

Nutrient Intakes of Pregnant Women and their Associated Factors in Eight Cities of China: A Cross-sectional Study

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Abstract

Background: During the last 3 decades, China has dramatic changes of the dietary pattern among its citizens, particularly in urban cities. This study aimed to determine the nutrient intake status and factors associated with nutrient intakes of urban Chinese pregnant women now-a-day.

Methods: The multistage stratified random sampling method was applied in the cross-sectional study. 479 women in three trimesters of pregnancy from eight cities of China were recruited. Nutrient intakes were evaluated with one 24 h dietary recall, and compared with the Chinese Dietary Reference Intakes (DRIs) 2013 for available nutrients.

Results: Most pregnant women had imbalanced macronutrient distribution with excessive energy derived from fat. Intakes of Vitamin A, B₆, calcium, magnesium, and selenium were below Chinese Recommended Nutrient Intake (RNI) and Estimated Average Requirements (EARs) in all trimesters. Most pregnant women took more folic acid in the first trimester with a significant decrease in the second and third trimester ($P < 0.05$). Shortfall in iron intake was found in the third trimester whereas some women may be at the risk of excessive iron intake. Intakes of thiamin met RNI in the first trimester but were below EAR in all trimesters. Trimester phasing was positively associated with most nutrients ($P < 0.05$). Prepregnancy body mass index was inversely associated with energy, fat, Vitamin C, and calcium intake ($P < 0.05$). Educational level and household income were positively associated with folic acid intake ($P < 0.05$).

Conclusions: Current prenatal dietary choices of urban pregnant women in China are imbalanced in the nutrient intake when compared with national DRIs 2013, particularly in intakes of energy derived from fat and micronutrients. Appropriate dietary advice to pregnant women should promote a balanced diet with emphasis on avoidance of foods of high fat content and incorporation of foods that are good sources of the key micronutrients that are usually lacking in a regular pregnancy diet. Further research is needed to understand the eating habits and food patterns that contribute to this imbalanced diet in order to be able to effectively improve prenatal women's nutrient intake status.

Key words: Dietary Assessment; Fat; Nutrient Intake; Physiological Status; Pregnant Women

INTRODUCTION

During pregnancy, it is a priority for mothers-to-be to obtain a balanced profile of nutrition to ensure optimal fetal growth and mothers' own health. It is clear that adequate nutrition in the first 1000 days is critical to a child's healthy growth and development to health and productivity later in life.^[1] Meeting nutritional needs during pregnancy is well-recognized as one of the most critical issues in public health. In general, pregnant women pay more attention than nonpregnant women to nutrition and diet.^[2] In developed countries, nutrient intakes among pregnant

women are relatively higher than those in developing countries.^[3] Previous reports in China have suggested that the diet of pregnant women is predominantly plant-based.^[4,5] But vitamin and minerals intake standards are hardly to be fulfilled,^[3,6] especially calcium, iron, zinc, Vitamin A, B₂, and folic acid.^[4] However, recent reports have it that more fat-content foods and other nutrients are consumed during the past decades in China.

To determine the status of nutrition intake transition comparing with the past on pregnant women's diet, there must be a thorough understanding of the nutritional intake of pregnant women to date. However, limited information across all trimesters and nationwide areas are available. Instead, many studies only focused on one or two trimesters^[7]

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or were restricted to limited districts.^[6] Most importantly, to our knowledge, no studies have been conducted to compare the current nutrition status of Chinese pregnant women with the latest Chinese Dietary Reference Intakes (DRIs) 2013.^[8] This study aims to describe nutrient intakes of pregnant women using data from the Maternal Infant Nutrition and Growth (MING) study, in which dietary intake data were collected on pregnant women in different trimesters of pregnancy from eight cities representing different geographical and economic profiles. This study, focusing on intakes from foods, beverages, and supplements, evaluates the nutrient intake level compared with current dietary recommendations in China.

METHODS

Subjects

The MING study, conducted in 2011 and 2012, is a cross-sectional study designed to investigate the dietary and nutritional status of pregnant women, lactating mothers,^[9] and young children aged from birth up to 3 years^[10] living in urban areas of China. The breast milk of lactating mothers was also collected in various lactation periods, with the objective to understand the breast milk composition profile of Chinese lactating mothers.

Pregnant women aged 20–40 years old were recruited in this study with a multistage stratified random sampling method. In the first stage, considering the geographical and economical status, eight cities were chosen for their geographical location (north, south, central, east, and west) and status of economic development (first- or second-tier) in China. Among these eight cities, there are 4 first-tier cities like Beijing, Shanghai, Chengdu and Guangzhou, and 4 second-tier cities like Shenyang, Lanzhou, Zhengzhou and Suzhou. In the second stage, two service centers of maternal and child care (SCMCC) in each city were randomly selected, with one in an urban area and the other in a suburban area. In the third stage, the sample was stratified considering pregnancy stage (first, second, and third trimester) and selected by systematic sampling method in each of SCMCC, based on pregnancy registration information, since we wanted to compare nutrient intakes with the specific nutrient recommendations at each stage. Target sample size was 480 in total, which was calculated by the cross-sectional study sample size calculation formula.^[11] In eight cities, each SCMCC contributed 50% sample for a city. Each SCMCC recruited 30 pregnant women, in which 10 from the first trimester, 10 from the second trimester and 10 from the third trimester. To participate in the study, pregnant women needed to be generally healthy without any history of chronic disease, alcohol consumption (defined as no more than two drinks per week) or smoking habits. Pregnant women with gestational diabetes, hypertension, infectious disease (tuberculosis, viral hepatitis, and HIV infection), mental disease or recall deficit that could limit their ability to answer questions and receiving medical drugs during the period of the study were also excluded. Final sample size was 479, with 158 women

in the first pregnancy trimester, 160 in the second and 161 in the third trimester. Once recruited, all participants would be requested to sign a written consent form before being interviewed. The study was conducted according to the guidelines in the *Declaration of Helsinki*. And the protocol was approved by the Human Research Ethics Committee of Peking University (Number: IRB00001052-11042).

Data collection

All information collected was obtained through face to face interviews conducted in each site. The interview covered different types of aspects of pregnancy, including general information, anthropometry, lifestyle habits, and dietary information. For the dietary intake assessment, one 24 h recall, one nutrition supplements questionnaire, and one food frequency questionnaire (FFQ) were administered. All interviewers were trained with a standard protocol for conducting the interviews. Participants were instructed on how to complete the questionnaires. If dietary information on the form was not completed, the questionnaire would be considered invalid.

This study focuses on the nutrient intake assessment from 24 h dietary recall. All foods, beverages, and supplements consumed on the previous day for each pregnant woman were recorded. A picture booklet of common foods consumed in China and typical measuring utensils were used to help participants to estimate serving sizes.

Analytical methods

Data entry was performed by two researchers on two separate computers with EpiData3.1 (EpiData Association Odense, Denmark). Nutrient intakes were calculated based on the 24 h dietary recall data with a food composition database created for this study combining Chinese Food Composition Tables (CFCT) 2004^[12] and 2009^[13] (CFCT, National Institute of Nutrition and Food Safety, China CDC). CFCT covers information on 36 nutrients for more than 800 foods. In addition, the database was expanded with another 22 kinds of food from published literature. The Standard Tables of Food Composition in Japan 2010^[14] was also referenced for 246 foods' content of Vitamin B6, biotin, and folic acid, which has not been reported in China.

Statistical analyses were performed using Statistical Package for Social Sciences 16.0 (SPSS version 16.0, SPSS Inc., Chicago, IL, USA). Nutrient intakes were assessed by being compared to DRIs 2013.^[8] Mean intakes of energy and nutrients for each pregnancy subgroup (by trimester) were compared, with the Recommended Nutrient Intake (RNI) or Adequate Intake (AI) since only 1-day 24 h recall data was available for our sample. However, the distributions of nutrient intakes,^[15] Estimated Average Requirement (EAR), and tolerable upper intake level (UL), are also presented for reference and discussion. The energy requirements are expressed in terms of estimated energy requirements (EERs).

Comparisons of group means in three trimesters were performed using ANOVA *F*-test. Multiple comparisons

were carried out among different levels of variables. The associations of dietary intake of energy and nutrients and demographic factors such as trimester, age and prepregnancy body mass index (BMI), education, and household income were examined by multiple linear regression. All reported *P* values were 2-tailed, and a *P* < 0.05 was considered statistically significant.

RESULTS

Sample description

The characteristics of the pregnant women [Table 1] revealed that the average age of them were 27.0 ± 3.6 years. Most of them received senior high school education or above. Over 90% participants had a household income per capita per month over RMB 1500 Yuan. Using adjusted prepregnancy BMI for Chinese, 65.6% of subjects had a normal BMI, 12.5% were overweight or obese while 21.9% were underweight.

Nutrient intakes

Table 2 describes mean (standard deviation) energy and nutrient intakes among Chinese pregnant women across trimesters. Mean energy intake was 2098 ± 915 kcal/day with a wide range of variability and significantly higher in the third trimester (*P* < 0.05). Pregnant women consumed significantly more folic acid in the first trimester than the second and third trimester (*P* < 0.01). On the contrary, significantly less Vitamin A in the first trimester than the second and third trimester were consumed (*P* < 0.05). Niacin, calcium, phosphorus, potassium, and magnesium intake were significantly higher in the third trimester than the first trimester (*P* < 0.05).

Table 1: Demographic characteristics of Chinese pregnant women in eight cities (*n* = 479)

Characteristics	Results (<i>n</i>)	Percentage (%)
Age at interview (years)		
<25	122	25.5
25–29	242	50.5
≥30	112	23.4
Trimester		
First	158	33.0
Second	160	33.4
Third	161	33.6
Education		
Junior high school or lower	60	12.5
Senior high school and college	378	78.9
Graduate or higher	34	7.1
Household income per capita per month (RMB, Yuan)		
≤1500	55	11.5
1501–3999	245	51.2
≥4000	175	36.5
Prepregnancy BMI (kg/m ²)		
<18.5	105	21.9
18.5–23.9	314	65.6
≥24.0	60	12.5

BMI: Body mass index.

The intake distributions of energy, macronutrients, and micronutrients for participants in the first, second, and third trimesters are presented in Tables 3–5, respectively. The proportion of energy derived from protein (14.7%, 15.6%, and 14.7%) and carbohydrate (51.2%, 50.8%, and 52.6%) were adequate compared with the recommendation (10–15% and 50–65%, respectively),^[8] whereas fat contribution (37.0%, 36.8%, and 35.5%) compared with the recommendation (20–30%)^[8] was excessive. Mean and median intakes of Vitamin A, B₆, calcium, magnesium, and selenium were below the RNI (mean intake), and EAR (median intake) defined by the Chinese DRIs 2013.^[8] Mean intake of folic acid was below RNI in all trimesters, even though there was a significant difference between the first trimester and the others. Iron intake in the third trimester was also below the RNI and EAR. Thiamin met the defined RNI in the first trimester but could not reach the EAR in all trimester.

Factors associated with intake of nutrients

The first model of multiple linear regression included age, education, household income, prepregnancy BMI, and trimester. Trimester was positively associated with most nutrients intakes (*P* < 0.05), such as energy, protein, carbohydrate, Vitamin A, niacin, Vitamin C, calcium, phosphorus, potassium, magnesium, and zinc. Prepregnancy BMI was inversely associated with energy, fat, Vitamin C, and calcium intake (*P* < 0.05). Educational level and household income were positively associated with folic acid intake (*P* < 0.05) [Table 6].

DISCUSSION

This is the first large-scale study to examine the nutrient intakes of pregnant women compared with Chinese DRIs 2013; this is also the most up-to-date and comprehensive study integrating nutrient intakes and the association between demographic factors and dietary intake in a representative sample of Chinese pregnant women from eight major cities across the country.

For pregnant women with light physical activity, energy intake increased over the course of pregnancy and met the EER. But it was below the EER for pregnant women with moderate physical activity.^[8] Our study (unpublished data) indicates that most of the subjects tend to have a low physical activity pattern, thus energy intake may be adequate to meet their needs to a large extent. However, the variation of intakes of energy as well as some energy-related nutrients was considerable, which were in part related to the level of physical activity in the individual.^[16] Differences in the published reference values from different countries on energy needs during pregnancy are considered to partially due to the reason above.^[17,18] In addition, China has a vast territory, and people living in the different places may have different diet pattern, which may contribute to the variation of energy and energy-related nutrients intakes. Compared with the earlier data reported from China NNHS 2002 for urban pregnant women (1975.4 kcal/day),^[19]

Table 2: Energy and nutrient intakes (mean ± SD) of women during pregnancy from 24 h recall

Energy and nutrients	All subjects (n = 479)	First trimester (n = 158)	Second trimester (n = 160)	Third trimester (n = 161)	P*
Energy (kcal)	2098 ± 915	2001 ± 990	2060 ± 773	2219 ± 960 [§]	0.034
Percentage of energy from fat (%)	36.4 ± 11.5	37.0 ± 12.1	36.8 ± 11.6	35.5 ± 10.6	0.242
Percentage of energy from carbohydrates (%)	51.5 ± 12.6	51.21 ± 13.0	50.77 ± 13.1	52.57 ± 11.5	0.333
Percentage of energy from protein (%)	15.0 ± 5.0	14.7 ± 4.9	15.6 ± 4.9	14.7 ± 4.2	0.963
Carbohydrate (g)	268.9 ± 137.1	257.2 ± 155.6	258.6 ± 111.6	290.7 ± 139.0 [§]	0.029
Fat (g)	84.5 ± 46.5	81.5 ± 48.7	85.0 ± 45.7	86.9 ± 45.1	0.577
Protein (g)	79.3 ± 44.4	73.5 ± 42.3	80.8 ± 41.3	83.6 ± 48.8 [§]	0.042
Cholesterol (mg)	514.5 ± 490.9	483.3 ± 343.6	557.9 ± 645.0	501.9 ± 433.4	0.735
Dietary fiber (g)	14.9 ± 10.6	13.6 ± 10.4	15.3 ± 9.4	15.8 ± 11.7	0.063
Vitamin A (μg, RAE [†]) [‡]	591.5 ± 878.4	437.5 ± 374.3	662.6 ± 988.9 [§]	671.9 ± 1077.4 [§]	0.017
Retinal (μg)	378.9 ± 824.5	260.8 ± 285.7	447.8 ± 948.3	426.4 ± 1018.1	0.088
Thiamin (mg)	1.2 ± 0.9	1.2 ± 1.0	1.2 ± 0.9	1.2 ± 0.7	0.778
Riboflavin (mg)	1.3 ± 0.9	1.2 ± 0.9	1.4 ± 1.1	1.4 ± 0.9	0.323
Niacin (mg)	17.2 ± 10.6	15.4 ± 9.5	17.7 ± 9.9	18.4 ± 12.1 [§]	0.001
Vitamin B6 (mg)	1.1 ± 0.7	1.1 ± 0.6	1.1 ± 0.6	1.2 ± 0.7	0.162
Biotin (μg)	51.8 ± 52.0	47.9 ± 52.5	51.0 ± 37.1	56.4 ± 63.1	0.394
Folic acid (μg DFE)	425.9 ± 317.7	583.4 ± 301.7	346.9 ± 245.9	347.2 ± 339.3	0.000
Vitamin C (mg)	133.0 ± 129.2	113.9 ± 93.5	140.2 ± 131.7	144.4 ± 153.2 [§]	0.035
Vitamin E (mg α-TE)	14.5 ± 14.0	14.0 ± 15.1	15.6 ± 16.1	14.1 ± 12.1	0.914
Ca (mg)	734.1 ± 562.9	633.2 ± 492.4	746.6 ± 460.0	820.6 ± 693.4	0.003
P (mg)	1182.7 ± 603.9	1089.5 ± 609.8	1189.9 ± 510.2	1272.3 ± 669.9 [§]	0.006
K (mg)	2353.3 ± 1263.3	2102.1 ± 1153.6	2415.2 ± 1108.9	2535.4 ± 1460.1	0.002
Na (mg)	4496.4 ± 6210.1	4334.9 ± 2518.1	5147.3 ± 9739.3	4008.1 ± 3747.3	0.638
Mg (mg)	336.3 ± 193.2	309.3 ± 199.1	335.8 ± 171.0	363.5 ± 205.3 [§]	0.040
Fe (mg)	27.3 ± 20.1	26.2 ± 20.8	26.8 ± 16.7	28.9 ± 22.4	0.234
Zn (mg)	12.6 ± 6.9	11.7 ± 7.1	12.7 ± 5.8	13.3 ± 7.6 [§]	0.003
Se (μg)	54.4 ± 35.0	50.2 ± 31.7	57.6 ± 36.1	55.5 ± 36.8	0.179
Cu (mg)	2.5 ± 2.1	2.4 ± 2.0	2.5 ± 1.5	2.6 ± 2.6	0.478
Mn (mg)	6.0 ± 5.9	5.7 ± 3.4	6.1 ± 7.6	6.8 ± 10.8	0.070

*P for one-way ANOVA; [†]RAE: Retinol activity equivalents; [‡]The formula of Vitamin A defined in Chinese DRIs 2013; RAE: Retinol + 1/12 total carotene; [§]P<0.05 compared with the first trimesters; ^{||}P<0.01 compared with the first trimesters. SD: Standard deviation; α-TE: Alpha-tocopherol equivalents.

mean intake in this study (2093.7 kcal/day) was higher, which suggested an improvement of energy intake among Chinese pregnant women over the past 10 years. However, there seems to be still a gap between energy intakes among pregnant women in China and some Western countries, such as USA/Canada (2211.4 ± 173.3 kcal/day) and Europe (2207.3 ± 275.8 kcal/day).^[20]

In addition to an increase in calorie intake over the last decade, we have also seen a shift in the traditional macronutrient sources of energy. In line with earlier surveys in China,^[19,21] most of the participants in our study had excessive energy contribution from fat (%TE). Overconsumption of animal-based foods and/or especially oil may contribute to high fat intake. This is supported by our FFQ data (unpublished), which shows that 59.0% participants consumed more oil than the recommendations from *Dietary Guideline for Chinese Residents* (2008).^[22] The macronutrient distribution of energy may indicate that Chinese pregnant women are likely to consume more energy-dense foods, rather than nutrient-dense alternatives which could contribute to the increasing rate of overweight and obesity reported in China,^[23] and subsequently increase

the risk of caesarean section^[24] and macrosomia.^[25] It is also noteworthy that the intake of protein in the third trimester was below the RNI (85 g/day) and EAR (75 g/day), which may imply that some women could be at the risk of inadequate protein intake. This is relevant in this particular trimester since protein requirements are increased to supply adequate protein for the fetus's growth.

Results in this study highlighted the possibility of inadequate dietary fiber consumption in urban Chinese pregnant women. A wealth of information supports the importance of consuming adequate amounts of dietary fiber from a variety of plant foods. In this study, the mean intake of dietary fiber was 14.9 g/day, which accounted for <60% AI (25–30 g/day).^[8] This may lead to not only the low intake of dietary fiber, but also the associated nutrients found in high fiber foods including Vitamins B, C, and some minerals. Therefore, a further promotion of consuming dietary fiber and education around good food sources is needed.

Mean intakes of a number of micronutrients were below the RNIs, including Vitamin A, Vitamin B₆, folic acid, calcium, magnesium, and selenium. For all of these nutrients, the

Table 3: Energy and nutrient intakes distribution of Chinese pregnant women in the first trimester (n = 158)

Energy and nutrients	DRIs			Intake percentiles				
	EAR*	RNI†/AI‡	UL§	10 th	25 th	Median	75 th	90 th
Energy (kcal)	–	–	–	1075.6	1345.9	1794.9	2343.0	3138.0
Fat (g)	–	–	–	34.5	52.7	70.1	100.4	141.0
Protein (g)	50	–	–	35.4	43.9	62.4	91.7	144.5
Carbohydrate (g)	130	–	–	110.4	153.8	239.4	308.7	410.6
Fat (%TE)**	–	–	–	22.0	29.0	37.7	44.5	52.4
Protein (%TE)**	–	–	–	9.2	11.7	13.9	16.8	21.6
Carbohydrate (%TE)**	–	–	–	35.9	42.2	50.1	60.2	67.7
Dietary fiber (g)	–	25	–	4.5	7.3	10.8	15.9	25.1
Cholesterol (mg)	–	–	–	37.5	197.2	465.3	715.4	938.4
Vitamin A (µg, RAE)††	480	700	3000	80.6	174.2	328.0	498.2	666.0
Retinal (µg)†	–	–	3000	16.7	72.5	193.3	326.3	496.7
Thiamin (mg)	1.0	1.2	–	0.4	0.6	0.9	1.3	2.3
Riboflavin (mg)	1.0	1.2	–	0.4	0.7	1.0	1.4	2.5
Niacin (mg Ne)	10	12	35	6.2	9.1	12.6	20.3	28.4
Vitamin B6 (mg)	1.9	2.2	60	0.4	0.6	1.0	1.4	2.0
Biotin (µg)	–	40	–	16.9	25.3	34.6	50.0	78.7
Folic acid (µg DFE)	520	600	1000	187.0	459.4	569.4	697.0	951.3
Vitamin C (mg)	85	100	2000	19.9	45.5	83.8	167.6	253.0
Vitamin E (mg α-TE)	–	14	700	5.3	7.6	10.6	14.1	20.0
Ca (mg)	650	800	2000	188.2	291.0	498.5	814.8	1311.2
P (mg)	600	720	3500	525.1	682.6	969.1	1331.1	1822.2
K (mg)	–	2000	–	873.2	1262.3	1934.4	2637.4	3609.1
Na (mg)	–	1500	–	2333.0	2968.7	3939.7	5032.7	6471.7
Mg (mg)	310	370	–	138.6	179.1	272.6	370.7	528.5
Fe (mg)	15	20	40	10.5	14.5	20.0	28.2	52.2
Zn (mg)	7.7	9.5	40	5.2	6.9	10.1	14.4	19.7
Se (µg)	54	65	400	17.0	29.9	44.0	59.7	90.1
Cu (mg)	0.7	0.9	8	0.9	1.2	1.8	3.0	4.9
Mn (mg)	–	4.9	11	2.1	3.0	4.1	6.2	9.9

*EAR: Estimated average requirement; †RNI: Recommended nutrient intake; ‡AI: Adequate intake; §UL: Upper intake level; ††RAE: Retinol activity equivalents. †††The UL for Vitamin A is based on preformed Vitamin A (retinol). Assessment of the proportion of the population with intakes above the UL is based on intakes of preformed Vitamin A rather than total RAEs. **%TE: Percentage of total energy. α-TE: Alpha-tocopherol equivalents; DRIs: Dietary reference intakes.

median intakes generally also fell below the EARs during all gestational periods, which further demonstrate the risk of inadequate intake in this population of pregnant women. The inadequacy of micronutrient intakes is commonly seen in developing countries,^[3,26,27] in contrast to generally AI seen in developed countries.^[28,29] Vitamin A deficiency, in particular, remains a public health issue in developing countries.^[30] In line with NNHS 2002,^[19] our study showed a low intake of Vitamin A among Chinese urban women. This may be explained by a limited consumption of good sources of Vitamin A, such as eggs and dairy products. Results from the FFQ (unpublished) suggested that over 50% of participants consumed a smaller quantity of eggs than the recommendation (50 g/day)^[22] for pregnant women while a large majority of participants (83%) consumed less dairy foods than the recommendation.^[22]

This situation may also explain the insufficient intake of calcium in all trimesters shown in this study. However, median intake from our study was much higher than the previous Chinese studies.^[19] Calcium supplements may

contribute to the increase, for there were 6.3%, 16.8%, and 21% calcium supplement users in respective trimesters. It is suggested that calcium supplements may reduce the risk of preeclampsia and hypertensive disorder especially in women with low calcium intake.^[31,32] Together with the consumption of calcium-rich foods, such as milk, milk products, soy and soy products, achieving an adequate amount of calcium may prevent pregnant mothers from calcium deficiency symptoms.

Iron intake of the third trimester was below RNI and EAR, which suggests a risk of inadequate intake. This finding was consistent with Lai *et al.*'s study^[4] and China NNHS 2002.^[19] On the other hand, we found in the study some subjects had an intake above UL and could be at the risk of excessive iron intake. Iron supplements would account for this increased intake for 10.2% participants used such supplements. This observation is relevant since generally it is suggested to complement diet with iron supplements regularly from the first prenatal visit.^[33] Researchers from Finland suggested supplying iron twice a week would have similar benefits to

Table 4: Energy and nutrient intakes distribution of Chinese pregnant women in the second trimester (n = 160)

Energy and nutrients	DRIs			Intake percentiles				
	EAR*	RNI†/AI‡	UL§	10 th	25 th	Median	75 th	90 th
Energy (kcal)	–	–	–	1213.1	1505.1	1946	2418.7	3137.6
Fat (g)	–	–	–	39.6	52.2	76.3	109.0	137.3
Protein (g)	60	–	–	39.3	50.2	69.8	99.4	141.3
Carbohydrate (g)	130	–	–	133.1	183.1	241.8	312.5	416.3
Fat (%TE)**	–	–	–	20.9	28.6	36.4	44.8	53.6
Protein (%TE)**	–	–	–	10.7	12.4	14.2	17.9	22.2
Carbohydrate (%TE)**	–	–	–	33.2	41.5	50.9	59.6	69.3
Dietary fiber (g)	–	25	–	6.6	8.2	13.2	19.7	27.3
Cholesterol (mg)	–	–	–	82.2	192.6	438.9	709.5	1201.7
Vitamin A (µg, RAE)†	530	770	3000	127.5	197.1	343.3	589.9	1024.7
Retinal (µg)†	–	–	3000	26.5	87.5	199.5	363.0	745.0
Thiamin (mg)	1.1	1.4	–	0.5	0.7	1.0	1.5	2.2
Riboflavin (mg)	1.1	1.4	–	0.5	0.8	1.2	1.7	2.8
Niacin (mg NE)	10.0	12.0	35	7.3	10.7	15.5	22.0	32.8
Vitamin B ₆ (mg)	1.9	2.2	60	0.5	0.7	1.1	1.5	1.9
Biotin (µg)	–	40	–	22.0	28.0	40.2	58.8	92.2
Folic acid (µg DFE)	520	600	1000	94.3	147.5	264.1	490.1	713.1
Vitamin C (mg)	95	115	2000	23.8	64.9	111.7	187.7	262.3
Vitamin E (mg α-TE)	–	14	700	4.9	7.9	11.9	19.6	27.3
Ca (mg)	810	1000	2000	236.9	392.4	659.3	1007.3	1314.2
P (mg)	600	720	3500	578.2	809.3	1086.2	1447.2	2027.0
K (mg)	–	2000	–	1110.1	1567.6	2263.3	3209.6	3774.2
Na (mg)	–	1500	–	984.1	2729.3	3888.1	5005.4	7056.6
Mg (mg)	310	370	–	141.8	209.5	305.5	399.2	602.2
Fe (mg)	19.0	24.0	40	11.9	15.7	21.7	32.2	50.0
Zn (mg)	7.7	9.5	40	5.8	8.2	11.6	15.9	21.3
Se (µg)	54	65	400	24.6	32.7	48.1	70.9	102.0
Cu (mg)	0.7	0.9	8	1.0	1.4	2.0	3.4	4.7
Mn (mg)	–	4.9	11	2.2	3.2	5.0	7.0	8.5

*EAR: Estimated average requirement; †RNI: Recommended nutrient intake; ‡AI: Adequate intake; §UL: Upper intake level. †RAE: Retinol activity equivalents. †The UL for Vitamin A is based on preformed Vitamin A (retinol). Assessment of the proportion of the population with intakes above the UL is based on intakes of preformed Vitamin A rather than total RAEs. **%TE: Percentage of total energy; DRIs: Dietary reference intakes; α-TE: Alpha-tocopherol equivalents.

daily supplementation, yet, the risk of over consumption can be reduced.^[34]

The trend of folic acid intake drastically decreased from the second trimester. This highest intake in the first trimester could be mostly explained by the contribution of supplements since 118 (74.7%) pregnant women in this trimester reported to take folic acid supplements. Despite this, the mean intake in each trimester was below the RNI, thus it would be important to guarantee folic acid supplements intake in addition to a large quantity of folic acid dense food sources, like green leafy vegetables, whole-grain products, and legume.

Finally, high sodium consumption was confirmed to remain a public health issue. Mean intake of sodium in this study (4500 mg/d) was greatly above the AI for sodium (1500 mg/d). In addition to this result, equivalent of 11.5 g/day of salt consumption is very similar to the value reported in the intermap study^[35] of 12 g/day in women, which suggest that there are no relevant changes in sodium intake spite of pregnancy. It is also similar to what has been

reported at the China NNHS 2002 (12.5 g/day)^[19] which suggests that in spite of the public health efforts, high sodium consumption remains stable in urban China.

A large number of western studies have indicated a positive association between socioeconomic status and diet quality.^[33] In our study, it was also found that education, household income, prepregnancy BMI, and trimester phasing were significantly associated with some of the nutrient intakes. Pregnant women who consumed relative higher folic acid were more likely to have acquired higher education levels and greater household income, which were consistent with other reports.^[3,36] Pregnant women with a higher prepregnancy BMI consumed significantly less energy, fat, Vitamin C, and calcium during pregnancy than women with a lower prepregnancy BMI contradicting with previous reports from China,^[6] but consistent with a German study.^[37] It was evident that food intake patterns were less often positively associated with BMI in women.^[38] A possible reason would be that pregnant women with higher prepregnancy BMI were educated by prenatal physicians

Table 5: Energy and nutrient intakes distribution of Chinese pregnant women in the third trimester (n = 161)

Energy and nutrients	DRIs			Intake percentiles				
	EAR*	RNI†/AI‡	UL§	10 th	25 th	Median	75 th	90 th
Energy (kcal)	–	–	–	1306.0	1564.2	2043.8	2564.6	3520.6
Fat (g)	–	–	–	43.8	54.0	80.8	107.7	134.3
Protein (g)	75	–	–	37.5	49.5	72.7	105.2	142.6
Carbohydrate (g)	130	–	–	142.5	195.1	266.9	341.6	481.1
Fat (%TE)**	–	–	–	22.4	27.7	35.1	43.3	50.3
Protein (%TE)**	–	–	–	10.3	11.7	14.0	17.0	20.7
Carbohydrate (%TE)**	–	–	–	37.8	44.8	51.6	61.2	67.2
Dietary fiber (g)	–	25	–	5.2	8.2	13.6	19.8	27.6
Cholesterol (mg)	–	–	–	60.9	159.4	399.9	707.3	1028.2
Vitamin A (µg, RAE)†	530	770	3000	90.2	203.7	353.6	625.6	973.5
Retinal (µg)†	–	–	3000	26.3	79.0	201.9	362.4	577.8
Thiamin (mg)	1.2	1.5	–	0.5	0.7	1.0	1.4	2.1
Riboflavin (mg)	1.2	1.5	–	0.5	0.8	1.2	1.7	2.4
Niacin (mg NE)	10	12	35	7.8	10.8	14.8	21.6	33.8
Vitamin B ₆ (mg)	1.9	2.2	60	0.4	0.7	1.1	1.5	2.2
Biotin (µg)	–	40	–	18.2	28.2	39.5	60.8	104.6
Folic acid (µg DFE)	520	600	1000	91.9	143.2	269.3	431.5	670.1
Vitamin C (mg)	95	115	2000	30.7	64.3	111.6	178	256.9
Vitamin E (mg α-TE)	–	14	700	6.3	8.3	11.2	15.7	24.7
Ca (mg)	810	1000	2000	233.6	417.7	710.5	1008.8	1319.6
P (mg)	600	720	3500	582.2	858.0	1105.9	1572.1	2080.9
K (mg)	–	2000	–	1133.0	1506.0	2312.4	3268.1	4081
Na (mg)	–	1500	–	918.5	2544.8	3707.4	4748.9	6392.5
Mg (mg)	310	370	–	166.0	227.8	322.7	445.1	586.8
Fe (mg)	22	29	40	11.8	16.1	21.6	33.7	53.7
Zn (mg)	7.7	9.5	40	6.5	8.3	11.6	16	24.4
Se (µg)	54	65	400	20.0	30.5	51.0	66.3	97.5
Cu (mg)	0.7	0.9	8	0.9	1.4	2.1	2.9	4.4
Mn (mg)	–	4.9	11	2.5	3.6	5.3	6.9	10.9

*EAR: Estimated average requirement; †RNI: Recommended nutrient intake; ‡AI: Adequate intake; §UL: Upper intake level. †RAE: Retinol activity equivalents; †The UL for Vitamin A is based on preformed Vitamin A (retinol). Assessment of the proportion of the population with intakes above the UL is based on intakes of preformed Vitamin A rather than total RAEs. **%TE: Percentage of total energy; DRIs: Dietary reference intakes.

Table 6: Multiple linear regression between energy and nutrients and pregnant women's demographic characteristics

Energy and nutrients	Trimester		Pregpregnancy BMI		Household income		Education	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Energy (kcal)	115.57	14.463, 216.678	–169.894	–312.396, –27.391				
Protein (g)	5.204	0.303, 10.106						
Fat (g)			–8.512	–15.752, –1.271				
Carbohydrate (g)	18.627	3.497, 33.757						
Vitamin A (µg, RAE)	118.942	20.489, 217.395						
Niacin (mg NE)	1.593	0.413, 2.774						
Folic acid (µg DFE)					57.147	11.414, 102.88	87.321	20.263, 154.379
Vitamin C (mg)	15.077	0.752, 29.402	–23.469	–44.14, –2.798				
Ca (mg)	94.846	32.904, 156.789	–101.168	–188.471, –13.865				
P (mg)	93.52	26.736, 160.304						
K (mg)	220.971	81.15, 360.793						
Mg (mg)	28.597	7.319, 49.876						
Zn (mg)	0.878	0.112, 1.644						

β: Regression coefficient; CI: Confidence interval; BMI: Body mass index; RAE: Retinol activity equivalents.

to cautiously prevent excessive gestational weight gain through diet control in order to have an easier delivery. However, an Irish study reported pregnant women with a

BMI of ≥ 25 kg/m² were more likely to underreport their energy intake during early pregnancy (12–20 weeks) comparing with that of a BMI < 25 kg/m² (odds ratio: 4.4;

95% confidence interval: 2.5–7.7).^[39] A causal association needs to be explored by further research.

The subjects of this study were recruited from eight major cities located in different regions of China including the most developed cities. Therefore, the results should reasonably reflect the contemporary diet of pregnant women in urban China. A major limitation of this study is that the information on food was collected using a single 24-h dietary recall. Although 1-day 24-h dietary recall is sufficient to provide estimates of the average nutrient intakes of a large sample and to characterize the intakes to a certain extent,^[40] there are random errors due to day-to-day variation in individual diets which could lead to over or underestimation. The most appropriate way to estimate the prevalence of inadequate intakes of a population is to obtain the usual intakes of the population and use EAR cut-point method based on the distribution of intakes.^[41] While we have identified a few significant issues with nutrient intakes in the diets, it is not possible to conclude with certainty that the other nutrients are consumed in adequate amounts, due to this limitation of using 1-day of intake. Secondly, similar to most epidemiological nutritional surveys, the reliability of food intake data based on self-reported information may have some limitations. Although investigators explained food portion sizes, participants still may not have been able to estimate them accurately enough. And this may lead to some inaccurate results. Finally, the cross-sectional nature of the study hampers the drawing of conclusions on any causal inferences between socioeconomic level, gestational situation, and dietary intakes.

In conclusion, current nutrient intake of urban pregnant women in China is imbalanced when compared with national DRIs. Intake of energy derived from fat is excessive. Mean and median intakes of Vitamin A, B₆, calcium, magnesium, and selenium are below Chinese RNI and EAR in all three trimesters. Adequate folic acid intake has been fulfilled for most pregnant women in the first trimester but significantly decreases in the second and third trimester. The shortfall in iron intake was found in the third trimester while some women may be at the risk of over consumption. Intakes of thiamin met RNI in the first trimester but were below EAR in all trimesters. Based on a single day dietary recall, we cannot determine that these nutrients are inadequate; however, if pregnant women expose themselves to a long-term nutrient imbalance, the risk of malnutrition may increase and they may compromise the health of their fetus and their own. Further research in rural areas and a longer period of dietary assessment to determine usual nutrient intakes would be relevant to confirm the situation among pregnant women in China. Researchers, healthcare providers, and public authorities need to collaborate to place great emphasis on promoting the DRI guidelines more effectively with the public and nutrition research with particular focus on food habits and how they can be influenced to achieve a more nutrient adequate diet for pregnant women.

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