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RESEARCH

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Integrative development of a concise screening questionnaire for early detection of pregnant women at risk for dystrophy

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Abstract

Background Maintaining a healthy diet during pregnancy is vital for reducing the risk of adverse birth outcomes. However, conventional methods of assessing the dietary behavior of pregnant women, such as the FFQ, are often time-consuming. This study aims to develop a concise nutritional screening questionnaire tailored for pregnant women, empowering prenatal healthcare providers to quickly identify key adverse dietary behaviors and provide targeted guidance.

Methods To validate the Pregnancy Nutrition Checklist, we enrolled 208 women in early pregnancy and 200 women were included to analysis (with an average age of 31.54 ± 4.24 years). Spearman rank correlation analysis was used to assess the relative reliability of the Pregnancy Nutrition Checklist compared with the FFQ scale. Exploratory factor analysis was used to test the structural validity of the scale. A generalized linear model was used to analyze the correlation between dietary behavior and birth weight.

Results The pregnancy nutrition checklist includes 15 dietary items and 3 other lifestyle habit items. Compared with traditional FFQ questionnaires, the correlation analysis of corresponding items in the pregnancy nutrition checklist revealed statistical significance ($p < 0.05$), except for fat intake. EFA identified three underlying factors, namely, "high-fat foods," "moderate-fat foods," and "low-fat foods," indicating that the questionnaire has good construct validity. Insufficient consumption of vegetables by pregnant women(OR = 2.64, 95% CI: 1.08–6.46, $p = 0.033$) was associated with a significantly greater risk of developing LGA fetuses. Pregnant women whose sugar, coffee, or tea intake did not exceed the classification criteria had significantly greater fetal birth weights than those whose intake exceeded the classification criteria (OR = 3.38, 95% CI: 1.18–9.68, $p = 0.023$). In contrast, consuming fewer highly palatable snacks can reduce the incidence of LGA babies (OR = 0.29, 95% CI: 0.11–0.74, $p = 0.010$).

Conclusions This tool has great potential for identifying unhealthy dietary behaviors, potentially leading to improved pregnancy outcomes.

Trial registration This study was preregistered on May 5, 2023, at the Chinese Clinical Trial Registry (ChiCTR2300071126).

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Introduction

Pregnant women not only need to meet their own nutritional requirements, but also play a crucial role in supporting the development and growth of the fetus [1]. Malnutrition, including both undernutrition and overnutrition, during pregnancy affects gestational weight gain and metabolism and leads to a series of pregnancy complications (e.g., postpartum hemorrhage) and adverse fetal or offspring outcomes (e.g., dystocia, and offspring obesity) [2–4]. Several countries and organizations have issued dietary guidelines for pregnant women, underscoring the importance of optimal nutrition during pregnancy [5–7]. However, the prevalence of malnutrition among pregnant women and the resulting adverse pregnancy outcomes remain concerning [8–10].

A dietary assessment tool for pregnant women can not only understand their dietary status and help develop targeted intervention plans, but also accurately evaluate the effectiveness of interventions [11]. The dietary assessment methods we usually use include weight food record (WFR), 3-day 24-hour review method, dietary frequency method, and dietary quality index [12]. The WFR method is the most accurate way to obtain dietary intake and is often used as the gold standard for dietary assessment [13]. The 3-day 24-hour review method and dietary frequency method require respondents to review their past dietary intake, which is more time-saving and labor-saving compared to the WFR method, but there is a significant recall bias. Moreover, studies have shown that overweight and obese individuals often underreport their intake of high-fat and high carbon foods when reporting [14]. These three dietary assessment methods usually require more time, more professional investigators, and more complex analysis, and have significant limitations when used for adults with low education levels. Dietary quality index is a simple evaluation method developed on the basis of other dietary assessments, suitable for a larger and wider population. The objective of a dietary quality index is to assess the overall quality of a person's diet by considering various aspects like variety, adequacy, moderation, and balance across different food groups, ultimately aiming to evaluate how well a diet al.igns with established dietary guidelines and potentially predict the risk of diet-related chronic diseases; it provides a numerical score that reflects the overall healthfulness of someone's eating patterns [15]. But the formation of dietary index is based on the health needs of the general population. Pregnant women are in a special physiological state, and their needs for various diets and nutrients are different from those of ordinary people. Therefore, we hope to develop an evaluation tool for pregnant women that combines the accuracy of traditional dietary surveys with the convenience of dietary quality index.

The review by Kee June Ooi et al. showed that among the six maternal dietary scoring tools in high-income countries, only one reference standard came from the Maternal Dietary Guidelines [16, 17]. A validated questionnaire is crucial for accurately assessing the dietary status of pregnant women and predicting possible outcomes [18]. Prior validation, such as correlation analysis between dietary survey results and current health status or FFQ dietary assessment results, and posterior validation, such as correlation analysis between dietary survey results and long-term health status and delivery outcomes, are commonly used validation methods. Only one of the six studies included gestational weight gain as an effectiveness measure [19]. The review results of Liska Robb et al. showed that dietary assessment tools for pregnant women mostly come from developed countries (9/11), and the reference standards for dietary assessment tools for pregnant women are mostly general population dietary guidelines [20]. The selection of dietary components often includes grains, fruits, vegetables, etc., with only one questionnaire distinguishing between dark and light colored vegetables; The classification of meat is mostly white meat, red meat, fish, etc [20]. Therefore, it is essential to establish an accurate and effective method for assessing pregnant women's dietary intake across various food categories and to develop dietary guidance tailored to their specific needs.

The aim of this study is to develop a simple dietary assessment tool for pregnant women in developing countries, and to use multiple biological indicators and pregnancy outcomes to conduct prior and predictive evaluations of the questionnaire's effectiveness, in order to better assess the dietary status of Chinese pregnant women.

Methods

Study population

The study population was derived from the Effect and Mechanism of Lipid-focused Nutrition Education Intervention in Pregnancy on Adverse Pregnancy Outcomes in Chinese Women (TELNEI) study [21], which is a multicenter randomized controlled trial conducted in China. This study aimed to assess the effectiveness of prenatal nutritional behavior interventions grounded in behavior change theory in reducing adverse pregnancy outcomes. Detailed information about this study can be accessed on the Chinese Clinical Trial Registry website (https://www.chictr.org.cn/) by searching for the clinical registration number (ChiCTR2300071126). The study was approved by the ethical approval from the Capital Medical University Ethics Committee(Z2022SY077, Z2023SY137). The inclusion and exclusion criteria for the study population can be found in the protocol [21]. From May 22, 2023, to December 1, 2023, early pregnant women were recruited at the obstetric clinic. This study follows the STARD(2015) reporting guidelines.

Basic information and physical measurements

The basic information of pregnant women, such as age, education level, parity, occupation, height, and weight, will be inquired about by the community health service center where the pregnant woman is located and uploaded to the Beijing Maternal and Child Phase II System. Our data is downloaded and organized from the system (pregnant women's pre-pregnancy weight and height are mostly recalled and reported by the pregnant women themselves, and those who are unclear will measure their weight on-site at the health service center as pre-pregnancy weight). Pre-pregnancy body mass index (Pre-BMI) is calculated as weight (kg)/height (m)^2.

Blood measurements

Trained nurses collect peripheral blood samples from pregnant women after fasting for at least 8 h. Collect 3 milliliters of peripheral blood from pregnant women using vacuum venous blood collection tubes, centrifuge at 4000 rpm for 5 min at room temperature, and collect the upper layer of serum for analysis. Total bilirubin, direct bilirubin, triglycerides, total cholesterol, high-density lipoprotein, low-density lipoprotein, apolipoprotein a1, apolipoprotein b1, serum potassium, calcium, phosphorus, sodium, chlorine, and ferritin were measured through a Hitachi 7600 instrument.

Dietary measurements

Although WFR is the gold standard for dietary surveys, the food frequency questionnaire (FFQ) is more commonly used in validation studies of dietary indices for pregnant women [13]. In this study, given that the site was a clinical outpatient clinic and pregnant women did not have sufficient time, we also used the FFQ as a criterion for dietary assessment. A food frequency questionnaire [22–24] was used to assess dietary intake, comprising 17 food categories, including whole grains, tubers, vegetables, dark vegetables, fruits categorized by glycemic index (high, moderate, and low), preserves, red meat, fatty meat, seafood, soybean products, dairy, beverage, nuts, and snacks. Additionally, the investigation extended to various cooking methods such as stir-frying, barbecuing, frying, steaming, etc. The estimation of portion size includes using references such as palms, fingers, plates, etc., with frequencies ranging from no consumption to three or more times a day, for a total of six options. This study only used dietary consumption frequency as an analytical indicator.

Pregnancy nutrition checklist

The items of the pregnancy nutrition checklist questionnaire were formed with reference to the 14-point Mediterranean Diet Adherence Screener (MEDAS) [18], the 9-point low-fat diet adherence questionnaire [19], and the International Federation of Gynecology and Obstetrics (FIGO) Nutrition Checklist [20]. Additionally, we referred to the Chinese Dietary Guidelines [21]. We created a library of scale entries by referring to the question types of the above scales. The options of the scale, i.e., the cut-off values for determining whether or not the standard is met, are based on the recommendations given by the Dietary Guidelines for Pregnant Women in China. The final scale mainly includes 15 dietary issues and two behavioral issues (Table 1), where the intake of vegetables, fruits, seafood, dairy, and animal meat in mid to late pregnancy is adjusted based on early pregnancy (before 12^{+6} weeks). All adjustments are based on the dietary guidelines for pregnant women in the Chinese Dietary Guidelines for Residents (see Supplement Table 2 for details). Based on the different dietary intake cut-off values, pregnant women will be categorized into adequate or inadequate intake groups, excessive or moderate intake groups, and inadequate, moderate, or excessive intake groups.

Statistical analyses

Prior to analysis, 8 pregnant women were excluded because of incomplete basic information and dietary questionnaire responses, resulting in a total of 200 pregnant women being included in the final analytic dataset. The sample size of this study is 10 times the number of items in the scale, which meets the sample size requirement. For demographic information, continuous variables are described as the means±standard deviations, and categorical variables are described as frequency percentages. Data analysis was conducted via R software and SPSS version 25. The following statistical packages were used: "readxl", "tableone".

Relative validity

Based on the screening table, we categorized the FFQ items into whole grains, tubers, vegetables, dark vegetables, fruits with a high glycemic index (GI), fruits with a moderate GI, fruits with a low GI, preserves, red meat, fat meat, seafood, soybean products, milk products, beverages, nuts, snacks, fast foods, fried foods, grilled foods, fried cooking, steaming and grilling. To test the relative validity between the Pregnancy Nutrition Checklist and reference questions from the FFQ, Spearman rank correlation coefficients were used for the scale data of each

Table 1 Pregnancy nutrition checklist items

Over the past two weeks	Criteria for recommendations
Q1 How many times a week do you eat whole cereals, coarse cereals, or tubers	Almost once a day
Q2 The proportion of daily whole cereals, coarse cereals, or tubers to staple food	More than one-third
Q3 Edible oil (used for stir-frying, salads, fried foods, eating out, and homemade meals, etc.)	Less than 25 ml
Q4 How many grams of vegetables can you eat every day	More than 300 g
Q5 The proportion of daily dark vegetables to total vegetable intake	More than one-two
Q6 How many grams of fruits can you eat every day	More than 200 g, less than 300 g
Q7 How many grams of red meat can you eat every day	More than 40 g, less than 65 g
Q8 How many grams of fat (margarine, butter, lard (animal fat)) can you eat every day	Less than 10 g
Q9 How many milliliters of sugary drinks, coffee, or tea do you drink every day	Less than 100 ml
Q10 How many grams/times of soybeans and soybean products can you eat every week	More than 100 g or 3–4 times a week
Q11 How many grams/times of seafood can you eat every day/week	More than 40 g or 2–3 times a week
Q12 How many times per week do you consume highly palatable foods	Less than 2 times a week
Q13 How many milliliters of milk do you drink every day.	More than 300 ml
Q14 How many grams of nuts can you eat every day	About 70 g a week
Q15 Have you started to reduce frying and grilling, and have you been removing the skin and fatty parts of meats such as chicken, duck and fish?	Yes
Q16 Do you smoke	NO
Q17 Do you drink alcohol	NO
Q18 Have you taken any nutritional supplements after pregnancy, such as folic acid, iron supplements, calcium tablets, or other multivitamins.	Specific explanation

diet behavior [25]. Pregnant women were divided into two or three groups based on each dietary behavior item on the pregnancy nutrition checklist. The objective indicators for this analysis will be maternal serum metabolic indicators. The objective of this study was to examine variations in metabolic indicators across different groups and validate the calibration of the scale.

Construct validity

Finally, factor analysis through principal component analysis(PCA) and QUARTIMAX rotation were used to extract factors with eigenvalues greater than 1. The number of factor extractions was determined based on the gravel plot and variance interpretation [26]. Then, PCA was repeated, and QUARTIMAX rotation was used to extract a fixed number of factors to obtain the final analysis results and verify the structural validity of the scale. Generalized linear regression was used to analyze the correlation between diet and birth weight. The test level $\alpha < 0.05$ was taken as the criterion.

Test-retest reliability

After 32 weeks, the pregnant woman will undergo a dietary assessment again using the Pregnancy Nutrition Checklist. Because the survey results were all binary or ternary ordered variables, and dietary guidance was provided to pregnant women during the survey process, non-parametric tests were used to screen for changes in pregnant women's diets.

Table 2 Demographics and pregnancy information ($N = 200$)

Demographic characteristics	Mean ± SD/*n*(%)
Age, year	31.54 ± 4.24
Height, cm	162.23 ± 4.94
Weight, kg	58.95 ± 9.11
Pre-BMI	22.44 ± 3.23
Occupation (%)	
Office work	146(73.0)
Commercial and service Works	38 (19.0)
Full time at home	16 (8.0)
Education (%)	
College degree or below	48 (24.0)
Bachelor degree	103 (51.5)
Graduate degree	49 (24.5)
Parity (%)	
Parity 1	156 (78.0)
Parity 2 and above	44 (22.0)

Results

General characteristics

The study included 200 pregnant women, with an average age of 31.54±4.24 years and a Pre-BMI of 22.44±3.23 kg/m^2. Among them, 73.0% were employed in office settings, and 76% held a bachelor's degree or above. Additionally, 78% of the pregnant women were primiparous (Table 2). The average completion time for the Pregnancy Nutrition Checklist was 4.16±2.13 min.

Table 3 Relative validity of pregnancy nutrition checklist and reference Instruments

Checklist items	FFQ items	R[a]	p-value
Q1 Whole cereals and Tubers	Whole grains	0.40	< 0.001
	Tubers	0.30	< 0.001
Q2 Proportion of whole cereals and tubers	Whole grains	0.31	< 0.001
	Tubers	0.33	< 0.001
Q3 Edible oil	Frying cooking	0.21	0.003
Q4 Vegetables	Vegetables	0.36	< 0.001
	Dark vegetables	0.16	0.025
Q5 Dark vegetables	Vegetables	0.37	< 0.001
	Dark vegetables	0.44	< 0.001
Q6 Fruits	Fruits with a high GI	0.14	0.046
	Fruits with a moderate GI	0.06	0.430
	Fruits with a low GI	0.27	< 0.001
	Preserves	0.02	0.758
Q7 Red meat	Red meat	0.5	< 0.001
Q8 Fats	Fat meat	-0.05	0.523
Q9 Sugar, coffee or tea drink	Beverage	0.42	< 0.001
Q10 Soybean and soybeans products	Soybean products	0.46	< 0.001
Q 11Sea foods	Sea food	0.46	< 0.001
Q12 Highly palatable foods	Snacks	0.20	0.004
Q13 Milk	Milk products	0.46	< 0.001
Q14 Nuts	Nuts	0.51	< 0.001
Q15 Diet behaviors	Fast foods	0.15	0.040
	Fried foods	0.19	0.006
	Grilled foods	0.19	0.007

[a] Spearman rank correlation; *a < 0.05; **a < 0.01

Table 4 Summary of rotated exploratory factor analysis on the final retained PCI scale items [a]

	Low-fat foods	High-fat foods	Moderate-fat foods
Q1 Tubers and whole cereal	0.693	0.005	-0.059
Q2 Proportion of whole cereals and tubers	0.625	-0.118	-0.158
Q4 Vegetables	0.520	0.068	-0.029
Q10 Soybeans and soybeans products	0.461	0.059	0.108
Q5 Dark vegetables	0.457	0.001	0.166
Q6 Fruits	0.289	0.093	0.167
Q8 Fats	0.035	0.721	-0.029
Q9 Sugar, coffee or tea drinks	-0.087	0.677	-0.023
Q12 Highly palatable foods	-0.048	0.461	0.023
Q15 Diet behavior	0.103	0.442	-0.176
Q3 Edible oil	0.120	0.375	0.027
Q13 Milk	-0.102	-0.042	0.659
Q11 Sea foods	0.184	-0.078	0.625
Q7 Red meat	0.188	0.332	0.565
Q14 Nuts	0.045	-0.141	0.419
Accumulate Explained Variance Percent	12.573	23.618	32.711
Accumulate Explained Variance Percent after rotation	11.751	23.051	32.711

[a] Extraction Method: Principal Component; Rotation: QUARTIMAX

Questionnaire validation

The Cronbach's alpha coefficient of the FFQ is 0.76, and the half coefficient is 0.767, indicating acceptable questionnaire reliability. Table 3 shows statistically significant correlation coefficients between various types of food and the question categories in the FFQ, except for animal fat. The correlation coefficient ranges from 0.13 to 0.49. Diet has the potential to influence metabolic indicators, and this relationship can be assessed. The correlation analysis between the early pregnancy diet and serum metabolic indicators showed that uric acid was higher in pregnant women with excessive edible oil intake and those with inadequate intake of soybean and soybean products ($p=0.010;p=0.027$). Triglycerides, HDL, apoa1, and apob1 were significantly higher in pregnant women with higher red and fatty meat intake. Pregnant women with higher red meat intake also had higher hemoglobin levels (supplement Table 1).

Through PCA and QUARTIMAX rotation, three factors were ultimately obtained, as shown in Table 4. The sample size of this study is approximately 10 times that of the items. Because the options are all binary, the Kaiser−Meyer−Olkin test result of this questionnaire was 0.521. Bartlett's test of sphericity was highly significant ($p<0.001$), indicating that the variables were correlated in the population. The factor loadings of these items, except for fruits, are all greater than 0.3, indicating that the scale has good structural validity.

The results of Table 5 show that among the 98 pregnant women who underwent repeated testing, the recommended intake of low-fat and moderate-fat foods, except for seafood, significantly increased, while the intake of non-recommended high-fat foods did not increase or decrease.

Table 6 shows the relationships between birth weight and various types of food intake. The results revealed that pregnant women whose vegetable consumption reached or exceeded the classification criteria had significantly lower fetal birth weights (OR = 2.64, 95% CI: 1.08–6.46, p = 0.033). Pregnant women whose sugar, coffee, or tea intake did not exceed the classification criteria had significantly greater fetal birth weights than those whose intake exceeded the classification criteria (OR = 3.38, 95% CI: 1.18–9.68, p = 0.023). Pregnant women whose intake of highly palatable foods exceeded the classification criteria had significantly greater fetal birth weights than those whose intake did not exceed the classification criteria (OR = 0.29, 95% CI: 0.11–0.74, p = 0.010).

Discussion

This study introduces a concise prenatal nutrition screening scale, the pregnancy nutrition checklist, comprising 15 food and beverage behaviors and 3 lifestyle behaviors (Table 1). Through various statistical comparisons, the pregnancy nutrition checklist has proven to be effective in reflecting the dietary status of pregnant women and identifying differences in various biochemical indicators, making it highly feasible for clinical application.

Table 5 Analysis of the difference in dietary assessment results between two repeated measurements using the Pregnancy Nutrition Checklist

Influencing Factors		First test	Re-test	*p*
Q1 Whole cereals and Tubers [a]	Below	43(43.9)	26(26.5)	0.010
	Meet	55 (56.1)	72 (73.5)	
Q2 Proportion of whole cereals and tubers [b]	Below	57 (58.2)	32 (32.7)	< 0.001
	Meet	34 (34.7)	53 (54.1)	
	Above	7 (7.1)	13 (13.3)	
Q3 Edible oil [a]	Below	75(76.5)	74(75.5)	1.000
	Above	23 (23.5)	24 (24.5)	
Q4 Vegetables [a]	Below	47(48.0)	24(24.5)	0.001
	Meet	51 (52.0)	74 (75.5)	
Q5 Dark vegetables [b]	Below	47 (48.0)	26 (26.5)	0.004
	Meet	41 (41.8)	59 (60.2)	
	Above	10 (10.2)	13 (13.3)	
Q6 Fruits [b]	Below	12 (12.2)	10 (10.2)	0.052
	Meet	63 (64.3)	81 (82.7)	
	Above	23 (23.5)	7 (7.1)	
Q7 Red meat [b]	Below	52 (53.1)	15 (15.3)	< 0.001
	Meet	35 (35.7)	69 (70.4)	
	Above	11 (11.2)	14 (14.3)	
Q8 Fats [a]	Below	86(87.8)	78 (79.6)	0.170
	Above	12 (12.2)	20(20.4)	
Q9 Sugar, coffee or tea drink [a]	Below	81(82.7)	73 (74.5)	0.201
	Above	17 (17.3)	25(25.5)	
Q10 Soybean and soybeans products [a]	Below	33(33.7)	84(85.7)	< 0.001
	Meet	65 (66.3)	14 (14.3)	
Q 11Sea foods [a]	Below	51(52.0)	44(44.9)	0.296
	Meet	47 (48.0)	54 (55.1)	
Q12 Highly palatable foods [a]	Below	70(714.)	73(74.5)	0.749
	Above	28 (28.6)	25 (25.5)	
Q13 Milk [a]	Below	54(55.1)	18(18.4)	< 0.001
	Meet	44 (44.9)	80 (81.6)	
Q14 Nuts [a]	Below	48(49.0)	28(28.6)	0.004
	Meet	50 (51.0)	70 (71.4)	
Q15 Diet behaviors [a]	Below	88(89.8)	91(92.9)	0.607
	Above	10 (10.2)	7 (7.1)	

[a] Mcnemar test, [b] Kendall's W test

Table 6 Correlation analysis between dietary compliance and birth weight [a]

Influencing Factors		B	OR	OR Value of 95% of CI	*p* Value
Q1 Whole cereals and Tubers	Below	0.28	1.33	0.53to3.31	0.543
	Meet	--	--	--	--
Q2 Proportion of whole cereals and tubers	Below	-0.08	0.92	0.12to6.88	0.935
	Meet	0.39	1.48	0.19to11.52	0.711
	Above	--	--	--	--
Q3 Edible oil	Below	-0.69	0.50	0.20to1.27	0.146
	Above	--	--	--	--
Q4 Vegetables	Below	0.97	2.64	1.08to6.46	0.033
	Meet	--	--	--	--
Q5 Dark vegetables	Below	-0.97	0.38	0.10to1.43	0.151
	Meet	-0.88	0.42	0.11to1.57	0.195
	Above	--	--	--	--
Q6 Fruits	Below	0.47	1.60	0.43to5.9	0.484
	Meet	-0.11	0.89	0.36to2.23	0.807
	Above	--	--	--	--
Q7 Red meat	Below	0.05	1.05	0.21to5.17	0.954
	Meet	0.15	1.17	0.24to5.61	0.849
	Above	--	--	--	--
Q8 Fats	Below	0.26	1.30	0.39to4.28	0.671
	Above	--	--	--	--
Q9 Sugar, coffee or tea drink	Below	1.22	3.38	1.18to9.68	0.023
	Above	--	--	--	--
Q10 Soybean and soybeans products	Below	-0.22	0.81	0.3to2.19	0.670
	Meet	--	--	--	--
Q 11Sea foods	Below	-0.3	0.74	0.32to1.73	0.490
	Meet	--	--	--	--
Q12 Highly palatable foods	Below	-1.23	0.29	0.11to0.74	0.010
	Above	--	--	--	--
Q13 Milk	Below	-0.85	0.43	0.18to1.01	0.052
	Meet	--	--	--	--
Q14 Nuts	Below	-0.05	0.95	0.42to2.17	0.904
	Meet	--	--	--	--
Q15 Diet behaviors	Below	-0.84	0.43	0.10to1.78	0.244
	Above	--	--	--	--

a: Newborns with measured birth weights below the 10th percentile for gestational age for the same sex (P10) were evaluated as small-for-gestational age(SGA); above the 90th percentile for gestational age for the same sex (P90) were assessed as large-for-gestational age(LGA); and between P10 and P90 for gestational age for the same sex were evaluated as appropriate-for-gestational age(AGA)

In this study, the average time for pregnant women to complete the FFQ questionnaire was 15.9±5.5 min, and the time required to complete the pregnancy nutrition checklist was 4.2±2.1 min. The FFQ questionnaire needs to be calculated based on the frequency and portion size of various foods after completion, leading to a longer duration from completion to obtaining results [27–29]. This scale summarizes the dietary categories of pregnant women that have been the focus of many studies. With reference to the Dietary Guidelines for Pregnant Women in China, the pictures and contents of the Dietary Guidelines have been reduced to 15 yes or no questions, each of which contains a method of measuring dietary portion size so that pregnant women can answer as accurately as possible and at the same time, help clinicians to immediately understand whether or not a specific type of diet complies with the standards for pregnant women. The 15 questions not only included the staples, vegetables, fruits, proteins, nuts, and cooking oils highlighted in the dietary pagoda but also highlighted the proportion of whole and mixed grains and dark-green vegetables. We have also included four unrecommended food groups, including the guidance on fatty meats, sugary drinks, highly palatable snacks, and fried foods, which are not mentioned in the Dietary Guidelines. Dietary feedback is automatically generated once all questions are completed and submitted. The feedback includes the health benefits and harms of each food group, the harms caused by insufficient or excessive intake, and how to make your diet satisfy the requirements in your daily life in a simple way.

Non-nutritionist clinical obstetricians can use questionnaires as a guide and conduct brief inquiries to quickly and conveniently understand the main unhealthy diets and behaviors of pregnant women and then re-emphasize to pregnant women in an authoritative capacity based on the feedback given by us to increase the likelihood of pregnant women changing their dietary behaviors. Additionally, using food categories as the question stem not only reduces the number of questions and response time but also enhances the inclusiveness of the question stem, covering a wider range of foods and facilitating response accuracy [27].

Pregnant women and related medical personnel generally have a low level of understanding of basic nutrition-related knowledge [30]. A survey in China revealed that the average awareness rate of basic nutritional knowledge among normal pregnant women is significantly higher than that of gestational diabetes mellitus (GDM), but does not exceed 50% [31]. Among medical personnel, the average awareness rate of pregnancy nutrition among doctors is 68.04%, and that of nurses is 64.41% [31]. Higher health literacy among women can help reduce the risk of obesity, improve diet, and increase the weight and height of offspring [32]. Due to limited access to nutritionists, popularizing prenatal dietary assessment and guidance is a challenge [33]. In China, pre-pregnancy and prenatal care are an important measure for reducing the incidence and mortality rates of complications in pregnant women and fetuses, as well as for reducing the incidence of birth defects [34]. Community hospitals and obstetricians are responsible for the main prenatal care work. Pregnant women lack nutrition knowledge, and learning a large amount of nutrition knowledge and improving nutrition in a short period of time is a challenge. Therefore, the development of a simple nutritional assessment and guidance questionnaire for clinical doctors is needed. Through simple inquiries, the main unhealthy dietary behaviors of pregnant women can be identified. This approach allows highly feasible and specific nutritional behavior guidance. For example, if a pregnant woman is currently experiencing iron deficiency and consumes less than one palm-sized portion of red meat per day without other iron supplements, a direct recommendation can be made to increase her daily intake of red meat, such as beef or lamb. This will help improve the efficiency and effectiveness of maternal nutrition and healthcare. When pregnant women can fully adhere to the pregnancy nutrition checklist, they will likely achieve a balanced diet. If time and energy permit, screening can be conducted through FFQ dietary surveys, and more nutritional knowledge can be learned.

The 15 dietary behavior questions in this questionnaire focus on six nutrients: dietary fiber, fat, sugar, calcium, iron, and protein, among which fat includes plant fat, animal fat, and unsaturated fatty acids. Dietary behaviors include dietary behaviors and cooking behaviors. Three lifestyle behaviors are alcohol consumption and smoking, which are known to be highly correlated with fetal malformations and are therefore added as screening indicators at the end of the questionnaire [35]. Whole grains, tubers, fruits, and vegetables are important sources of dietary fiber. Studies have shown that dietary fiber intake is associated with appropriate weight gain during pregnancy, reduced GDM, and prevention of constipation [36, 37]. Although the correlation coefficients between fat-related questions and the questions in the dietary FFQ questionnaire were not statistically significant, they addressed important dietary aspects such as cooking oils, nuts, seafood, and cooking methods that jointly determine dietary fat content. Moreover, studies have shown that excessive animal fat, including cholesterol and monounsaturated fatty acid intake, increases the risk of GDM [38]. The results of our analysis similarly showed that excessive fatty meat intake increased cholesterol in pregnant women. Therefore, fat-related questions are retained in the questionnaire as a reminder item in the guidance. Red meat is an important source of divalent iron, which helps prevent iron deficiency and the resulting anemia in pregnant women. This study showed that pregnant women who consumed more red meat had a significant increase in Hb. Milk is the main source of calcium, and the Chinese Dietary Guidelines for Pregnant Women recommend the daily consumption of no less than 300 ml of milk during pregnancy to supplement calcium and protein, which can help alleviate lower back and leg pain caused by calcium deficiency [39]. Highly palatable foods and beverages present characteristics such as high sugar, high salt, and high-fat content. Coffee and milk tea, in particular, contain caffeine, which can affect the mother's metabolism and fetal health [35, 40]. Soybeans are an important source of plant protein, and the Chinese Dietary Guidelines recommend that pregnant women consume 20 g of protein per day. Studies have shown that plant protein intake is a protective factor for against GDM [41]. Therefore, this scale covers common issues of dietary fiber, calcium, iron, protein, polyunsaturated fatty acid deficiency, and excessive sugar and fat levels during pregnancy and childbirth. This approach can help pregnant women with limited nutritional knowledge quickly identify dietary problems, prevent calcium and iron deficiencies, mitigate constipation, and even prevent GDM and other adverse pregnancy outcomes.

The repeated measures showed a significant increase in the intake of foods such as coarse grains, vegetables, milk, and nuts, which we encouraged pregnant women to increase their intake of, while there was no significant improvement in the intake of foods such as fatty meats, highly palatable snacks, and sugar-sweetened beverages, which we encouraged to decrease their intake of. This may be due to increased craving for highly palatable foods during pregnancy leading to difficulty in overcoming the temptation of such foods [42]. The fact that pre-packaged high palatable snacks and drinks can be more convenient and quicker to help pregnant women to obtain energy is also one of the important reasons. This also suggests that future interventions should focus on helping pregnant women to overcome the barriers to reducing the intake of high-energy, low-nutrient foods, such as by providing healthier and more convenient alternatives to pregnant women's snacks.

The 2016 dietary survey of pregnant women in Shaanxi Province sorted and analyzed the proportions of energy sources and extracted five important food groups. The main sources of energy for pregnant women are snacks (19%), poultry and livestock meat (16%), and edible oil (11%), whereas the main sources of fat are edible oil (25%), meat (24%), and nuts (16%) [40]. Table 4 shows that excessive intake of edible oil and highly palatable snacks significantly increases fetal birth weight, whereas consuming more vegetables helps to reduce fetal birth weight. The current dietary issues among pregnant women and the dietary behaviors highly correlated with fetal birth weight that we screened are consistent, further indicating that replacing highly palatable snacks with vegetables and fruits and controlling oil intake will help improve pregnancy outcomes.

Burgraff et al. summarize the preferred features of a priori indices for the questionnaire validation process, including theoretical framework, index structure, indicator selection, normalization methods, valuation function, weighting and aggregation [43]. Against the above summary, first, our checklist covered all key aspects of diet, including adequacy (enough or not), moderation (not exceeding the limit level), and balance (right proportion). Second, our checklist was arranged in a clear and nested structure, with eating behaviors at the beginning and cooking and lifestyle questions at the end. Third, we used food-group indicators so the checklist is more understandable for individuals receiving health advice. We carefully select components for accuracy and ease of use. Fourth, we set meaning standards and use normative cutoff values (set standards by referring to the Chinese dietary guidelines). Fifth, we added all the scores and used scoring that reflects complex health relationships.

The main limitation of this study stems from its focus on pregnant women from Beijing, the capital city of China, with 76% possessing a bachelor's degree or higher, thus potentially limiting the generalizability of the questionnaire. Second, the description of the question stem has broad coverage and is more influenced by the individual cognition of pregnant women. Third, although this questionnaire yields research results similar to those of the FFQ and can reflect biochemical indicators, it is not suitable for calculating the specific intake of various foods by pregnant women. Instead, it falls under the category of a relatively rough screening method. Last but not least, due to the survey site and time issues, we used the FFQ rather than the WFR as a criterion for assessing dietary intake to compare with the assessment scales, and the results were somewhat biased.

Conclusion

This scale can effectively screen out the adverse eating behaviors of pregnant women and may change pregnancy outcomes by improving their corresponding behaviors. We designed further randomized controlled clinical trials to compare the effects of rapid screening and guidance through the Pregnancy Nutrition Checklist on the incidence of adverse pregnancy outcomes in pregnant women. This is aimed at better validating the effectiveness of the pregnancy nutrition checklist.

Abbreviations

WFR	Weight food record
FFQs	Food frequency questionnaires
MEDAS	Mediterranean diet adherence screener
FIGO	The international federation of gynecology and obstetrics
TELNEI	The effect and mechanism of lipid-focused nutrition education intervention in pregnancy on adverse pregnancy outcomes in chinese women
EFA	Exploratory factor analysis
Pre-BMI	Pre-pregnancy body mass index
GI	Glycemic index
PCA	Principal component analysis
GDM	Gestational diabetes mellitus
SGA	small-for-gestational age
LGA	large-for-gestational age
AGA	appropriate-for-gestational age

Supplementary Information

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Supplementary material 1

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Author contributions

Huanling Yu and Shengzhi Sun proposed and designed a research plan, and revised and guided the initial draft of the article. Yadi Zhang analyzed the data and co-wrote the first draft of the article with Xiaoge Gao. Xiaxia Cai, Qi Zhou and Haiyan Zhu are responsible for coordinating the site and collecting survey questionnaires. Pamela Ann Koch provided guidance and revisions to this research protocol.

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Data availability

The data can be obtained by contacting the corresponding author via email, email: yuhlzjl@ccmu.edu.cn.

Declarations

Ethics approval and consent to participate

The study was approved by the ethical approval from the Capital Medical University Ethics Committee (Z2022SY077, Z2023SY137). All pregnant women started answering questions after reading the electronic version of the informed consent form and confirming their consent after oral explanation.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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