the rural areas. As for education level, most participants only had primary school education or lower, 17.6% of the participants had junior middle school and above in urban areas and 2.2% in rural areas. Most of participants had a significant other accounting for 79.6% in urban areas and 72.2% in rural areas. In the 2002 survey and surveillance in 2010–2012 and 2015, the number of participants increased to 26,566 (54.4% in rural areas), 36,388 (45.8% in rural), and 58,750 (57.9% in rural). The proportion in these 3 datasets of elderly residents aged 75 years and above was 14.2%, 18.1%, and 15.5% in urban areas, respectively, and 12.5%, 15.6%, and 14.6% in rural areas, respectively. The percentage of illiteracy decreased while the percentage of at least primary school education and junior middle school education increased from 1992 to 2015. The percentage of urban participants with an education level of primary school or above was higher than that of rural participants ($P<0.001$). As for income, the proportion of low-income levels of participants had decreased to 6.0% in urban areas and 15.7% in rural areas in 2015. Among the group aged 60–74 years, the average BMI in 1992 was 24.1 kg/m^2 in urban areas and 21.1 kg/m^2 in rural areas and then increased in the survey in 2015 to 24.9 kg/m^2 in urban areas and 23.7 kg/m^2 in rural areas. Similarly, the BMI level among the group aged 75 years and above also increased from 22.3 kg/m^2 to 24.1 kg/m^2 in urban areas and from 20.3 kg/m^2 to 22.5 kg/m^2 in rural areas during the survey intervals. There were statistically significant differences in the age group, education level, income, marital status, and BMI level when compared among these surveys ($P<0.001$).

Table 2 showed the distribution of prevalence of underweight malnutrition among older participants in the four surveys. Although the underweight prevalence decreased in both urban and rural areas, it was significantly higher in older respondents of rural areas than that in urban areas in subgroups of age, gender, and education level from 1992 to 2015 ($P<0.05$). Underweight malnutrition was much higher in the group aged 75 years and above in rural areas than that in other age groups, which was still 10.9% in the surveillance in 2015. As for older female participants in rural areas, the prevalence of underweight malnutrition decreased from 21.5% in 1992 to 5.8% in 2015 with a proportion decrease of 73.0%. In addition, underweight malnutrition proportion in individuals with unknown education levels and illiteracy subgroups in rural areas was 6.7% in 2015, which was still higher than that in other education subgroups. Meanwhile, it was interesting that undernutrition among the elderly in single, divorced and widowed status of marital was much higher than that in having partners, which was 7.1%, 9.3%, and 8.3% respectively in 2015.

Figure 1 showed the trends of underweight malnutrition prevalence among the participants. From 1992 to 2015, there was 80.5% decrease of underweight malnutrition among the elderly population. The underweight malnutrition prevalence decreased from 17.4% in 1992 to 9.4% in 2002 and then to 4.8% in 2010–2012 and then to 3.4% in 2015. Underweight malnutrition decreased from 20.3% in 1992 to 6.6%, a 67.5% reduction, in rural areas and from 8.6% to 2.8% in urban areas, a reduction of 67.4%. The reduction of underweight malnutrition prevalence in rural areas was significantly larger than that in urban areas. The prevalence of underweight malnutrition in males and females also decreased. In females, the prevalence of underweight malnutrition decreased dramatically from 16.5% in 1992 to 3.4% in 2015, a 79.4% reduction, and in males, the rate declined from 14.7% in 1992 to 3.5% in 2015, an average reduction of 76.2%. In each of four surveys, the prevalence of underweight malnutrition increased with age. Although there appeared a trend of decline from 1992 to 2015 for every age group, the prevalence of underweight malnutrition in the 75 years age group was the highest in each survey and was still 7.6% in 2015.

DISCUSSION

This study demonstrated that the prevalence of

TABLE 1. General characteristics of participants aged 60 years and above in China, 1992–2015.

Variables	1992*		2002		2010–2012		2015		*P* value ¶
	Urban (n=2,687)	Rural (n=4,027)	Urban (n=12,099)	Rural (n=14,467)	Urban (n=19,731)	Rural (n=16,657)	Urban (n=24,727)	Rural (n=34,023)	
Age groups (n, %)									<0.001
60–74 years	2,319 (86.3)	3,484 (86.5)	10,384 (85.8)	12,658 (87.5)§	16,150 (81.9)	14,062 (84.4)§	20,888 (84.5)	29,041 (85.4)§	
75– years	368 (13.7)	543 (13.5)	1,715 (14.2)	1,809 (12.5)	3,581 (18.1)	2,595 (15.6)	3,839 (15.5)	4,982 (14.6)	
Sex (n, %)									0.062
Male	1,367 (50.9)	2,069 (51.4)	5,913 (48.9)	7,557 (52.2)§	9,144 (46.3)	8,271 (49.7)§	11,922 (48.2)	17,628 (51.8)§	
Female	1,320 (49.1)	1,958 (48.6)	6,186 (51.1)	6,910 (47.8)	10,587 (53.7)	8,386 (50.3)	12,805 (51.8)	16,395 (48.2)	
Education level (n, %)									<0.001
Unknown	792 (30.2)	2,691 (68.4)	20 (0.2)	43 (0.3)§	1 (0.0)	–	–	–	
Illiteracy	624 (23.8)	703 (17.9)	2,585 (21.4)	6,290 (43.5)	3,110 (15.8)	5,479 (32.9)§	4,399 (17.8)	11,442 (33.6)§	
Primary school	744 (28.4)	457 (11.6)	3,862 (31.9)	5,792 (40.0)	6,564 (33.3)	7,703 (46.2)	8,745 (35.4)	16,494 (48.5)	
Junior high school	259 (9.9)	60 (1.5)	2,646 (21.9)	1,625 (11.2)	5,444 (27.6)	2,820 (16.9)	6,707 (27.1)	4,690 (13.8)	
Senior high school	72 (2.7)	11 (0.3)	1,753 (14.5)	610 (4.2)	3,012 (15.3)	582 (3.5)	3,224 (13.0)	1,231 (3.6)	
College and above	130 (5.0)	14 (0.4)	1,233 (10.2)	107 (0.7)	1,600 (8.1)	73 (0.4)	1,652 (6.7)	166 (0.5)	
Income† (n, %)									<0.001
Low	864 (32.2)	1,431 (35.5)	5,078 (42.0)	12,920 (89.3)§	3,347 (17.0)	7,806 (46.9)§	1,491 (6.0)	5,353 (15.7)§	
Middle	936 (34.8)	1,313 (32.6)	3,893 (32.2)	1,018 (7.0)	3,335 (16.9)	4,281 (25.7)	1,717 (6.9)	4,007 (11.8)	
High	887 (33.0)	1,283 (31.9)	2,792 (23.1)	309 (2.1)	11,592 (58.8)	3,854 (23.1)	8,262 (33.4)	5,669 (16.7)	
No response	–	–	336 (2.8)	220 (1.5)	1457 (7.4)	716 (4.3)	13,257 (53.6)	18,994 (55.8)	
Marital status (n, %)									<0.001
Single	13 (0.5)	55 (1.4)	81 (0.7)	142 (1.0)§	102 (0.5)	142 (0.9)	109 (0.4)	308 (0.9)	
Have a partner	2,097 (79.6)	2,849 (72.2)	9,677 (80.0)	10,982 (75.9)	16,277 (82.5)	13,584 (81.6)	2,1941 (88.7)	29,993 (88.2)	
Divorced	17 (0.6)	15 (0.4)	109 (0.9)	109 (0.8)	198 (1.0)	121 (0.7)	127 (0.5)	86 (0.3)	
Widowed	506 (19.2)	1,028 (26.0)	2,232 (18.4)	3,234 (22.4)	3,154 (16.0)	2,810 (16.9)	2,550 (10.3)	3,636 (10.7)	
BMI [kg/m^2, mean (SD)]									<0.001
60–74 years	24.1 (4.1)	21.1 (3.2)	24.8 (3.7)	22.2 (3.6)§	24.6 (3.4)	23.3 (3.6)§	24.9 (3.5)	23.7 (3.5)§	
75– years	22.3 (3.8)	20.3 (3.2)	23.6 (3.8)	21.3 (3.3)	23.9 (3.6)	22.2 (3.5)	24.1 (3.5)	22.5 (3.4)	

Note: − means data are unavailable;

Abbreviation: BMI=body mass index;

* Because original data was inaccessible, the results were extracted from the published book of "The dietary and nutritional status of Chinese population — elderly (1992 National Nutrition Survey)";

† The value of income was published as continuous data in the survey conducted in 1992, but income was categorical data in other surveys. Therefore, low income was defined as household income lower than 5,000 CNY per capita annually; middle income was defined as 5,000–9,999 CNY per capita annually; and high level was defined as 10,000 CNY and above per capita annually in the other three surveys;

§ Difference between urban areas and rural areas in independent survey, *P*<0.01;

¶ Comparison of general characteristics among the three surveys.

TABLE 2. Underweight malnutrition proportion among participants aged 60 years and above in China, 1992–2015 (n, %).

Variables	1992[*]		2002		2010–2012		2015		*P* value[¶]
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	
Total	227 (8.6)	799 (20.3)	573 (4.5)	2,028 (15.4)	698 (3.8)	1,380 (9.1)	706 (2.8)	689 (6.6)	<0.001
Age groups									
60–74 years	168 (7.4)	642 (18.8)	426 (4.1)	1,659 (13.1)[§]	492 (3.0)	1,014 (7.2)[§]	508 (2.4)	1,445 (5.0)[§]	<0.001
75– years	59 (16.5)	157 (30.0)	147 (8.6)	369 (20.4)[§]	206 (5.8)	366 (14.1)[§]	198 (5.2)	545 (10.9)[§]	<0.001
Gender									
Male	109 (8.2)	385 (19.1)	305 (5.2)	1,047 (13.9)[§]	338 (3.7)	717 (8.7)[§]	350 (2.9)	1,045 (5.9)[§]	<0.001
Female	118 (9.1)	414 (21.5)	268 (4.3)	981 (14.2)[§]	360 (3.4)	663 (7.9)[§]	356 (2.8)	945 (5.8)[§]	<0.001
Education level									
Unknown/Illiteracy	–	–	189 (7.3)	959 (15.1)[§]	195 (6.3)	506 (9.2)[§]	189 (4.3)	765 (6.7)[§]	<0.001
Primary school	–	–	186 (4.8)	827 (14.3)[§]	244 (3.7)	641 (8.3)[§]	291 (3.3)	953 (5.8)[§]	<0.001
Junior high school	–	–	95 (3.6)	166 (10.2)[§]	154 (2.8)	197 (7.0)[§]	130 (1.9)	206 (4.4)[§]	<0.001
Senior high school	–	–	63 (3.6)	69 (11.3)[§]	66 (2.2)	33 (5.7)[§]	64 (2.0)	56 (4.5)[§]	<0.001
College and above	–	–	40 (3.2)	7 (6.5)	39 (2.4)	3 (4.1)	32 (1.9)	10 (6.0)[§]	0.037
Income									
Low	–	–	317 (6.2)	1,885 (14.6)[§]	189 (5.6)	737 (9.4)[§]	63 (4.2)	316 (5.9)[†]	<0.001
Middle	–	–	149 (3.8)	101 (9.9)[§]	134 (4.0)	317 (7.4)[§]	74 (4.3)	227 (5.7)[†]	0.325
High	–	–	84 (3.0)	26 (8.4)[§]	332 (2.9)	254 (6.6)[§]	185 (2.2)	343 (6.1)[§]	0.535
No response	–	–	23 (6.8)	16 (7.3)	43 (3.0)	72 (10.1)[§]	384 (2.9)	1,104 (5.8)[§]	0.003
Marital status									
Single	–	–	7 (8.6)	19 (13.4)	8 (7.8)	17 (12.0)	7 (6.4)	22 (7.1)	0.063
Have a partner	–	–	408 (4.2)	1,437 (13.1)[§]	544 (3.3)	1,084 (8.0)[§]	598 (2.7)	1,659 (5.5)[§]	<0.001
Divorced	–	–	11 (10.1)	17 (15.6)	7 (3.5)	7 (5.8)	5 (3.9)	8 (9.3)	<0.001
Widowed	–	–	147 (6.6)	555 (17.2)[§]	139 (4.4)	272 (9.7)[§]	96 (3.8)	301 (8.3)[§]	<0.001

Note: − means data are unavailable;

[*] Because original data was inaccessible, the results was from the published book of "The dietary and nutritional status of Chinese population — elderly (1992 National Nutrition Survey)";

[†] Chi-squared test between urban areas and rural, P<0.05;

[§] Chi-squared test between urban areas and rural, P<0.01;

[¶] Chi-squared test among three surveys.

underweight malnutrition in the elderly population declined remarkably from 1992 to 2015. On one hand, the results showed that the nutritional status of older people had been greatly improved with socioeconomic development. On the other hand, we still need to pay attention to the elderly populations in rural areas who are still at high risk of underweight malnutrition.

Underweight malnutrition is associated with anemia, infection, and some NCDs that may lead to deterioration of health status and increasing risk of dependency and disability, which brings heavy social and family burdens (*1*,*12*). One study reported that early identification and treatment of underweight malnutrition could improve the outcomes and quality of life in the elderly (*2*). In the elderly population, underweight malnutrition increased with age because of digestive dysfunction and loss of appetite, which always influence the nutritional absorption and utilization. However, underweight malnutrition was not only being neglected by family members and doctors, but also ignored by the elderly themselves especially in rural areas. In our study, 7.6% of individuals 75 years old and above experienced underweight malnutrition in the 2015 surveillance. Many elderly people in rural areas continued to work for a living but additionally had to care for their grandchildren left behind by parents working away from home. Due to less developed economic conditions, lack of medical resources, lower levels of education, living alone, poor nutritional knowledge, and low dietary quality, many older people have

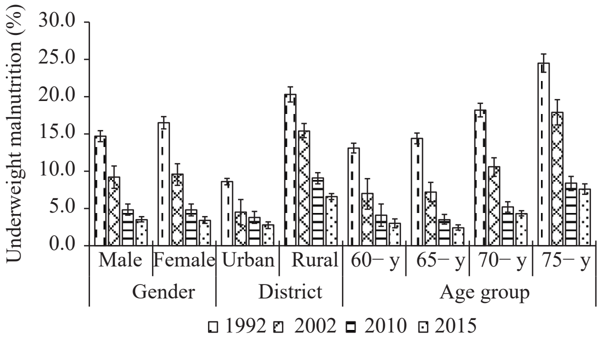

FIGURE 1. Trends of underweight malnutrition among older adults aged 60 years and above in China, 1992–2015.

serious nutritional and health problems and their nutritional status was not improved in rural areas (*13*). Therefore, precise nutrition improvement action plans and health management of underweight malnutrition should be carried out for these elderly people, especially as China experiences population aging. It is necessary to carry out malnutrition screening and nutritional status assessment in the community combined with basic public health services. For high-risk groups and patients of underweight malnutrition, we need to make treatment and management as early as possible. Meanwhile, education on healthy diet and balanced nutrition and nutrition interventions and treatment among the elderly need to strengthen further.

This study was subject to some limitations. First, this study used secondary analysis of published data of the 1992 survey, which might not be as applicable when compared to the underweight malnutrition distribution among the 4 surveys. Second, data in this study were collected by qualified staff, but some anthropometric measurement biases may occur that influence the results. Third, although we analyzed standardized values based on the same national census data for variations in age, gender, and districts, the results were subjected to some level of bias or mistakes, especially for the difficulty to avoid the variation of BMI caused by the difference of sample size in these surveys.

Nevertheless, the study showed the nutritional status of the elderly during the past 23 years and provides valuable information on health maintenance and promotion for older people in China.

doi: 10.46234/ccdcw2021.066

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Submitted: January 06, 2021; Accepted: March 09, 2021

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Preplanned Studies

Intake of Vitamin A, Thiamine, Riboflavin, Vitamin C, and Niacin Among Children Aged 6–11 Years Old — China, 2016–2017

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Summary

What is already known on this topic?

Insufficient intake of vitamins is one of the major nutritional problems in children aged 6–11 years old in China, and the problem is particularly severe for rural populations.

What is added by this report?

Among children aged 6–11 years old in 2016–2017, the average intakes of vitamin A, thiamine, riboflavin, vitamin C, and niacin were 336.37 μgRAE/d, 0.7 mg/d, 0.7 mg/d, 51.5 mg/d, and 11.4 mg/d, respectively. The proportions of vitamin intakes reaching recommended nutrient intakes of the 5 nutrients were 18.2%, 13.8%, 14.95%, 24.6%, and 51.3%, respectively.

What are the implications for public health practice?

Imbalance of nutritional conditions among different regions and populations in China should be seriously prioritized in nutritional improvement. Systematic measures including government policy, economy improvement, education, behavior intervention, and food resource safety should be applied.

Vitamins are essential substances for life and were recognized by the World Health Organization (WHO) as malnutrition and undernutrition are always accompanied with vitamin deficiency, which has become a significant child health challenge in many developing countries. Millions of children are more susceptible to disease and death due to vitamin deficiency (*1*). Previous domestic regional surveys in China had shown that significant proportions of school age populations suffered from nutrition deficiency, including insufficient vitamin intakes (*2–3*). The results drawn from China National Nutrition and Health Survey (2002) and China Nutrition and Health Surveillance (2010–2013) had revealed that vitamin deficiencies were still severe health problems in the Chinese population, especially in children and adolescents. China Nutrition and Health Surveillance of Children and Lactating Mothers in 2016–2017 was conducted by China CDC in 31 provincial-level administrative divisions (PLADs). Nationally and provincially representativeness of the study population was tested. Multistage stratified random sampling method was used in this survey. Four methods were designed to obtain the survey data, including interviews, physical examinations, laboratory tests, and dietary interviews (*4*). The study aimed to analyze the nutritional status of the Chinese population, including the conditions of vitamin intakes. The data in this paper were from the China Nutrition and Health Surveillance conducted between 2016 and 2017, which focused on the key vitamin intakes of children aged 6–11 years. This survey found that vitamin deficiencies were still severe in children aged 6–11 years old, and conditions were worse in rural populations. Systematic measures should be applied to solve the nutrition problems in children aged 6–11 years in China.

China Nutrition and Health Surveillance of Children and Lactating Mothers in 2016–2017 was a cross-sectional study conducted in 31 PLADs (*4*), and data of this paper was collected from the participants in this survey. Four methods were designed to obtain the survey data, including interviews to collect demographic information; physical examinations to observe the indicators of growth; laboratory tests to evaluate health conditions; and dietary interviews to obtain food intake information. The information on vitamins intake was drawn and assessed through 3 consecutive days of 24 hour dietary recalls and household weight records of edible oil, salt, and flavoring. Calculation of vitamins was conducted with reference to China Food Composition Tables (*5–6*). Study subjects were divided into different groups by sex and regions. The vitamin intakes of subjects were presented as means, standard errors, and 10, 25, 50, 75, 90 quantiles. Intake amounts of vitamin were assessed by the criteria of dietary reference intakes (DRIs), including estimated average criteria (EAR) and recommended nutrient intakes (RNI) (*7*). According to the assessing results, the subjects were allocated into <EAR, EAR–RNI, and ≥RNI groups. SAS (version 9.4, SAS Institute Inc., Cary, NC, USA) was used to conduct all the analyses. The protocol of this study was evaluated and approved by the ethical committee of China CDC (201614).

A total of 8,777 subjects were included for the calculation, with 4,364 males (2,034 in urban areas and 2,330 in rural areas) and 4,413 females (2,111 in urban areas and 2,302 in rural areas). The average ages of subjects were 9.2 ± 1.6 in total for both genders. The numbers of subjects for urban areas and rural areas were 4,145 and 4,632, respectively.

The intakes of vitamin A, thiamine, riboflavin, vitamin C, and niacin for children aged 6–11 years in China during 2016–2017 were shown in Table 1 and Table 2. The total average intakes of vitamin A, thiamine, riboflavin, vitamin C, and niacin were 336.4 μgRAE/d, 0.7 mg/d, 0.7 mg/d, 51.5 mg/d, and 11.4 mg/d, respectively. The total intakes of the five nutrients in urban areas were higher than that in rural areas, and similar trends were observed in different gender groups. For vitamin A, the average intake for males was 402.0 μgRAE/d, which was lower than the intakes of females (403.6 μgRAE/d) in urban areas, whereas vitamin A intake in rural areas was higher in males (283.1 μgRAE/d) than that in females (270.7 μgRAE/d). The intake characteristics of other four nutrients in both urban areas and rural areas were higher in males than in females.

Table 3 demonstrated the results of assessing the intakes of five nutrients based on EARs and RNIs values. The proportions of intakes that reached the RNIs of vitamin A, thiamine, riboflavin, vitamin C, and niacin were 18.2%, 13.8%, 14.95%, 24.6%, and 51.3%, respectively. The proportions in rural groups were all far below that in urban groups. In gender analyses, the proportions of the fives nutrients intakes reaching RNIs in males were higher than in females, except for the proportions of niacin intakes. The status of nutrient intakes in urban areas was better than that in rural areas, and same trends were observed in gender analyses between the two regions.

TABLE 1. Total intake of vitamins among children aged 6–11 years in China, 2016–2017.

Nutrients	Mean	SD	Percentiles				
			10	25	50	75	90
Total							
Vitamin A (μgRAE/d)	336.4	362.6	88.4	153.2	252.1	408.9	630.9
Thiamine (mg/d)	0.7	0.3	0.3	0.4	0.6	0.8	1.1
Riboflavin (mg/d)	0.7	0.3	0.3	0.4	0.6	0.8	1.1
Vitamin C (mg/d)	51.5	89.5	14.0	23.7	39.6	62.6	91.7
Niacin (mg/d)	11.4	5.5	5.6	7.6	10.4	13.9	18.1
Male							
Vitamin A (μgRAE/d)	338.5	356.4	88.1	153.7	257.7	415.4	622.9
Thiamine (mg/d)	0.7	0.3	0.4	0.4	0.6	0.8	1.1
Riboflavin (mg/d)	0.7	0.3	0.3	0.5	0.6	0.8	1.1
Vitamin C (mg/d)	52.4	107.4	13.8	23.6	39.1	62.4	91.5
Niacin (mg/d)	11.6	5.9	5.7	7.7	10.6	14.2	18.5
Female							
Vitamin A (μgRAE/d)	334.3	368.7	88.8	152.7	248.9	404.0	635.2
Thiamine (mg/d)	0.7	0.3	0.3	0.4	0.6	0.8	1.1
Riboflavin (mg/d)	0.7	0.3	0.3	0.4	0.6	0.8	1.0
Vitamin C (mg/d)	50.7	67.3	14.0	23.8	40.1	62.9	92.1
Niacin (mg/d)	11.1	5.2	5.5	7.4	10.2	13.6	17.7

Abbreviation: SD=standard deviation.

TABLE 2. Intake of vitamins among children aged 6–11 years in urban and rural areas in China, 2016–2017.

Nutrients	Urban							Rural						
	Mean	SD	Percentiles					Mean	SD	Percentiles				
			10	25	50	75	90			10	25	50	75	90
Total														
Vitamin A (μgRAE/d)	402.8	444.0	114.2	189.6	307.8	474.2	748.5	276.9	255.5	74.0	129.3	214.0	336.4	530.7
Thiamine (mg/d)	0.7	0.3	0.4	0.5	0.6	0.9	1.1	0.6	0.3	0.3	0.4	0.6	0.7	1.0
Riboflavin (mg/d)	0.8	0.3	0.4	0.5	0.7	0.9	1.2	0.6	0.3	0.3	0.4	0.5	0.7	0.9
Vitamin C (mg/d)	55.0	97.9	14.5	25.6	43.1	66.4	97.1	48.4	81.1	13.6	22.4	36.8	59.1	87.7
Niacin (mg/d)	12.1	5.6	6.3	8.3	11.3	14.8	18.9	10.7	5.4	5.2	7.1	9.6	12.9	17.2
Male														
Vitamin A (μgRAE/d)	402.0	427.3	117.4	190.6	318.1	472.7	725.2	283.1	268.2	74.1	129.2	215.8	346.0	547.4
Thiamine (mg/d)	0.7	0.3	0.4	0.5	0.7	0.9	1.1	0.6	0.3	0.3	0.4	0.6	0.8	1.0
Riboflavin (mg/d)	0.8	0.3	0.4	0.5	0.7	1.0	1.2	0.6	0.3	0.3	0.4	0.5	0.7	0.9
Vitamin C (mg/d)	55.2	111.2	14.3	25.4	42.6	65.4	93.9	49.9	103.9	13.6	22.5	36.4	59.1	89.4
Niacin (mg/d)	12.4	5.9	6.3	8.4	11.4	15.2	19.2	11.0	5.8	5.3	7.2	9.8	13.1	17.8
Female														
Vitamin A (μgRAE/d)	403.6	459.6	110.6	188.4	299.6	474.8	758.3	270.7	241.8	73.6	129.5	212.7	329.1	518.2
Thiamine (mg/d)	0.7	0.3	0.4	0.5	0.6	0.9	1.1	0.6	0.3	0.3	0.4	0.5	0.7	1.0
Riboflavin (mg/d)	0.7	0.3	0.4	0.5	0.7	0.9	1.2	0.6	0.3	0.3	0.4	0.5	0.7	0.9
Vitamin C (mg/d)	54.8	83.1	14.7	25.6	43.5	67.7	100.8	46.9	48.2	13.6	22.3	37.2	58.8	85.6
Niacin (mg/d)	11.9	5.3	6.2	8.2	11.0	14.4	18.5	10.3	5.0	5.1	6.9	9.5	12.6	16.6

Abbreviation: SD=standard deviation.

TABLE 3. Distributions of vitamin intake among children aged 6–11 years in China 2016–2017.

Nutrients	Total (%)			Urban (%)			Rural (%)		
	<EAR	EAR–RNI	≥RNI	<EAR	EAR–RNI	≥RNI	<EAR	EAR–RNI	≥RNI
Total									
Vitamin A	67.4	14.5	18.2	57.0	18.3	24.7	76.6	11.0	12.3
Thiamine	72.5	13.7	13.8	66.7	16.1	17.3	77.7	11.5	10.8
Riboflavin	71.0	14.0	15.0	60.0	17.6	22.4	80.9	10.9	8.3
Vitamin C	66.6	8.9	24.6	62.5	9.7	27.8	70.2	8.1	21.7
Niacin	31.4	17.4	51.3	25.0	16.3	58.8	37.1	18.3	44.6
Male									
Vitamin A	66.1	15.5	18.4	55.6	19.4	25.0	75.3	12.1	12.7
Thiamine	71.6	14.1	14.3	65.7	16.6	17.8	76.8	12.0	11.2
Riboflavin	69.4	14.3	16.3	57.3	17.7	25.1	79.9	11.5	8.6
Vitamin C	66.8	8.5	24.7	62.9	9.4	27.7	70.2	7.7	22.1
Niacin	34.2	16.6	49.2	27.8	15.2	56.9	39.7	17.8	42.5
Female									
Vitamin A	68.7	13.4	17.9	58.5	17.2	24.4	78.0	10.0	12.0
Thiamine	73.4	13.2	13.4	67.6	15.6	16.8	78.7	11.0	10.3
Riboflavin	72.7	13.7	13.6	62.7	17.5	19.9	81.8	10.3	7.9
Vitamin C	66.3	9.2	24.5	62.1	10.0	28.0	70.1	8.6	21.3
Niacin	28.6	18.1	53.3	22.2	17.3	60.5	34.4	18.9	46.8

Abbreviation: EAR=estimated average criteria; RNI=recommended nutrient intakes.

DISCUSSION

Although the nutritional conditions for Chinese population have improved rapidly in recently years, insufficient vitamin intakes are constantly considered as public health problems. For children and adolescents, vitamin deficiencies affect not only physical health, but also ability to work during adulthood. Different from protein-energy malnutrition (PEM), vitamin deficiencies are always latent. Assessment of dietary nutrient intake is one of the reasonable methods to understand nutritional conditions of individuals and the overall population.

In this study, the intake levels of vitamin A, thiamine, riboflavin, vitamin C, and niacin were assessed based on DRIs. Among total participants, the average thiamine intake for males was 0.7 mg/d and the average vitamin C intake for females was 50.7 mg/d, both of which were lower than the results in China Nutrition and Health Surveillance 2010–2013. Compared with 2010–2013, all intakes of five nutrients in urban areas increased for both males and females, but in rural areas, the intake of thiamine for males (0.6 mg/d) and the intake of vitamin C for females (46.9 mg/d) were lower than that in 2010–2013. The gap between existing levels and recommended levels of intake for the five nutrients for children aged 6–11 years in China is concerning, especially as the intake levels of these nutrients were far below corresponding levels in the United States, the United Kingdom, and Japan. The large gaps between urban areas and rural areas for the 5 nutrient intakes were quite obvious, and that could be concluded in the results (*8*–*10*). Compared with 2010–2013, although most proportions of reaching or succeding the RNIs for each nutrient were slightly increased, the proportions of under EARs remained problematic. The results of this study suggested that the nutritional status of urban children was not adequate and was worse for rural children.

Generally, vitamin deficiencies were still severe in children aged 6–11 years old, and conditions were worse in rural populations. The results from national nutrition survey in 2002, 2010–2013, and 2016–2017 showed that the Chinese nutrition and health have achieved significant improvements overall, but the imbalance among different areas cannot be ignored. It is imperative that nutritional improvement actions should be implemented accurately. Government policy, economic improvement, education, behavior intervention, and food resource safety are all potential factors that can affect the results of nutrition improvement. In “Healthy China 2030”, rational diet and relative measures have been emphasized. Nutrition Improvement Program for Rural Compulsory Education Students had been performed to address nutritional problems for school-age children in rural areas since November 2011. To solve these problems, systematic measures should be applied.

This study was subject to at least two limitations. First, the data for 3 consecutive days of 24 hour dietary recalls were collected from children, teachers, care givers, schools, or families, so the accuracy of the results might be affected by recall bias. Second, some of the food compositions were needed to be updated due to the improvements and adjustments of crop varieties. These compositions might affect estimates for nutritional intake due to a lack of consistency.

Acknowledgment: Project teams from China CDC, provincial-level CDCs, and county/district-level CDCs, local school staff, and all participants.

Conflicts of interest: No conflicts of interest.

Funding: National Health Commission of the People’s Republic of China Medical Reform Major Program: China Nutrition and Health Surveillance of Children and Lactating Mothers (2016–2017).

doi: 10.46234/ccdcw2021.067

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Submitted: March 02, 2021; Accepted: March 11, 2021

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The inauguration of *China CDC Weekly* is in part supported by Project for Enhancing International Impact of China STM Journals Category D (PIIJ2-D-04-(2018)) of China Association for Science and Technology (CAST).

CCDC weekly

Vol. 3 No. 11 Mar. 12, 2021

Responsible Authority

National Health Commission of the People's Republic of China

Sponsor

Chinese Center for Disease Control and Prevention

Editing and Publishing

China CDC Weekly Editorial Office

No.155 Changbai Road, Changping District, Beijing, China

Tel: 86-10-63150501, 63150701

Email: weekly@chinacdc.cn

CSSN

ISSN 2096-7071

CN 10-1629/R1