Original Article

Socioeconomic correlates of adherence to mineral intake recommendations among pregnant women in north China: Findings from a cross-sectional study

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Background and Objectives: The purpose of the present study is to examine the socioeconomic correlates of adherence to minimum mineral intake recommended by the Chinese Dietary Guidelines during each trimester of pregnancy among Chinese women. **Methods and Study Design:** A total of 567 pregnant women with foetal age of 6 – 12 weeks were recruited from nine community health centres and three hospitals. Cross-sectional survey data were collected using structured interviews and questionnaires. Mineral intake was calculated from food consumption reported on 24-hour dietary reviews using the Chinese Food Composition Metrics. Logistic regression models were estimated to assess the relationship between sociodemographic factors and adherence to mineral intake recommendations for each trimester. **Results:** Significant predictors of adherence to mineral intake recommendations include: (1) age (zinc: OR=1.09, $p<0.05$; copper: OR=1.11, $p<0.05$), having bachelor's degree (copper: OR=2.23, $p<0.05$; phosphorus: OR=2.23, $p<0.01$), and household income ≥5,000RMB (potassium: OR=2.51, $p<0.001$; phosphorus: OR=1.91, $p<0.05$) during the first trimester, (2) being employed (zinc: OR=0.54, $p<0.001$; selenium: OR=0.53, $p<0.05$) and household income ≥5,000 RMB (zinc: OR=1.86, $p<0.05$) during the second trimester, and (3) husband/partner with associate degree or vocational school education (selenium: OR=3.26, $p<0.01$) and household income of 3,000–4,999 RMB (potassium: OR=1.71, $p<0.05$; zinc: OR=1.48, $p<0.05$) during the third trimester. **Conclusions:** To our knowledge, this is the first study that examines the relationship between socioeconomic factors and mineral intake among Chinese pregnant women at three trimesters. Findings highlight the importance of considering individuals' socioeconomic status to develop personalized interventions to prevent undernutrition among this population.

Key Words: mineral intake, pregnancy, China, socioeconomic status, women

INTRODUCTION

Identification and remedy of mineral deficiencies among pregnant women has been a common public health concern in both developing and developed countries. With changes in metabolism during pregnancy, mineral requirements both increase and fluctuate with fetal development.[1] Research has found that inadequate intake of potassium increases the risk of maternal cardiac arrest and death.[2] Inadequate intake of iron and magnesium is a risk factor of gestational anemia, complications during pregnancy and childbirth, and abnormal fetal development.[3] Inadequate calcium intake during pregnancy increases the risks of pre-eclampsia, edema, insomnia, cramps, and irritability for mothers[4] with effects on the child including slow fetal growth, low bone mineral density, muscle weakness, and rickets.[5] Phosphorus deficiency among pregnant women can cause fatigue, joint pain, myocarditis, loss of appetite, and may lead to foetal rickets.[6] Inadequate intake of minerals including magnesium, selenium, and zinc during pregnancy have been associated with congenital heart disease in the foetus, which affects foetal early growth and development[7-10] and increases the risks of osteoporosis and cancer in adulthood.[11] Zinc deficiency is one of the most common micronutrient deficiencies in the world, affecting about 2 billion people, especially in developing countries, where 3.1 million children die each year from zinc deficiency.[12] Consequences of zinc deficiency during pregnancy include increased incidence of prolonged labour, haemorrhage, and uterine dystocia in animal models, but results from the few existing human studies are conflicting.[13]

In developed countries, it has been well-established that compliance with dietary guidelines for pregnant women is related to socioeconomic factors including, but

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not limited to, education and income.[14-16] Socioeconomic status (SES) is positively associated with healthy dietary patterns in both developed and developing countries,[17] and in particular is linked to greater consumption of fruits and vegetables; two major sources of minerals.[15,16] Research on the socioeconomic risk factors of mineral intake deficiency remains scarce in developing countries and is typically based on a single observation during pregnancy.[18] As mineral requirements and impact of mineral deficiency differ by gestational age,[19] research examining the socioeconomic risk factors of mineral intake deficiency at different stages of pregnancy is needed. To date, no such studies have been conducted in China. Therefore, the purpose of the present study is to examine the socioeconomic correlates of adherence to minimum mineral intake recommended by the Chinese Dietary Guidelines during each trimester of pregnancy among Chinese women.

METHODS

Data source

Data were collected by the Maternal and Child Nutrition Chapter of the Chinese Nutrition Society. The study was conducted in accordance with the relevant provisions for biological human trials and was approved by the Chinese Nutrition Society Ethics Committee (Ethical Approval Number: CNS2014305-9Z). Inclusion criteria selected pregnant women who were Chinese citizens between 20 and 35 years old with a gestational age of 12 weeks or less. Participants reporting having kidney stone, renal insufficiency, abnormal thyroid function, gastrointestinal diseases, lung disease, HIV, active tuberculosis, diabetes, dementia, anaemia, mental disorders, or who reported experiencing threatened abortion were excluded. A total of 567 pregnant women with foetal age of 6–12 weeks were recruited from nine community health centres and three hospitals. A total of 567 participants were recruited between March 2013 and May 2014 with written informed consent. Of the original 567 participants interviewed during the first trimester, 5.9% (n=34) were lost to follow-up.

A trained professional field interviewer collected data on SES and pre-pregnancy height and weight through structured questionnaires and in-depth interviews in community health centres. Dietary structure and nutrient intake of pregnant women were investigated using 24-hour dietary reviews. Initial data collection occurred during the first trimester of pregnancy (0–13 weeks) and follow-up measurements were taken during the second (14–27 weeks) and third trimesters (28–41 weeks).

Measures

Mineral intake was calculated from food consumption measured as the average of 24-hour dietary reviews taken three days prior to interview using the Chinese Food Composition Metrics.[20] Participants were trained face-to-face by the research team to document their food intake with the dietary intake forms provided. Researchers collected the dietary intake forms, entered the data into our data management system, calculated the nutrient intake for the past three days based on all food items participants reported, and obtained a 24-hour average intake for each nutrient. We used this approach because it is easy to implement given that most of our participants do not have a college degree. Compared to food frequency questionnaires, this method is effective in capturing nutrient intake from all food sources within the observation period.[21] Minerals examined in our study included potassium, calcium, magnesium, iron, zinc, copper, phosphorous, and selenium. Adequate mineral intake was operationalized as a dichotomous indicator of whether the participant met the recommended minimum daily intake for each mineral according to the Chinese Dietary Reference Intakes from the National Health Commission of the People's Republic of China.[22-24] Table 1 shows the recommended minimum daily intake for each type of mineral by stage of pregnancy.

Characteristics of both the respondent and the respondents' husband/partner were included as predictors of mineral intake. Participant characteristics included ethnicity (0 = Han, 1 = ethnic minority (Hui, Manchu, and other non-Han ethnicities)), gestational age, employment status (0 = unemployed, 1 = employed), and education (high school graduate or below, associate's degree or vocational school graduate, bachelor's degree or higher). Husband/partner characteristics included age when participant became pregnant, employment status (0 = unemployed, 1 = employed), and education (high school graduate or below, associate's degree or vocational school graduate, bachelor's degree or higher). Household income (per month) was coded into three categories (<3,000 RMB, 3,000-4,999 RMB, ≥5,000 RMB). Pre-pregnancy body mass index (BMI) was included as a control variable as overweight or obese participants were advised by dietitians to change their dietary intake. For example, dietitians often recommend (1) lowering general food intake, which may reduce intakes of minerals that can be found in wide varieties of foods (e.g., copper), and (2) increas-

Table 1. The characteristics of participating restaurants (n=90)

	1st trimester	2nd trimester	3rd trimester
Potassium (mg/dL)	2000	2000	2000
Calcium (mg/dL)	800	1000	1000
Magnesium (mg/dL)	370	370	370
Iron (mg/dL)	20	24	29
Zinc (mg/dL)	9.5	9.5	9.5
Copper (mg/dL)	0.9	0.9	0.9
Phosphorus (mg/dL)	720	720	720
Selenium (μg/dL)	65	65	65

Source: Chinese Nutrition Society. Chinese Dietary Reference Intakes. Beijing, China: China Light Industry Press; 2010.

ing intake of specific types of food, such as shellfish and vegetables, as they recognize overweight and obesity may impair iron absorption.[25]

Statistical analysis

Descriptive statistics were used to summarize participant characteristics and adequacy of mineral intake at each stage of pregnancy. Logistic regression was used to examine the demographic and socioeconomic predictors of meeting recommended intake of each type of mineral for each separate trimester. All statistical analyses were conducted using Stata 15 SE.[26]

RESULTS

Descriptive statistics

Table 2 presents sample descriptive statistics separately for the first (n=567), second (n=547), and third trimester (n=533). During the first trimester, 2% of participants were identified as an ethnic minority. The mean participant age was 27.7 (SD=5.20). About 78% of participants were employed. Most of participants had either an associate degree or graduated from vocational school (37%) or received a bachelor's degree or higher (37%). The mean age of husband/partner was 29.0 (SD=7.35) and most husbands/partners had either an associate degree or graduated from vocational school (33%) or received a bachelor's degree or higher (39%). Most of the participants reported a household income of either <3,000 RMB (41%) or between 3,000–4,999 RMB (41%). The mean of participants' BMI before pregnancy was 21.2 (SD=2.92), with approximately 10% of participants overweight (BMI between 25.0 and 29.9) and 1% obese (BMI ≥30). These characteristics remained consistent over the three study periods. At all three observations, most participants did not meet the recommended intake of all minerals excluding copper and phosphorus. For all minerals except for calcium and iron, the percentages of women meeting the recommended intake during the second and third trimesters were greater than those meeting the requirement during the first trimester.

Likelihood of meeting mineral intake recommendations

Tables 3, 4, and 5 present odds ratios estimating the association between participant characteristics and likelihood of meeting recommended minimum mineral intake requirements for each trimester. During the first trimester, age was significantly associated with higher odds of meeting the recommended minimum intake of zinc (OR=1.09; $p<0.05$) and copper (OR=1.11; $p<0.05$). Reporting a bachelor's degree or higher was associated with greater odds of meeting the recommended minimum intake of copper (OR=2.23; $p<0.05$) and phosphorus (OR=2.36; $p<0.01$) during the first trimester. Also, participants with a household income of at least 5,000 RMB were more likely to meet recommended minimum intake of potassium (OR=2.51; $p<0.01$) and phosphorus (OR=1.91; $p<0.05$) during the first trimester than counterparts with household income below 3,000 RMB. During the second trimester, being employed was significantly associated with lower odds of meeting recommended minimum intake of potassium (OR=0.50; $p<0.01$), zinc (OR=0.54; $p<0.01$), and selenium (OR=0.53; $p<0.05$). Participants with a household income of at least 5,000 RMB were more likely to meet recommended minimum

Table 2. Socioeconomic characteristics and daily mineral intake of pregnant participants

	1st trimester (N=567)	2nd trimester (N=547)	3rd trimester (N=533)
	Mean (SD)/ %	Mean (SD)/ %	Mean (SD)/ %
Ethnic minority	2%	2%	2%
Age at early pregnancy	27.7 (5.20)	27.7 (5.21)	27.7 (5.22)
Employed	78%	79%	78%
Education			
High school graduate or below	26%	26%	26%
Associate degree or vocational school graduate	37%	38%	38%
Bachelor's degree or above	37%	36%	36%
BMI before pregnancy	21.2 (2.92)	21.1 (2.87)	21.1 (2.90)
Age of husband/partner	29.0 (7.35)	29.1 (7.45)	29.1 (7.50)
Husband/partner employed	95%	95%	95%
Education of husband/partner			
High school graduate or below	28%	27%	27%
Associate degree or vocational school graduate	33%	33%	33%
Bachelor's degree or above	39%	39%	40%
Household income (RMB)			
Below 3,000	41%	41%	41%
3,000–4,999	41%	41%	41%
5,000 or above	18%	18%	18%
Mineral intake, mean (SD) / % met recommendation			
Potassium (g/dL)	1.57 (0.53) / 20%	1.85 (0.53) / 35%	1.84 (0.56) / 34%
Calcium (g/dL)	0.46 (0.24) / 8%	0.56 (0.26) / 3%	0.57 (0.25) / 3%
Magnesium (g/dL)	0.25 (0.10) / 10%	0.30 (0.09) / 17%	0.29 (0.09) / 16%
Iron (mg/dL)	18.0 (9.05) / 28%	20.9 (8.28) / 22%	20.8 (8.70) / 11%
Zinc (mg/dL)	7.96 (2.89) / 26%	9.56 (2.71) / 44%	9.73 (2.74) / 47%
Copper (mg/dL)	1.44 (0.69) / 84%	1.79 (0.91) / 95%	1.72 (0.67) / 95%
Phosphorus (g/dL)	0.90 (0.69) / 69%	1.07 (0.29) / 91%	1.09 (0.29) / 91%
Selenium (μg/dL)	42.7 (19.1) / 9%	50.9 (15.3) / 13%	51.1 (15.9) / 14%

Table 3. Logistic regression estimates of the association between socioeconomic determinants and meeting recommended mineral intake during the first trimester (N=567)

	OR (95% CI)							
	Potassium	Calcium	Magnesium	Iron	Zinc	Copper	Phosphorus	Selenium
Ethnic minority	0.62 (0.13, 2.95)	2.74 (0.53, 14.2)	0.66 (0.08, 5.42)	1.22 (0.35, 4.25)	1.26 (0.35, 4.45)	0.61 (0.12, 3.07)	1.07 (0.28, 4.14)	N/A†
Age	1.06 (0.98,1.15)	1.14 (0.99, 1.30)	1.05 (0.94, 1.16)	0.98 (0.93, 1.04)	1.09* (1.01, 1.19)	1.11* (1.00, 1.23)	1.02 (0.97, 1.08)	1.11 (0.99, 1.25)
Employed	0.72 (0.43, 1.23)	0.93 (0.42, 2.06)	0.85 (0.41, 1.74)	0.72 (0.45, 1.16)	0.78 (0.48, 1.29)	0.80 (0.43, 1.50)	0.92 (0.57, 1.49)	0.73 (0.36, 1.46)
Education (ref: high school or below)								
Associate degree or vocational school	0.90 (0.46, 1.74)	1.09 (0.43, 2.77)	0.77 (0.31, 1.87)	1.00 (0.56, 1.78)	1.07 (0.58, 1.97)	1.90 (0.97, 3.71)	1.66 (0.96, 2.87)	0.77 (0.33, 1.82)
Bachelor's degree or above	1.33 (0.64, 2.76)	1.24 (0.43, 3.55)	1.29 (0.49, 3.36)	1.31 (0.69, 2.50)	1.34 (0.68, 2.64)	2.23* (1.00, 4.97)	2.36** (1.25, 4.46)	1.01 (0.38, 2.69)
BMI before pregnancy	0.97 (0.90, 1.04)	0.99 (0.89, 1.10)	0.94 (0.85, 1.04)	0.95 (0.89, 1.02)	0.96 (0.90, 1.03)	0.92* (0.85, 0.99)	1.01 (0.95, 1.08)	0.98 (0.89, 1.08)
Age of husband/partner	0.96 (0.89, 1.03)	0.88 (0.78, 1.01)	0.96 (0.87, 1.06)	1.02 (0.98, 1.07)	0.93 (0.86, 1.01)	1.01 (0.94, 1.10)	0.99 (0.96, 1.03)	0.92 (0.82, 1.03)
Husband/partner employed	0.96 (0.34, 2.77)	2.40 (0.30, 19.4)	2.73 (0.34, 21.68)	1.48 (0.56, 3.95)	1.06 (0.40,2.85)	0.30 (0.07, 1.41)	0.76 (0.30, 1.90)	0.84 (0.23, 3.12)
Education of husband/partner (ref: high school or below)								
Associate degree or vocational school	1.27 (0.67, 2.42)	0.88 (0.36, 2.11)	1.06 (0.45, 2.50)	1.21 (0.69, 2.13)	1.60 (0.88,2.91)	1.45 (0.72, 2.92)	1.18 (0.68, 2.05)	1.14 (0.50, 2.61)
Bachelor's degree or above	0.76 (0.37, 1.55)	0.52 (0.19, 1.44)	0.79 (0.30, 2.04)	0.86 (0.46, 1.60)	1.05 (0.54,2.03)	0.79 (0.37, 1.69)	0.72 (0.39, 1.31)	0.51 (0.19, 1.39)
Household income (ref: <3,000 RMB)								
3,000 – 4,999 RMB	1.55 (0.95, 2.54)	0.57 (0.27, 1.20)	1.08 (0.56, 2.10)	0.89 (0.59, 1.36)	1.01 (0.65,1.57)	1.50 (0.88, 2.53)	1.36 (0.91, 2.04)	1.39 (0.72, 2.71)
≥ 5,000 RMB	2.51** (1.38, 4.55)	1.16 (0.50, 2.71)	1.84 (0.85, 3.97)	1.19 (0.70, 2.03)	1.67 (0.97,2.87)	1.30 (0.65, 2.56)	1.91* (1.09, 3.35)	2.06 (0.91, 4.66)

OR: odds ratio; CI: confidence interval.
†Not included in the model because none of the ethnic minority participants met the selenium intake recommendation.
*$p<0.05$; ** $p<0.01$; ***$p<0.001$.

Table 4. Logistic regression estimates of the association between socioeconomic determinants and meeting recommended mineral intake during the second trimester (N=547)

	OR (95% CI)							
	Potassium	Calcium	Magnesium	Iron	Zinc	Copper	Phosphorus	Selenium
Ethnic minority	0.86 (0.25, 2.99)	2.54 (0.28, 23.3)	0.41 (0.05, 3.24)	0.34 (0.04, 2.76)	0.77 (0.23,2.57)	0.50 (0.06, 4.28)	0.84 (0.10, 7.00)	0.65 (0.08, 5.39)
Age	1.03 (0.97, 1.10)	1.15 (0.90, 1.46)	1.03 (0.95, 1.11)	1.05 (0.98, 1.12)	1.05 (0.99,1.11)	0.98 (0.88, 1.10)	1.01 (0.92, 1.10)	1.02 (0.95, 1.08)
Employed	0.50** (0.32, 0.80)	0.49 (0.16, 1.49)	0.81 (0.46, 1.45)	0.73 (0.44, 1.23)	0.54** (0.34,0.85)	1.09 (0.40, 2.98)	1.20 (0.56, 2.54)	0.53* (0.29, 0.97)
Education (ref: high school or below)								
Associate degree or vocational school	0.75 (0.43, 1.31)	0.67 (0.14, 3.12)	1.03 (0.51, 2.08)	1.40 (0.75, 2.62)	1.00 (0.59,1.72)	0.76 (0.24, 2.43)	1.11 (0.47,2.61)	2.17 (0.98, 4.80)
Bachelor's degree or above	0.94 (0.50, 1.75)	1.02 (0.19, 5.39)	1.18 (0.53, 2.62)	1.21 (0.58, 2.53)	1.34 (0.73,2.48)	1.25 (0.31, 4.99)	2.26 (0.79, 6.49)	2.05 (0.81, 5.17)
BMI before pregnancy	0.99 (0.93, 1.05)	0.93 (0.78, 1.11)	1.00 (0.92, 1.08)	1.03 (0.96, 1.11)	1.02 (0.96,1.08)	0.96 (0.84, 1.09)	0.96 (0.86, 1.06)	0.96 (0.87, 1.05)
Age of husband/partner	0.97 (0.93, 1.02)	0.86 (0.68, 1.07)	0.98 (0.92, 1.04)	0.99 (0.94, 1.04)	0.98 (0.94,1.02)	1.00 (0.91, 1.11)	1.00 (0.94, 1.05)	1.00 (0.95, 1.05)
Husband/partner employed	1.48 (0.60, 3.69)	1.00 (0.11, 9.06)	1.55 (0.43, 5.56)	0.92 (0.35, 2.41)	1.61 (0.66,3.89)	0.75 (0.09, 6.27)	0.74 (0.16, 3.47)	1.37 (0.38, 5.00)
Education of husband/partner (ref: high school or below)								
Associate degree or vocational school	1.42 (0.81, 2.48)	0.99 (0.22, 4.52)	1.25 (0.62, 2.50)	0.72 (0.39, 1.33)	1.51 (0.89, 2.58)	1.16 (0.36, 3.71)	0.84 (0.34, 2.04)	0.79 (0.38, 1.65)
Bachelor's degree or above	1.24 (0.67, 2.30)	1.20 (0.23, 6.29)	0.99 (0.45, 2.16)	0.70 (0.35, 1.39)	0.91 (0.50, 1.65)	0.98 (0.27, 3.50)	0.66 (0.24, 1.79)	0.48 (0.20, 1.14)
Household income (ref: <3,000 RMB)								
3,000–4,999 RMB	1.37 (0.92, 2.06)	1.58 (0.51, 4.86)	1.04 (0.62, 1.74)	0.76 (0.48, 1.21)	1.20 (0.81, 1.78)	0.91 (0.38, 2.15)	0.95 (0.49, 1.82)	1.20 (0.68, 2.13)
≥5,000 RMB	1.44 (0.85, 2.45)	1.92 (0.48, 7.66)	1.33 (0.70, 2.53)	0.73 (0.39, 1.35)	1.86* (1.12, 3.09)	1.34 (0.39, 4.64)	1.62 (0.60, 4.35)	0.97 (0.44, 2.13)

OR: odds ratio; CI: confidence interval.
*$p<0.05$; ** $p<0.01$; ***$p<0.001$.

Table 5. Logistic regression estimates of the association between socioeconomic determinants and meeting recommended mineral intake during the third trimester (N=533)

	OR (95% CI)							
	Potassium	Calcium	Magnesium	Iron	Zinc	Copper	Phosphorus	Selenium
Ethnic minority	1.52 (0.46, 5.03)	2.79 (0.31, 25.0)	1.28 (0.26, 6.23)	2.02 (0.41, 10.02)	1.11 (0.35, 3.58)	0.72 (0.08, 6.18)	0.34 (0.07, 1.75)	N/A†
Age	1.02 (0.97, 1.08)	1.00 (0.92, 1.09)	1.09 (0.98, 1.22)	1.05 (0.94, 1.18)	1.02 (0.95, 1.08)	0.96 (0.82, 1.13)	1.04 (0.91, 1.19)	1.06 (0.95, 1.18)
Employed	1.02 (0.63, 1.64)	1.01 (0.29, 3.53)	0.72 (0.40, 1.30)	0.79 (0.40, 1.57)	0.82 (0.52, 1.29)	0.96 (0.32, 2.84)	1.04 (0.46, 2.35)	0.75 (0.40, 1.40)
Education (ref: high school or below)								
Associate degree or vocational school	1.03 (0.59, 1.79)	1.00 (0.24, 4.13)	0.81 (0.40, 1.66)	0.96 (0.42, 2.21)	0.85 (0.50, 1.46)	0.28 (0.07, 1.05)	0.57 (0.22, 1.46)	0.76 (0.34, 1.67)
Bachelor's degree or above	0.77 (0.40, 1.47)	0.57 (0.11, 3.02)	0.61 (0.26, 1.43)	0.64 (0.24, 1.67)	1.01 (0.55, 1.85)	0.43 (0.09, 1.97)	0.74 (0.24, 2.26)	0.77 (0.32, 1.87)
BMI before pregnancy	1.04 (0.98, 1.11)	0.91 (0.76, 1.09)	1.01 (0.93, 1.09)	1.11* (1.01, 1.21)	1.03 (0.97, 1.10)	0.93 (0.81, 1.06)	0.98 (0.88, 1.10)	0.99 (0.90, 1.08)
Age of husband/partner	0.99 (0.95, 1.03)	1.01 (0.96, 1.07)	0.90 (0.81, 1.00)	0.96 (0.87, 1.07)	0.97 (0.92, 1.02)	1.03 (0.89, 1.20)	1.01 (0.91, 1.11)	0.95 (0.86, 1.05)
Husband/partner employed	0.79 (0.32, 1.94)	0.76 (0.08, 6.87)	1.46 (0.40, 5.28)	0.99 (0.27, 3.65)	1.33 (0.55, 3.20)	1.05 (0.12, 9.18)	0.82 (0.17, 3.95)	0.58 (0.19, 1.72)
Education of husband/partner (ref: high school or below)								
Associate degree or vocational school	1.26 (0.72, 2.19)	1.00 (0.23, 4.31)	1.89 (0.92, 3.88)	2.15 (0.90, 5.13)	1.14 (0.67, 1.95)	2.78 (0.82, 9.44)	2.24 (0.87, 5.78)	3.26** (1.42, 7.50)
Bachelor's degree or above		1.21 (0.25, 5.78)	1.10 (0.48, 2.55)	2.06 (0.78, 5.42)	0.85 (0.48, 1.53)	1.37 (0.41, 4.51)	1.21 (0.46, 3.19)	1.88 (0.73, 4.82)
Household income (ref: <3,000 RMB)								
3,000–4,999 RMB	1.71* (1.13, 2.58)	1.18 (0.41, 3.40)	1.38 (0.80, 2.37)	0.91 (0.50, 1.64)	1.48* (1.00, 2.18)	0.93 (0.36, 2.41)	1.11 (0.57, 2.19)	1.16 (0.67, 2.03)
≥5,000 RMB	1.14 (0.66, 1.99)	0.85 (0.19, 3.79)	1.71 (0.85, 3.43)	0.58 (0.24, 1.40)	1.61 (0.97, 2.68)	0.54 (0.19, 1.54)	1.79 (0.66, 4.82)	0.85 (0.38, 1.89)

OR: odds ratio; CI: confidence interval.
†Not included in the model because none of the ethnic minority participants met the selenium intake recommendation.
*p<0.05; ** p<0.01; ***p<0.001.

intake of zinc (OR=1.86; $p<0.05$) than those with household income below 3,000 RMB. During the third trimester, having an associate degree or graduating from vocational school was positively associated with meeting the recommended minimum intake of selenium (OR=3.26; $p<0.01$). Participants with a household income of 3,000–4,999 RMB were more likely to meet the recommended minimum intake of potassium (OR=1.71; $p<0.05$) and zinc (OR=1.48; $p<0.05$) during the third trimester than counterparts with household income below 3,000 RMB.

DISCUSSION

The present study examined associations between SES and the likelihood of adhering to minimum mineral intake recommendations based on Chinese Dietary Guidelines during each trimester of pregnancy in a sample of Chinese women. Results show that at all stages of pregnancy, less than half of the participants met the recommended intake of all minerals excluding copper and phosphorus, confirming that mineral intake deficiency is common among pregnant women in China. Education and income were associated with sufficient intake of select minerals at different stages of pregnancy, but few participant characteristics were consistently associated with meeting recommended minimum mineral intakes. Our findings suggest that interventions aimed at increasing mineral intake among pregnant Chinese women are necessary regardless of the stage of pregnancy and the mother's demographic and socioeconomic characteristics. Limitations of this study and future directions are discussed.

We found partial support for an association between socioeconomic characteristics and likelihood of meeting minimum mineral intake requirements. Participants' education was positively associated with adherence to meeting recommended intake of copper and phosphorus during the first trimester. Also, participants whose husbands/partners had an associate degree or vocational school were more likely to adhere to minimum intake of selenium during the third trimester than those whose husbands/partners had an education of high school or below. Education may influence nutrient intake directly as those with greater education have a greater capacity to access and understand these recommendations, but more broadly education may be a proxy for advantageous social position, allowing greater access to and utilization of health enabling factors including monetary resources, occupational prestige, autonomy, and social connections.[27] Income was also positively associated with adherence to recommended intake of potassium during the first and third trimesters and zinc during the second and third trimesters. One explanation is that low-income families are more likely than high-income families to prioritize purchasing rice and flour to address hunger first, but less likely to purchase fruits and vegetables (rich in potassium), meat and seafood (rich in zinc), and fine grains and nuts (rich in zinc) due to price. We also found that the relationship between income and adherence to recommended mineral intake were not consistently linear, given that the ORs of at least 5,000 RMB were smaller than 3,000–4,999 RMB for several outcomes. One possible explanation is that the sample size for 5,000 RMB group was much smaller than the other two income groups, contributing to the random error of results. In addition, the large range between 3,000 and 4,999 RMB may greatly determine whether the study population can afford foods that contain necessary minerals. Taken together, the socioeconomic resources measured in our study appear to have some association with mineral intake among pregnant Chinese women. These measures of socioeconomic status may have a direct impact on access to nutrient-dense foods and information supporting regular consumption of these foods, but these measures of SES should also be recognized as fundamental causes of health inequality, representing various health-enabling resources that pattern both nutrient intake, prenatal health, and consequent disease outcomes across the life course. As such, dietitians should consider clients' education and income not only as direct influences on consumption of healthy food, but also as mechanisms that pattern exposure to multiple risk factors related to nutrition and pregnancy outcomes of the mother and child.

Though there were few associations between participant characteristics and meeting recommended mineral intake that were consistent across stage of pregnancy, several factors were associated with adherence to mineral intake among pregnant Chinese women at different pregnancy stages. Although participants in this study were predominantly Han, none of the few ethnic minority participants met the recommended selenium intake during the first and third trimesters. Future research should investigate the dietary patterns and preferences of pregnant ethnic minority women to provide more culturally appropriate interventions. We found that age was positively associated with the likelihood of adherence to recommended minimum intake of zinc and copper during the first trimester. Older pregnant women may have better nutritional knowledge than their younger counterparts,[28] which may result in non-adherence to recommended zinc and copper intake during the first trimester. Being employed was negatively associated with adherence to recommended intake of potassium, zinc, and selenium during the second trimester. It has been well-established that strenuous work is adversely related to micronutrient intake among pregnant women.[29] Thus, it is important to investigate the impact of occupational stress on diet in this population so that nutrition interventions can be tailored to prevent compromised diets related to reduced time for shopping and cooking and promote access to healthy diet at the workplace.

Several limitations should be acknowledged. First, data for mineral intake were obtained using 24-hour dietary reviews. We could not verify whether participants correctly reported their dietary intake, which may introduce measurement error due to recall bias. We could not evaluate the large day-to-day variations of mineral intakes, which limits our ability to assess participants' habitual intake. Future research may use observational techniques or more frequent dietary reviews to more accurately assess mineral intake. Second, results of this study should not be generalized to the general population in China as participants were recruited only from nine community health centres and three hospitals through convenience sampling. Third, mineral intake data were calculated only using dietary review, which did not include minerals from dietary supplements. Thus, the actual intake of minerals might be different from what we report. Finally, measures assessing the SES of participants were limited. Research that comprehensively examines SES including measures of occupation, financial resources from various sources, hierarchical position, and social status is needed to clearly identify the role of SES in mineral intake among pregnant Chinese mothers.

Maternal nutrition intake during pregnancy plays a critical role in metabolism in children's later life.[28] Since the Family Planning Policy became effective in China in the 1980s, malnutrition among pregnant women has been a key issue. With the developing economy and increase in health awareness, nutritional intake during pregnancy has been greatly improved. Nevertheless, unbalanced dietary intake and mineral inadequacy persists due to lack of access to healthy foods and nutritional guidance from dietitians.[30] To address these issues, the Office of the State Council initiated the National Nutrition Plan 2017–2030, describing strategies of nutritional assessment and guidance in pre-pregnancy and during the pregnancy health examination to ensure adequate mineral intake, and development of personalized interventions to prevent undernutrition and overnutrition in this population. The effectiveness of these strategies remains to be tested. In addition, research that examines nutritional knowledge among pregnant women in China, which could potentially mediate or moderate the relationship between socioeconomic factors and adherence to mineral intake, remains scarce and should be investigated to enhance the effectiveness of nutrition interventions in this population.

AUTHOR DISCLOSURES

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