

A China Healthy Diet Index-based evaluation of dietary quality among pregnant women in coastal areas across trimesters and residential areas

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Abstract

Background: Good dietary quality among pregnant women is critical for maternal and fetal health. Comprehensive assessments of large representative samples are lacking.

Methods: Pregnant women were enrolled using a multistage, stratified, random-sampling method in Shanghai. We used a personal food frequency questionnaire and a household condiment weighing method for dietary assessments. Participants' scores on the China Healthy Diet Index (CHDI) were analyzed to evaluate diet quality.

Results: Significant differences in the median daily intake of almost all food types were found across all trimesters, and all food types were found across all residential areas (urban, suburban and rural). Significant differences were found in the median total CHDI scores across trimesters, and on all CHDI components, except whole grains, dry beans and tubers, across all residential areas; 13.7% of participants scored below 60 points, indicating "poor" dietary quality. Significant differences in CHDI scores were found across trimesters and residential areas. Participants in early and middle pregnancy had lower scores than those in late pregnancy. Women in urban areas had higher scores than those in suburban and rural areas.

Conclusions: Pregnant women living in coastal areas of China suffer from an unbalanced diet of average quality. Pregnant women in the early and middle stages of pregnancy had worse scores than those in the late stage, while suburban and rural women had worse scores than urban women.

Introduction

Nutrition during pregnancy is a key determinant of pregnancy success and maternal and fetal health [1, 2]. Increased caloric and macronutrient intake in the 2nd and 3rd trimesters and micronutrients (e.g., iron and folate) throughout the gestational period are necessary for a healthy pregnancy. There is mounting evidence that a deficient or excessive intake of one or more macro- and micronutrients is common among pregnant populations through diets [3, 4]; under- and over-nutrition are thought to be involved in diseases, such as obesity, gestational diabetes mellitus, cardiovascular mortality and infant abortion. Thus, it is essential to monitor the dietary intake of pregnant populations to determine the degree to which they meet nutritional requirements in order to update public health messages and tailor recommendations.

Contrary to popular single-food and -nutrient studies, the Diet Quality Index has been used since 1999 [5], and has received increased attention as a tool for evaluating overall diet quality and for categorizing individuals based on their eating behavior, as dietary components are not consumed in isolation, but interact with one another [6]. The Healthy Eating Index (HEI), Diet Quality Index (DQI), Healthy Diet Indicator (HDI) and Mediterranean Diet Score (MDS) are the four original diet-quality scales that were based on dietary recommendations and validated internationally. However, these indexes may not be applicable to China because of its distinct dietary habits. The previous Chinese Diet Balance Index (DBI) and the revised instrument (DBI_16) were developed successively in China. The 2017 Chinese Healthy Diet Index (CHDI) is the latest comprehensive evaluation approach [7]. It is based on the 2016 Chinese Dietary Guidelines which captures variation in the components of dietary patterns, sensitively reflects under- and over nutrition and has proved useful in surveilling national nutrition transitions and epidemiological trends [7, 8].

Historically, numerous studies have examined the importance of dietary patterns and their long-term effects on health among various populations. A cross-sectional study found that higher scores for "vegetables-fruits" and "snacks-drinks-milk products" patterns were associated with a reduced risk of cognitive impairment in older Chinese women [9]. Children who are breastfed are more likely to have healthier dietary patterns and those who eat more fruits and vegetables in late infancy are more likely to continue their eating habits at age 6 [10]. However, few investigations have focused on maternal dietary intake, and there is a lack of well-designed, population-representative studies. Furthermore, as an international coastal metropolis, Shanghai has its own regional and diet characteristics. The people have undergone noticeable changes in their diets and eating behaviors in the past decades, which probably have affected their food intake and health outcomes. Yet, with the rapid development of the economy and the food processing industry, diet quality among pregnant women in China has not been adequately assessed, and the associations of trimester and residential areas with diet quality need to be further investigated.

Pregnant women living in Shanghai were selected as the study's target population to address this gap in the literature and propose up-to-date suggestions. The primary objective of our study was to examine the food quality of pregnant woman along the coastal area across trimesters and residential areas using the CHDI.

Materials And Methods

Study Sample

We collected data from participants in the Iodine Status in Pregnancy and Offspring Health Cohort (ISPOHC) study, which was conducted in April–October 2017. The formula for calculating stratified random sampling sample size which was $n = z^2 * S^2 * deff / d^2$ was used to calculate the sample size required for analysis. At least 4269 pregnant women without illnesses that could interfere with the research process were needed for the survey. Women with missing food-consumption data, and those whose energy intake was below 800 kcal/d or above 5000 kcal/d were excluded from the study after a discussion with experts, leaving 4574 eligible participants for the survey. A multistage, stratified random sampling method was used to obtain a representative sample. The metropolis consisted of urban, suburban and rural areas and they were categorized based on the ratio of the non-agricultural registered population in the sub-districts to those in town. The sample size in each administrative district was evenly determined in accordance with the sample size and the number of pregnant women in each administrative district in 2016. Each district was divided into five sections, a street was randomly selected from each section and an equal number of pregnant women were selected from each section. Participants in the different stages of pregnancy were evenly distributed.

The Ethics Committee of the Shanghai Center for Disease Control and Prevention approved the survey. All of the surveys were conducted after written consent from the respondents was obtained.

Data Collection

Eligible participants were interviewed face-to-face to collect data on their demographics, pregnancy history, dietary habits, physical activity and related information. Dietary assessments were conducted using a personal food-frequency questionnaire and a household condiment weighing method to measure cooking oil, salt and sugar.

A validated and reliable food frequency questionnaire (FFQ) [11] was used to measure the frequency and amount of foods consumed by participants over the past three months. The average food recordings were calculated according to the requirements for each food (e.g., raw weight, edible weight, dry weight and fresh weight) and the conversion rate. Similar foods were counted together. Food and nutrient intake was estimated using food composition tables published for use in China [12]. Oil, salt and sugar data were obtained by dividing weight changes in the condiment inventory over one week by the number of people who consumed the household condiments together at each meal.

All data were reviewed by the local district Centers for Disease Control and Prevention (CDC) project team, and at least 5% of the data was reviewed by the Shanghai CDC project team.

Assessment of Diet Quality

The China Healthy Diet Index was used to evaluate overall patterns of dietary intake of the Chinese population, and it corresponds to the Chinese Dietary Guidelines and the Chinese Food Pagoda. The CHDI consists of 13 indexes, including (1) food variety (0–10 points); (2) refined grains (0–5 points); (3) whole grains, dry beans and tubers (0–5 points); (4) total vegetables (0–5 points); (5) dark green and orange vegetables (0–5 points); (6) fruit (0–10 points); (7) dairy (0–10 points); (8) soybeans (0–10 points); (9) meat and eggs (0–5 points); (10) fish, shellfish and mollusks (0–5 points); (11) calories from saturated fatty acids (SoFAAS) (0–10 points); (12) sodium (0–10 points); and (13) calories from empty calories (0–10 points).

The variable, food types reflects the degree of food diversity, and nine food intake indicators are required to evaluate food intake. While calories from SoFAAS reflect the proper selection of high quality protein-source food, empty calories is an indicator for less oil, sugar control and limited alcohol. Scores on each component are summarized and the total score ranges from 0 to 100 (0 being the lowest and 100 being the highest possible score). A higher score reflects a better quality of dietary intake. A total score of less than 60 indicates a “poor” quality of dietary intake; a score between 60 and 80 indicates an “average” quality of dietary intake; and a score above 80 indicates “good” dietary intake.

Definitions of Related Indicators

Calories from SoFAAS was defined as the ratio of saturated fat intake to total energy intake. Empty calories was defined as alcohol, sugar and cooking oil. Sodium intake included the total intake from food, cooking salt and other condiments. Former smokers was defined as that participants who smoked cigarettes in the past, excluding those who took a few tentative puffs. Former drinkers was defined as that participants who drank alcoholic beverages during non-gestational periods in the past, excluding those who sipped some wine.

Statistical Analysis

All statistical analyses were conducted using EXCEL (2010 Edition, Microsoft, China) software and IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). A p -value < 0.05 was considered to be statistically significant. Regression coefficients and the 95% confidence intervals were calculated.

The data on the variables were not normally distributed, and were therefore, summarized as median (interquartile range) and percentage. The Kruskal–Wallis one-way ANOVA (k samples) test was used with the multiple independent samples. All pairwise methods were implemented as pairwise comparisons. Comparisons of proportions were evaluated using the Chi-square test. Univariate and multivariate logistic regression were used in the analyses.

Results

Characteristics of the Study Participants Stratified by Stage of Pregnancy

A total of 4574 women were enrolled in the study. Participants were evenly distributed among the three trimesters, with 1661 in early pregnancy (1st trimester), 1549 in middle pregnancy (2nd trimester) and 1364 in late pregnancy (3rd trimester). Among all the participants, 43.6% lived in urban areas, 26.1% in suburban areas and 30.4% in rural areas; 14.4% were ≥ 35 years of age. Differences in parity, educational status, family income during the past year and residential area were significant across the three stages of pregnancy ($p < 0.05$) (Table 1).

Table 1
Characteristics of the study participants stratified by stage of pregnancy.

	Early pregnancy	Middle pregnancy	Late pregnancy	Pooled	χ^2	<i>p</i>
N	1661	1549	1364	4574	/	/
Maternal age (years) at delivery (n, %)						
< 35	1410 (84.9)	1337 (91.6)	1174 (85.9)	3921 (85.7)	2.36	0.308
≥ 35	251 (15.1)	207 (13.4)	184 (13.5)	642 (14.04)		
Parity (n, %)						
0	1044 (37.5)	920 (33.1)	819 (29.4)	2783 (60.8)	50.60	< 0.001
≥ 1	617 (34.5)	629 (35.1)	545 (30.4)	1791 (39.2)		
Educational status (n, %)						
≤ 9 years	204 (12.3)	277 (17.9)	222 (16.3)	703 (15.4)	36.53	< 0.001
Senior high school and college	647 (39.0)	661 (42.7)	554 (40.6)	1862 (40.7)		
Bachelor's degree and above	809 (48.7)	609 (39.3)	587 (43.0)	2005 (43.8)		
Occupational status (n, %)						
Mental	955 (57.5)	863 (55.7)	751 (55.1)	2569 (56.2)	2.04	0.361
Physical	699 (42.1)	679 (43.8)	608 (44.6)	1986 (43.4)		
Family income for the past year YUAN (n, %)						
< 100000	237 (14.3)	287 (18.5)	256 (18.8)	780 (17.1)	17.95	0.001
100000–200000	679 (40.9)	644 (41.6)	554 (40.6)	1877 (41.0)		
≥ 200000	743 (44.7)	613 (39.6)	551 (40.4)	1907 (41.7)		
Former smoker (n, %)						
Former smoker (n, %)	47 (2.8)	41 (2.7)	29 (2.2)	117 (2.6)	1.59	0.452
Former drinker (n, %)						
Former drinker (n, %)	162 (9.8)	177 (11.4)	134 (9.8)	473 (10.3)	2.91	0.234
Ridential area (n, %)						
Urban	762 (45.9)	637 (41.1)	593 (43.5)	1992 (43.6)	22.65	< 0.001
Suburban	459 (27.6)	414 (26.7)	320 (23.5)	1193 (26.1)		
Rural	440 (26.5)	498 (32.1)	451 (33.1)	1389 (30.4)		

Analysis of Daily Dietary Intake of Participants Stratified by Pregnancy Stage and Residential Area

The median daily intake of the food types are presented in Table 2. Significant differences were found in the median daily intake of cereal, vegetables, livestock and poultry meat, fish and shrimp, eggs, milk and milk products, soybeans and nuts and cooking oil among the women in the different stages of pregnancy ($p < 0.05$). The median daily intake of cereal, vegetables, livestock and poultry meat, fish and shrimp and cooking oil among participants in late pregnancy was higher than those in middle and early pregnancy. The median daily intake of soybeans and nuts of participants in the middle stage of pregnancy was higher than that of the participants in the early and late stages. Significant differences in the median daily intake of all food types were observed in women from the three residential areas ($p < 0.05$). The median daily intake of cereal, fruits, soybeans and nuts and cooking oil by participants living in rural areas was higher than that of the participants in the suburban and urban areas, whereas the median daily intake of vegetables and livestock and poultry meat by participants in urban areas was higher than that of the women in the suburban and rural areas (Table 2).

Table 2
Median (M) daily dietary intake of participants stratified by stage of pregnancy and residential area (M, I

Food types (g/d)	Pooled	Pregnancy stage						F	p	R
		Early	Recommended	Middle	Recommended	Late	Recommended			
Cereal	258.3 (189.6,350.6)	249.1 (184.8,338.2)	250–300	262.3 (190.8,354.3)	275–325	264.3 (193.3,358.8)	300–350	12.92	0.002	2
Vegetables	158.6 (92.9,267.1)	154.3 (89.5,259.4)	300–500	152.9 (90.0,260.1)	300–500	172.1 (100.0,285.7)	300–500	14.71	0.001	1
Fruits	221.3 (129.9,360.0)	224.3 (130.0,361.6)	200–350	225.9 (130.5,364.3)	250–350	213.3 (128.6,350.0)	250–350	2.51	0.285	2
Livestock and poultry meat	85.3 (50.0,142.9)	78.5 (42.9,129.9)	40–65	84.9 (50.2,144.1)	50–75	92.9 (59.3,152.4)	50–75	55.00	< 0.001	9
Fish and shrimp	53.6 (28.6,92.9)	50.0 (26.4,88.2)	40–65	51.7 (28.6,92.9)	50–75	57.1 (30.2,101.3)	50–75	18.82	< 0.001	5
Eggs	50.0 (28.6,60.0)	50.0 (28.6,57.1)	50	50.0 (28.6,57.1)	50	50.0 (30.6,60.0)	50	15.69	< 0.001	5
Milk and milk products	200.0 (85.7,250.0)	200.0 (70.7,250.0)	300	200.0 (71.4,250.0)	300–500	200.0 (100.0,250.0)	300–500	38.26	< 0.001	2
Soybeans and nuts	31.6 (15.2,59.4)	29.80 (14.15,57.10)	25	34.10 (16.20,63.70)	30	31.3 (15.9,58.8)	30	11.46	0.003	3
Salt	5.5 (3.4,7.8)	5.4 (3.3,7.9)	< 6	5.5 (3.4,7.8)	< 6	5.5 (3.4,7.7)	< 6	1.00	0.608	5
Cooking oil	22.1 (11.9,33.9)	21.1 (11.3,32.1)	25–30	22.3 (12.0,34.8)	25–30	23.1 (12.4,35.5)	25–30	8.92	0.012	2

Analysis of CHDI Scores of Participants Stratified by Pregnancy Stage and Residential Area

The median score for each component of the CHDI and the total median CHDI score is presented in Table 3. The total scores of the participants in the early, middle and late stages of pregnancy were 71.5, 71.1 and 71.2., respectively. Significant differences in median scores were found for the CHDI components, including food variety, total vegetables, dark green and orange vegetables, fruit, dairy, soybeans, meat and eggs, calories from saturated fatty acids, sodium and empty calories and the total scores of the women across the three trimesters ($p < 0.05$). The median CHDI scores for total vegetables, dairy, fish, shellfish and mollusks and sodium among participants in late pregnancy were higher than those of the women in the early and middle stages. The scores of participants in early pregnancy for dark green and orange vegetables and calories from saturated fatty acids were higher than those of participants in middle and late pregnancy.

Table 3
Distribution of the China Healthy Diet Index (CHDI) scores by residential area and pregnancy stage (M, P25, P75).

CHDI components	Score range	Pooled	Pregnancy stage			Residential area						
			Early	Middle	Late	F	p	Urban	Suburban	Rural	F	p
Food variety	0–10	10.0 (7.9,10.0)	10.0 (7.5,10.0)	10.0 (8.2,10.0)	10.0 (8.3,10.0)	27.74	< 0.001	10.0 (7.8,10.0)	10.0 (7.3,10.0)	10.0 (8.9,10.0)	60.7	< 0.001
Refined grains	0–5	5.0 (4.8,5.0)	5.0 (4.8,5.0)	5.0 (4.7,5.0)	5.0 (4.8,5.0)	2.84	0.242	5.0 (4.5,5.0)	5.0 (5.0,5.0)	5.0 (4.8,5.0)	21.8	< 0.001
Whole grains, dry beans and tubers	0–5	1.0 (0.4,1.8)	1.0 (0.4,1.8)	1.0 (0.5,1.8)	0.9 (0.4,1.8)	0.59	0.743	1.0 (0.5,1.8)	1.0 (0.5,1.8)	0.9 (0.4,1.8)	4.1	0.129
Total vegetables	0–5	2.4 (1.6,3.8)	2.4 (1.6,3.8)	2.3 (1.5,3.6)	2.5 (1.7,4.0)	13.25	0.001	2.6 (1.7,4.1)	2.4 (1.5,3.6)	2.3 (1.5,3.6)	36.2	< 0.001
Dark green and orange vegetables	0–5	2.0 (1.3,3.3)	2.1 (1.3,3.3)	1.9 (1.2,3.1)	2.1 (1.3,3.5)	11.46	0.003	2.2 (1.4,3.6)	1.9 (1.2,3.2)	1.8 (1.2,3.1)	34.3	< 0.001
Fruits	0–10	10.0 (6.1,10.0)	10.0 (6.3,10.0)	10.0 (6.1,10.0)	9.5 (5.9,10.0)	12.84	0.002	9.7 (6.1,10.0)	10.0 (6.7,10.0)	9.7 (5.9,10.0)	21.0	< 0.001
Diary	0–10	8.2 (4.0,10.0)	8.0 (3.8,10.0)	8.0 (3.6,10.0)	8.7 (4.5,10.0)	13.43	0.001	8.6 (4.0,10.0)	8.2 (4.3,10.0)	7.8 (3.6,10.0)	6.8	0.034
Soybeans	0–10	10.0 (6.1,10.0)	10.0 (5.7,10.0)	10.0 (6.4,10.0)	10.0 (6.6,10.0)	11.70	0.003	10.0 (6.8,10.0)	10.0 (5.7,10.0)	10.0 (5.6,10.0)	17.2	< 0.001
Meat and eggs	0–5	5.0 (5.0,5.0)	5.0 (4.8,5.0)	5.0 (4.9,5.0)	5.0 (5.0,5.0)	28.68	< 0.001	5.0 (5.0,5.0)	5.0 (4.7,5.0)	5.0 (4.5,5.0)	77.6	< 0.001
Fish, shellfish and mollusks	0–5	4.7 (2.5,5.0)	4.7 (2.4,5.0)	4.5 (2.4,5.0)	4.9 (2.6,5.0)	4.38	0.112	5.0 (3.0,5.0)	4.0 (2.1,5.0)	4.7 (2.2,5.0)	67.2	< 0.001
Calories from saturated fatty acids	0–10	2.2 (0.0,6.9)	2.7 (0.0,7.3)	1.8 (0.0,6.9)	2.0 (0.0,6.5)	6.63	0.036	2.2 (0.0,6.7)	1.6 (0.0,6.5)	2.7 (0.0,7.7)	9.7	0.008
Sodium	0–10	7.2 (4.8,8.9)	7.1 (4.7,8.8)	7.1 (4.7,9.0)	7.3 (5.1,9.0)	8.44	0.015	7.1 (4.8,8.8)	6.8 (4.3,8.7)	7.5 (5.3,9.3)	45.8	< 0.001
Empty calories	0–10	10.0 (10.0,10.0)	10.0 (10.0,10.0)	10.0 (10.0,10.0)	10.0 (10.0,10.0)	11.47	0.003	10.0 (10.0,10.0)	10.0 (10.0,10.0)	10.0 (10.0,10.0)	32.6	< 0.001
Total score	100	71.5 (63.9,77.9)	71.1 (63.7,77.5)	71.2 (63.3,77.5)	72.3 (65.1,78.7)	16.65	< 0.001	72.4 (64.6,78.6)	70.4 (63.3,76.3)	71.2 (63.4,78.2)	30.1	< 0.001

The total scores of participants living in urban, suburban and rural areas were 72.4, 70.4 and 71.2, respectively. Significant differences were found in the median CHDI scores on all components except whole grains and dry beans and tubers among the participants in the three residential areas. The median CHDI scores for total vegetables, dark green and orange vegetables, dairy and fish, shellfish and mollusks were higher in the participants in urban areas than those of participants in suburban and rural areas. The CHDI scores for calories from saturated fatty acids and sodium were higher among the participants in rural areas than those of participants in urban and suburban areas (Table 3).

The analysis of the composition ratio of CHDI showed that 13.7% of participants had scores below 60 points. Significant differences in the CHDI score compositions of the participants in the different trimesters and residential areas were found ($\chi^2 = 14.95, 33.75; p = 0.005, < 0.001$). The proportion of scores < 60 among women in the late stage of pregnancy was lower than that of the women in the early and middle stages. The proportion of participants with a score < 60 was higher among those in suburban and rural areas compared to those in urban areas (Fig. 1).

Multivariate Analysis of CHDI Scores

CHDI scores were categorized as < 60 and ≥ 60 for the analyses. Univariate and multivariate logistic regression analyses were conducted; scores < 60 points were set as “0” and scores ≥ 60 as “1.” General characteristics, pregnancy stage and residential area were treated as independent variables and CHDI score as the dependent variable.

The univariate logistic regression showed that residential area, stage of pregnancy, educational background and family income were significantly correlated with CHDI score ($p < 0.05$). The multivariate logistic regression showed a significant difference in CHDI scores among participants in the different trimesters. Participants in early and middle pregnancy had lower scores, compared to those in late pregnancy ($p < 0.05$). Participants living in urban areas tended to have higher CHDI scores, compared to those in suburban and rural areas. Women with less than nine years of formal education had lower scores compared to those with more education (i.e., senior high school and college) and above, and a family income less than 100000 Yuan during the past year was associated with lower scores compared to the two higher levels of family income (Table 4).

Table 4
Logistic regression models for the China Healthy Diet Index (CHDI).

Item	CHDI score	Univariate Model				Multivariate Model					
	Median (IQR)	B	Coeff.	95% CI	p	β	Coeff.	95% CI	p		
Maternal age at delivery \geq 35 years											
No	71.5 (64.0,78.0)	Reference					Reference				
Yes	71.0 (63.6,77.4)	0.001	/	/	0.980	0.090	/	/		0.764	
Parity											
0	71.6 (64.0,78.0)	Reference					Reference				
\geq 1	71.3 (63.7,77.7)	3.720	/	/	0.054	0.396	/	/		0.529	
Educational status											
\leq 9 years	69.5 (62.2,76.7)	Reference					Reference				
Senior high school and college	71.1 (63.7,77.4)	0.399	1.490	1.182–1.880	0.001	0.287	1.332	1.044–1.700		0.021	
Bachelor's degree and above	72.3 (64.8,79.0)	0.498	1.645	1.304–2.075	< 0.001	0.322	1.379	1.058–1.798		0.018	
Occupational status											
Mental	72.0 (64.4,78.3)	Reference					Reference				
Physical	71.0 (63.5,77.3)	0.500	/	/	0.479	0.019	/	/		0.890	
Family income in the past year, YUAN											
< 100000	69.4 (61.7,75.6)	Reference					Reference				
100000–200000	71.4 (64.1,77.8)	0.416	1.515	1.209–1.898	< 0.001	0.338	1.402	1.107–1.777		0.005	
\geq 200000	72.3 (64.5,78.9)	0.467	1.595	1.272–2.001	< 0.001	0.302	1.352	1.047–1.747		0.021	
Former smoker											
No	71.6 (63.9,78.0)	Reference					Reference				
Yes	69.6 (63.4,74.8)	0.076	/	/	0.782	0.096	/	/		0.757	
Former drinker											
No	71.6 (63.9,78.0)	Reference					Reference				
Yes	70.7 (64.3,76.5)	1.179	/	/	0.278	1.197	/	/		0.274	
Pregnancy stage											

Item	CHDI score	Univariate Model				Multivariate Model			
	Median	B	Coeff.	95% CI	<i>p</i>	β	Coeff.	95% CI	<i>p</i>
Early	71.1 (63.7,77.5)	-0.313	0.732	0.588–0.910	0.005	-0.321	0.726	0.582–0.905	0.004
Middle	71.2 (63.3,77.5)	-0.375	0.687	0.552–0.856	0.001	-0.339	0.712	0.571–0.889	0.003
Late	72.3 (65.1,78.7)	Reference				Reference			
Residential area									
Urban	72.4 (64.6,78.6)	Reference				Reference			
Suburban	70.4 (63.3,76.3)	-0.375	0.688	0.558–0.847	< 0.001	-0.314	0.731	0.591–0.904	0.004
Rural	71.2 (63.4,78.2)	-0.331	0.718	0.587–0.878	0.001	-0.270	0.763	0.619–0.941	0.011

Discussion

Nutrition is a predictor of pregnancy success and dietary patterns can affect pregnant women for the rest of their lives. The overall diet quality of pregnant women in Shanghai was found in this study to be average, and unbalanced, which is similar to the previous findings of Shanghai residents [13]. The median CHDI score was 71.5 and merely 18.4% scored ≥ 80 points, which is higher than that of a national sample 7 and Shanghai senior high school students [14]. Pregnancy stages and residential areas were associated with CHDI scores, as were socioeconomic factors (educational level and family income). The dietary scores of urban residents were higher than those of suburban and rural residents, and being in the later stages of pregnancy served as a protective factor for good dietary intake.

Pregnant women in Shanghai ate a wide variety of foods with an over-intake of meat and under-intake of whole grains, dairy products and vegetables. The under-consumption of whole grains, dry beans and tubers may be related to the diet habits of Shanghai residents, which is difficult to change in a short time. Whole grains and its constituents have antioxidants and anti-inflammatory properties, which promote fertility [15]; a fertility clinic study showed that a higher intake of whole grains was associated with better birth outcomes [16]. Although the promotion of whole grain consumption has been on-going since the establishment of the Chinese Dietary Guidelines in 2016 [17], people in the southern region of China are accustomed to living on rice on a long-term basis, which leads to the insufficient consumption of whole grains, such as corn, millet, buckwheat and miscellaneous beans. The median dairy intake of the participants in this study was merely 200 g/d, which was far from the recommended intake for pregnant women (300–500 g/d). Milk products are excellent sources of calcium and protein for maternal and fetal health rather than other foods, and a chronic calcium deficiency may cause increased bone loss during pregnancy [18, 19]. Lactose intolerance is common in China as lactase deficiency affects 80%–90% of women three to four years after weaning, and 66.5% of adults have symptoms of lactose intolerance [20]. Fermented dairy products, such as cheese and yogurt, are alternatives that are more suitable for individuals with lactose intolerance. Another diet problem lies in the severely inadequate consumption of total vegetables, dark green and orange vegetables and over-consumption of meat, which was also reported in a previous national survey in 2010–2012 [21]. The median total intake of vegetables and livestock and poultry meat of the participants in this study was 158.6 g/d and 85.3 g/d, respectively. Interestingly, pregnant women were advised to have 300–500 g/d of total vegetables and 40–75 g/d of livestock and poultry meat and dark green and orange vegetables, which would account for over 66.7% of all the vegetables consumed [17]. Several studies have proposed that a healthy diet comprised of sufficient vegetables is associated with a reduction in the risk of gestational diabetes mellitus during pregnancy while a higher consumption of total meat, especially red and processed meat, could increase the hazard [22, 23].

We found that participants in later pregnancy had a relatively higher overall diet quality compared to those in early pregnancy, which may be related to the stress of pregnancy. A cohort study from the FUDAN School of Public Health, which included 2634 participants, found that increased pregnancy-specific stress in the middle and third trimesters may motivate pregnant women to follow a healthy balanced diet, and thus, equip them with more nutritional knowledge compared to novices in their first trimester, which was thought as the weak association with poor birth outcomes in previous studies [24, 25]. Compared to the chronic stress experienced during early pregnancy, the stress in the later trimesters is acute stress, characterized by increased blood sugar and poor appetite, which lure pregnant women to choose food that stimulates their appetite to meet their nutritional needs prior to labor [26, 27]. Hence, it is important to strengthen diet-related health education for pregnant women during all trimesters, especially the first one.

Residential area was found to be another determining factor of dietary quality. The dietary scores of the urban residents were higher than those of the suburban and rural residents. People dwelling in the countryside tend to consume more refined grain and less vegetables and meat, which is consistent with the finding Dibsall LA [28] and associated with the local food environment and food availability. Full-service supermarkets and grocery stores in downtown are more densely distributed than those in the remote areas are. Another explanation may be related to differences in socioeconomic status among the urban, suburban and rural areas. A large amount of epidemiologic data has revealed an association of diet quality with the socioeconomic status [29]. Educational and family income levels were also found to be protective factors in our study, the distribution of which differed between the residential areas. Pregnant

women with high educational levels have more opportunities to earn more money and settle downtown rather than in rural areas. They are likely to have higher rates of literacy and healthier dietary habits [30]. Their work experience might empower them to make better decisions about their dietary healthcare during pregnancy [31], and thus, have a higher diet quality. Pregnant women with lower incomes tend to consume fewer fruits and vegetables and more sugar-sweetened beverages [32], as the cost of food is an insurmountable gap for them, making it a challenge to access nutrient-dense diets [29].

To the best of our knowledge, this is the first study to apply CHDI indicators to assess diet quality among pregnant woman in coastal areas across trimesters and residential areas. This investigation was a systematic sampling survey covering all districts of Shanghai using a large representative sample and reasonable survey methods, which reflects the dietary intake of the population and should lead to generalizable conclusions. However, our study has limitations. The CHDI has some drawbacks. Each CHDI score has only a single threshold and it cannot explain the balance of the overall dietary pattern of a target population. Too much or too little consumption of one food type is not fully reflected in the total score; furthermore, this imbalance also affects the scores on the other items. Thus, the CHDI score needs to be evaluated and combined with a quantitative assessment of dietary intake. Health outcomes were not assessed in this study, and thus, the relationship between the CHDI and health outcomes should be evaluated in the future.

Conclusion

Pregnant women living in coastal areas of China suffer from an unbalanced diet of average quality, with 13.7% of participants in this study scoring below 60 points, indicating “poor” diet quality. Pregnancy stage and residential area were associated with diet quality. Pregnant women in the early and middle stages of pregnancy had worse scores than those in the late stage, while suburban and rural women had worse scores than urban women. Relevant health education should be strengthened to guide pregnant women in making reasonable food choices, especially those living in suburban and rural areas and those in their first and second trimesters.

Declarations

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Authors' contributions

Z.W., J.Z., C.W. and C.G. designed research; Z.W. and J.S. analyzed data; Z.W., J.S. and Y.W. wrote the paper; X.C, Q.S., Z.S. and W.J. conducted research; All authors have read and approved the final manuscript.

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Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Shanghai Municipal Centre for Disease Control and Prevention. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Conflict of Interest

All authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Figures

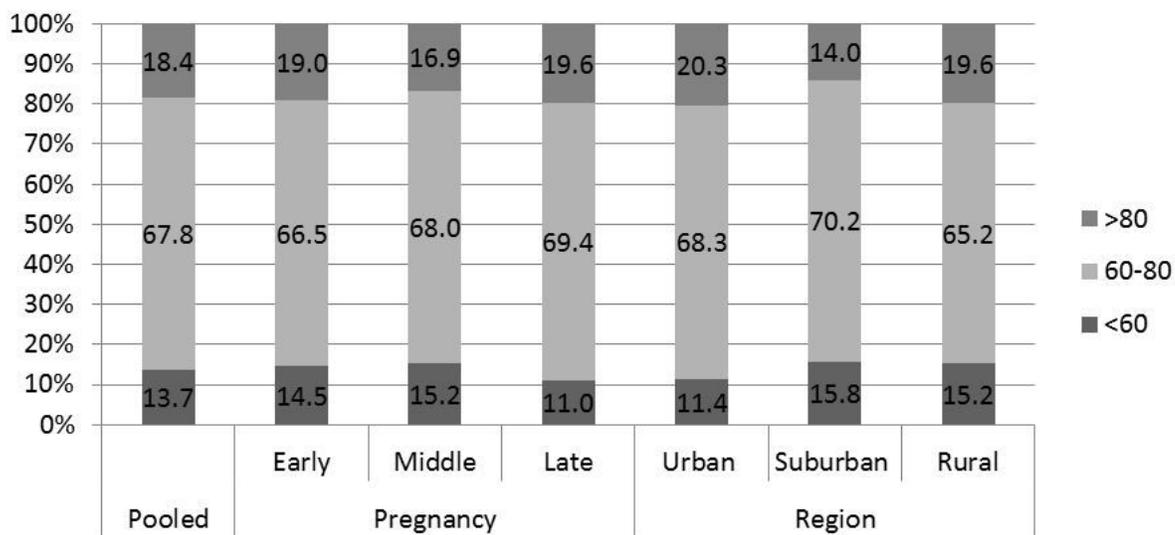


Figure 1

The China Healthy Diet Index (CHDI) composition ratios for the different residential areas and pregnancy stages.