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Validation and reproducibility of a FFQ focused on pregnant women living in Northeastern Brazil

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Abstract

Objective: The aim of the current study is to assess the validity and reproducibility of a FFQ focused on pregnant women living in Northeastern Brazil.
Design: Three 24-hour-dietary recalls (24 hR) and two FFQ were applied at 15-d intervals between research stages in order to confirm the validity and reproducibility of the FFQ. Validity assessment was based on Pearson's correlation coefficient (PCC) or Spearman's correlation coefficient (SCC) between FFQ and the mean of three 24 hR (the 24 hR was used as reference standard), whereas reproducibility assessment was based on the intraclass correlation coefficient (ICC) among FFQ, and $P < 0{\cdot}05$ was set as significance level.
Setting: Public health network of a capital city in Northeastern Brazil.
Participants: Overall, 100 pregnant women were included in the study.
Results: The PCC or SCC adopted in the validity analysis recorded the recommended values (from 0·4 and 0·7) for energy (0·44; $P < 0{\cdot}001$), carbohydrate (0·40; $P < 0{\cdot}001$), vitamins B_2 (0·40; $P < 0{\cdot}001$), B_5 (0·40; $P < 0{\cdot}001$), E (0·47; $P < 0{\cdot}001$), B_{12} (0·48; $P < 0{\cdot}001$), phosphorus (0·92; $P < 0{\cdot}001$), Mg (0·81; $P < 0{\cdot}001$), Se (0·70; $P < 0{\cdot}001$), cholesterol (0·64; $P < 0{\cdot}001$), saturated (0·76; $P < 0{\cdot}001$), polyunsaturated (0·73; $P < 0{\cdot}001$) and monounsaturated fats (0·87; $P < 0{\cdot}001$) and fibres (0·77; $P < 0{\cdot}001$). Mg (0·72; $P < 0{\cdot}001$), Fe (0·65; $P < 0{\cdot}001$), lipid (0·56; $P < 0{\cdot}001$) and energy (0·55; $P < 0{\cdot}001$) presented ICC within the recommended reproducibility values.
Conclusions: The FFQ developed in the current study is a useful tool to assess the usual food intake of pregnant women.

Keywords
Food survey
Pregnancy
Shelf life
Northeastern region
Brazil

Pregnancy encompasses a series of physiological, metabolic and nutritional adaptations in women's body[1,2], since rapid fetal growth and development demand different energy nutrient intake[1]. It is essential meeting this demand to assure the adequate health of the mother–child binomial, mainly due to the critical window of opportunities for fetal development[3,4]. Thus, pregnant women represent an attractive population group, whose eating habits must be well understood to help assessing future pregnancy outcomes[4,5].

The number of surveys gathering information about populations' dietary and health standards has increased in recent years, mainly when it comes to pregnant women[6–8], since this population has been associated with the epidemiologic transition, whose expressive increase lies on the worrying incidence of chronic non-communicable diseases[9,10].

Thus, different methods have been used to assess food intake[11,12] – food record and 24-hour-dietary recall (24 hR) are the most used ones[13,14]. However, these methods can lead to underreported food intake, since it is necessary adopting multiple applications to minimise intra and interpersonal, as well as seasonal, variations[15,16]. Therefore, the FFQ developed and validated for the herein investigated population is a valuable tool that allows investigating the usual diet of the target group in a proper manner[12].

Given the lack of validated methods to analyse the food intake of pregnant women, the aim of the current study was to validate and evaluate the reproducibility of a FFQ developed for pregnant women living in Northeastern Brazil.

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Methods

Sample

FFQ validation study and reproducibility analysis were carried out with pregnant women treated in the public health network in Maceió City (AL) in 2019.

Maceió City is located in Northeastern Brazil; its estimated population comprises 1 018 948 inhabitants and its Municipal Human Development Index is 0·721[17].

Nowadays, the local public health network is strategically divided into eight health districts comprising the total number of sixty-seven Basic Health Units (BHU). A random drawing of two BHU per health district (sixteen units, in total) was carried out to select the BHU in the current study. After the BHU definition process was over, the number of pregnant women treated in each unit was identified based on a list provided by the Municipal Health Department. Subsequently, the healthcare contribution rate of each unit was calculated, and the resulting values were used to calculate the proportional distribution of pregnant women to be recruited.

Recommendations by Cade *et al.*[11] and Serra-Majem *et al.*[18] were used to define the sample size, which comprised 100 pregnant women.

The inclusion criteria set for individuals' participation in the study were: 25-to-35-week pregnant women living in Maceió City, who were treated in the local public health network (the FFQ was developed to assess participants' food intake in the last six gestational months). Pregnant women with multiple pregnancies, with chronic or specific gestational diseases, illiterate, diagnosed with cognitive issues, as well as those with neurological or locomotion issues capable of hindering the interview or the anthropometric assessment were not included in the study.

Participants were recruited through convenience method at prenatal consultation time, when information about them was initially checked in their medical records by taking into consideration previously defined exclusion and inclusion criteria. Once participants met these criteria, they were invited to participate in the research. Those who agreed to participate in it were subjected to the first interview.

Maternal data

Properly trained interviewers were in charge of collecting participants' data; each interviewer accounted for applying all research stages to the same volunteer. Pregnant women were given a standardised questionnaire comprising socioeconomic (family income, receipt of government assistance, education and marital status), lifestyle (physical activity, drinking and smoking habits), obstetric (history of abortions or miscarriages), number of previous pregnancies and prenatal consultations (use of supplements/medications, among others), food intake (FFQ and 24 hR) and anthropometric assessment information.

Weight variables were measured in Marte LC200® digital scale and height was measured with the aid of Cardiomed® portable stadiometer, at interview time, to assess anthropometric data. These variables were used to calculate participants' BMI; anthropometric diagnosis was based on Atalah Samur and collaborators[19]. In addition, pre-gestational weight (used to calculate pre-gestational BMI) and weight gain during pregnancy were investigated based on the American Institute of Medicine (IOM-USA)[20].

Validation and reproducibility of the FFQ

The FFQ adopted in the current research was developed based on a database comprising 650 24 hR (two per pregnant woman) from a survey carried out in 2013 with pregnant women treated at the BHU in Maceió. The list of food items was defined based on Block *et al.*[21], whose list of food items included food types that contributed to approximately 95 % of nutrients of interest in the current research. The final version of the herein developed FFQ presented 112 food items categorised into food groups based on NOVA classification[22], which defines portion size (small, medium, large) and frequency by taking into consideration daily, weekly and monthly food intake. In addition, the elaborated FFQ was designed to be applied through interviews; it refers to the usual food intake in the last 6 months prior to its application to pregnant women.

Three 24 hR and two FFQ were applied at 15-d intervals between research stages in order to confirm the validity and reproducibility of the FFQ, as shown in Fig. 1.

Data about the first and third 24 hR were collected at the BHU, based on information about participants' food intake 24 h before the interview, which followed the order of meals. A photo album specifically developed for the current research was used to record the consumed food and beverages, the quantity in homemade measures, the preparation form, the place and time of food intake, as well as details about the brand and features of industrialised products. Data about the second 24 hR were collected through phone call 15 d after the first survey – such information corresponded to participants' food intake in atypical days (weekend)[23].

Some aspects were taken into consideration to help pregnant women (pregnant adolescents as well) to better understand the instrument used to assess them, namely (a) illiterate pregnant women were not included in the survey; (b) some aspects were taken into account at FFQ elaboration time to help better understand the applied instrument; among them one finds the vertical format of the instrument (it was considered the most suitable for application in children, elderly and low-schooling populations) enabled presenting the frequency options of each food in separate, as well as including frequency categories and portion sizes in the FFQ to help reduce coding time, error transcription and the number of questionnaires to be rejected due to incomplete or blank answers[11,24]; (c)

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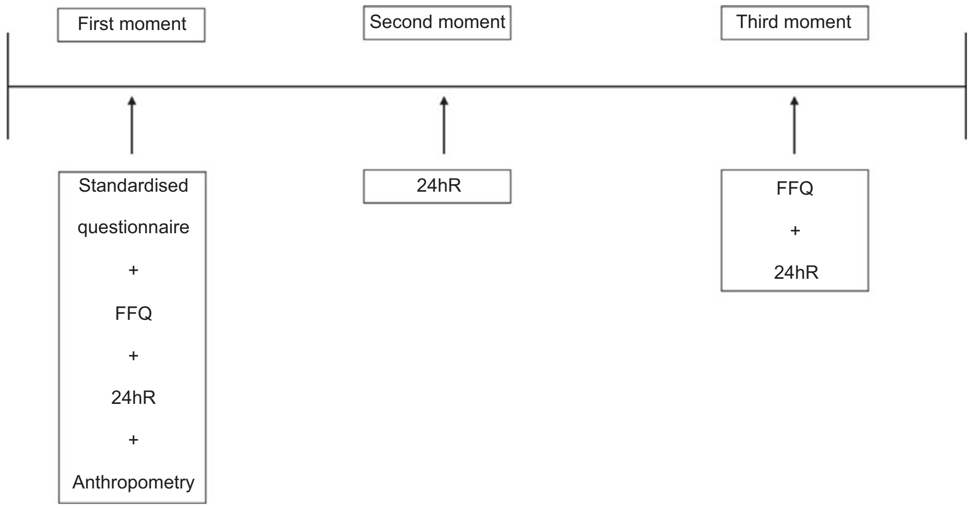

Fig. 1 Systematisation of the validation and reproducibility stages applied to the FFQ developed for pregnant women. Maceió, Alagoas State, Brazil, 2020

the questionnaire was applied by the researcher, who previously informed volunteers about the format and content of the instrument and (d) use of food photo album to help better understand the instrument[25].

Energy and nutrient intake estimates

The food intake frequency reported by the participants was converted into daily intake in g or ml in order to determine the nutritional content of the items included in the FFQ. Food intake frequency was multiplied by the informed portion and the product was defined as daily intake; it was divided by 7 to define weekly food intake, and by 30, for monthly intake.

Subsequently, total energy, macro and micronutrient values of the FFQ and 24 hR were determined based on the nutritional assessment and prescription system (Avanutri 4·0®). Whenever the software did not present nutritional values of regional food items, these items were inserted in it with the aid of the Brazilian Food Composition Table – TACO[26].

Statistical analysis

Data were processed in the Statistical Package for the Social Sciences software version 20.0. The Kolmogorov–Smirnov test was used to assess the normality of variables; logarithmic transformation was applied to variables that did not present Gaussian distribution.

Descriptive statistics results were expressed as means (SD), medians and frequencies. Wilcoxon test was applied to compare the energy, macro and micronutrient values of the FFQ and the mean of the 24 hR.

Pearson's (Gaussian distribution) and Spearman's (variables that did not present Gaussian distribution) correlation coefficients were used to compare the energy and nutrient values of the first FFQ to the mean of all three 24 hR. Correlation values ranging from 0·40 to 0·70 have indicated good agreement between the two food intake assessment methods[27].

Correlation coefficients were adjusted to intrapersonal and interpersonal variability (obtained through ANOVA test) to eliminate likely confounding factors. In order to do so, macro and micronutrients of all three 24 hR were adjusted to energy, based on the residual method[27]. This process comprised the following three steps: (1) constant and regression coefficient were estimated based on a simple linear regression model, according to which, nutrients of interest were adopted as dependent variables and energy was the independent variable; (2) the constant added to the residues was calculated – this variable was used as the predictive value for the nutrient-of-interest intake necessary to meet the mean energy intake by the investigated population and (3) nutrient intake adjusted to energy intake was estimated. In addition, the correlation coefficients attenuated by intrapersonal variability were obtained based on the following formula:

$$R_c = r_o\sqrt{[1 + (S^2{}_W/S^2{}_B)]/n},$$

wherein r_o is the observed correlation, $S^2{}_W/S^2{}_B$ is the intrapersonal/interpersonal variance ratio and n is the number of repetitions of each variable per person[28].

The intraclass correlation coefficients (ICC) of nutrients between the two FFQ were calculated for reproducibility analysis purposes.

P value < 0·05 was significant in all tests.

Results

One hundred pregnant women (mean age of 24·74 (SD 6·35) years) were included in the study: 25·0 % of them were adolescents and 8·0 % were ≥35 years old; mean gestational time at interview time was 29·02 (SD 3·66) weeks.

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Table 1 Features of pregnant women treated in the public health network. Maceió City-Alagoas State, Brazil, 2019

Variables	Total *n* 100	%	Variables	Total *n* 100	%
Age group (years)			Alcohol intake during pregnancy		
≤ 19	25	25·0	Yes	6	6·0
20–34	67	67·0	No	94	94·0
≥ 35	8	8·0	Smoking during pregnancy		
Education			Yes	18	18·0
Incomplete elementary school	27	27·3	No	82	82·0
Complete primary education	7	7·1	Pregnancy complications		
Incomplete high school	20	20·2	Yes	26	26·0
Complete high school	38	38·3	No	74	74·0
Major degree	7	7·1	History of miscarriage		
No information	1		Yes	17	17·2
Monthly family income (R$)			No	82	82·8
< 1 minimum wage	25	25·3	No information	1	
≥ 1 minimum wage	74	74·7	Pre-gestational nutritional status		
No information	1		Low weight	14	14·1
Black race			Eutrophy	55	55·6
Yes	23	23·0	Overweight	22	22·2
No	77	77·0	Obesity	8	8·1
Works outside the home			No information	1	
Yes	34	34·0	Gestational nutritional status		
No	66	66·0	Low weight	28	28·3
Stable union			Eutrophy	35	35·4
No	29	29·0	Overweight	24	24·2
Yes	71	71·0	Obesity	12	12·1
Parity			No information	1	
Nulliparous	44	44·0	Gestational weight gain		
Multiparous	56	56·0	Insufficient	53	53·5
			Adequate	28	28·3
			Excessive	18	18·2
			No information	1	

With respect to participants' socio-economic, lifestyle and anthropometric features, 74·7 % had monthly family income ≥ 1 minimum wage (mean income of R$ 1440·71 (SD 1029·32) reais); 66·0 % reported not to work outside the home; 71·0 % had stable union; 18·0 % were smokers and 6·0 % had alcohol use disorder; 30·3 % were overweight in the pre-pregnancy period; 36·3 % got overweight during pregnancy and 71·7 % of them presented inadequate gestational weight gain (Table 1).

Table 2 shows the median and percentile values (25; 75) recorded for the estimated energy, macro and micronutrient intake reported in FFQ1 and FFQ2 and the 24 hR. There was a significant difference in the intake of most nutrients between FFQ1 and FFQ2, which recorded the lowest values.

Table 3 shows raw, adjusted and attenuated data referring to the FFQ validation. Fourteen out of the total number of twenty-five nutrients have shown correlation ≥ 0·40; according to total raw data, nutrients ranged from 0·92 (phosphorus) to 0·10 (protein, vitamin D, folate and Na). According to the energy-based adjustment, a significant part of the nutrients has shown correlation equal to, or lower than, the raw data - values ranged from 0·43 (energy, carbohydrate and Mg) to 0·02 (vitamin D). Table 3 also shows that correlation coefficients calculated for attenuated data were substantially higher than those calculated for raw data, except for protein, vitamin D, folate and Na, which recorded values equal to the crude coefficients.

Finally, Table 4 presents reproducibility data, which recorded high ICC for Mg ($r = 0·72$), Fe ($r = 0·65$), lipid ($r = 0·56$) and energy ($r = 0·55$), as well as lower ICC for Mn ($r = 0·02$), vitamin B_{12} ($r = 0·07$) and vitamin D ($r = 0·14$). Participants reported greater intake of all nutrients in FFQ1 than in FFQ2.

Discussion

The current study has presented the validity and reproducibility of a FFQ comprising 112 food items, which was specifically developed for pregnant women living in a capital city in Northeastern Brazil. To the best of our knowledge, this is the first survey aimed at testing a FFQ developed for this population by taking into account participants' eating habits and local reality.

The herein proposed FFQ comprised food items often consumed by pregnant women living in the region (manioc, couscous, sweet potatoes); it evaluated twenty-five nutrients and showed adequate validity for this population. The FFQ was the instrument selected to be validated in the current research because it has the advantage of assessing food intake over a long period of time in a simple and economical way[29,30].

Overall, the herein identified nutrients were overestimated in the FFQ in comparison to the 24 hR nutrients, and in FFQ1 in comparison to FFQ2. The Similar fact

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Table 2 Daily intake of energy, macro and micronutrient based on the FFQ1 and FFQ2 and 24 hR of pregnant women treated in the public health network. Maceió City-Alagoas State, Brazil, 2019

	FFQ1		FFQ2		24 hR*	
Nutrient	Median daily intake	P25; P75	Median daily intake	P25; P75	Median daily intake	P25; P75
Energy (kcal/d)	4559·00**	3379·12; 6384·35	3217·00**	2629·10; 4054·50	1971·96	1662·36; 2323·94
Protein (g/d)	172·20**	123·86; 221·86	124·52**	105·50; 157·82	73·25	59·90; 90·57
Carbohydrate (g/d)	616·57**	450·35; 857·14	423·36**	348·22; 547·75	271·05	235·21; 327·54
Lipid (g/d)	183·77**	124·01; 295·18	139·50**	113·95; 193·50	61·41	48·50; 78·75
Vitamin A (RE/d)	2338·66**	1145·29; 3440·50	1959·66**	1066·50; 3181·82	486·12	221·35; 1058·79
Vitamin D (mcg/d)	5·01**	3·0; 12·75	4·02**	3·0; 6·74	1·45	0·64; 2·65
Vitamin B_2 (mg/d)	3·0**	2·0; 4·45	2·16**	1·55; 3·0	1·08	0·81; 1·54
Vitamin B_3 (mg/d)	31·31**	22·15; 48·27	25·94**	19·92; 32·55	15·42	10·52; 21·41
Vitamin B_5 (mg/d)	5·02**	3·29; 7·89	4·0**	3·03; 5·39	1·77	1·14; 2·74
Vitamin B_6 (mg/d)	2·45**	2·0; 3·99	2·13**	1·76; 3·00	0·88	0·66; 1·33
Vitamin E (mg/d)	41·67**	22·69; 63·45	33·54**	22·08; 45·00	9·85	5·24; 18·28
Vitamin B_{12} (mcg/d)	16·0**	8·92; 41·36	17·77**	6·12; 32·99	1·88	1·11; 3·88
Folate (mcg/d)	254·51**	191·25; 398·97	225·78**	150·97; 310·60	75·55	50·97; 130·94
Phosphorus (mg/d)	1739·00**	1206·64; 2407·22	1318·31**	1082·70; 1667·00	839·68	624·60; 1041·40
Mg (mg/d)	362·00**	272·09; 490·05	301·63**	243·39; 373·76	153·56	120·59; 187·56
Fe (mg/d)	24·0**	18·06; 35·75	20·70**	16·00; 27·29	9·58	7·57; 12·30
Zn (mg/d)	12·89**	9·23; 17·76	11·64**	9·00; 14·00	6·78	5·15; 9·10
Se (mcg/d)	116·63**	80·0; 196·72	86·50**	71·55; 112·75	45·93	28·56; 70·16
Mn (mg/d)	3·0**	2·0; 5·0	2·0**	2·0; 3·83	1·16	0·86; 1·63
Na (mg/d)	4437·18**	3408·03; 6296·72	1709·50	1202·50; 2354·00	2023·50	1409·04; 2588·39
Cholesterol (mg/d)	570·50**	370·45; 880·75	526·44**	380·43; 686·75	261·08	166·12; 360·81
Saturated fat (g/d)	39·0**	27·25; 59·63	30·00**	24·00; 40·00	15·48	12·47; 20·61
Polyunsaturated fat (g/d)	27·16**	17·70; 47·83	22·00**	16·88; 28·75	8·65	6·27; 12·79
Monounsaturated fat (g/d)	33·15**	23·16; 47·0	26·65**	20·00; 34·00	13·59	10·52; 17·88
Fibres (g/d)	34·00**	22·82; 46·38	26·91**	20·00; 33·11	15·53	11·91; 18·86

Wilcoxon test; 24 hR: 24-h-dietary recall.
*Mean of three 24 h.
**$P < 0·001$.

Table 3 Correlation coefficient between FFQ1 and the mean recorded for the 24 hR of pregnant women treated in the public health network. Maceió City-Alagoas State, Brazil, 2019

Nutrient	Gross correlation coefficient	Adjusted correlation coefficient	Attenuated correlation coefficient
Energy (kcal/d)	0·44†,***	0·43‡,***	0·48
Protein (g/d)	0·10†	0·10‡	0·10
Carbohydrate (g/d)	0·40†,***	0·43‡,***	0·43
Lipid (g/d)	0·17†	0·17†	0·19
Vitamin A (RE/d)	0·22‡,*	0·22‡,*	0·22
Vitamin D (mcg/d)	0·10‡	0·02‡	0·10
Vitamin B_2 (mg/d)	0·40†,***	0·36‡,***	0·43
Vitamin B_3 (mg/d)	0·11‡	0·10†	0·12
Vitamin B_5 (mg/d)	0·40†,***	0·09†	0·44
Vitamin B_6 (mg/d)	0·14‡	0·14‡	0·15
Vitamin E (mg/d)	0·47†,***	0·09‡	0·50
Vitamin B_{12} (mcg/d)	0·48†,***	0·12‡	0·51
Folate (mcg/d)	0·10‡	0·10‡	0·10
Phosphorus (mg/d)	0·92†,***	0·27‡,**	1·0
Mg (mg/d)	0·81†,***	0·43†,***	0·90
Fe (mg/d)	0·27‡,**	0·27‡,**	0·30
Zn (mg/d)	0·12‡	0·12‡	0·13
Se (mcg/d)	0·70†,***	0·15†	0·78
Mn (mg/d)	0·33‡,**	0·33‡,**	0·36
Na (mg/d)	0·10‡	0·10‡	0·10
Cholesterol (mg/d)	0·64†,***	0·10‡	0·67
Saturated fat (g/d)	0·76†,***	0·19‡,*	0·82
Polyunsaturated fat (g/d)	0·73†,***	0·11‡	0·75
Monounsaturated fat (g/d)	0·87†,***	0·14‡	0·93
Fibres (g/d)	0·77†,***	0·16‡	0·82

*$P < 0·05$.
**$P < 0·01$.
***$P < 0·001$.
†Pearson's correlation with logarithmic variables.
‡Spearman's correlation.

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Table 4 ICC between FFQ1 and FFQ2 applied to pregnant women treated in the public health network. Maceió City-Alagoas State, Brazil, 2019

	FFQ1		FFQ2			
Nutrient	Mean	SD	Mean	SD	ICC	P^*
Energy (kcal/d)	5095·09	2414·17	3669·63	1668·78	0·55	0·000
Protein (g/d)	191·94	98·14	149·06	78·43	0·51	0·000
Carbohydrate (g/d)	706·10	336·93	481·24	210·96	0·50	0·000
Lipid (g/d)	213·60	112·55	168·46	114·35	0·56	0·000
Vitamin A (RE/d)	2622·69	1769·10	2172·33	1296·27	0·45	0·001
Vitamin D (mcg/d)	9·40	10·20	8·18	13·26	0·14	0·227
Vitamin B_2 (mg/d)	3·36	2·25	2·59	1·74	0·33	0·019
Vitamin B_3 (mg/d)	37·99	22·54	29·72	16·77	0·40	0·006
Vitamin B_5 (mg/d)	6·14	4·13	4·53	2·47	0·40	0·008
Vitamin B_6 (mg/d)	3·02	1·60	2·45	1·15	0·40	0·003
Vitamin E (mg/d)	49·11	35·40	35·94	20·60	0·40	0·005
Vitamin B_{12} (mcg/d)	34·13	50·02	25·25	31·68	0·07	0·343
Folate (mcg/d)	350·44	281·14	257·96	149·89	0·48	0·000
Phosphorus (mg/d)	1940·66	1016·43	1515·96	726·06	0·47	0·000
Mg (mg/d)	414·91	229·39	341·99	251·86	0·72	0·000
Fe (mg/d)	30·28	18·90	24·40	14·98	0·65	0·000
Zn (mg/d)	15·18	9·04	12·85	6·32	0·40	0·012
Se (mcg/d)	145·18	91·76	104·89	59·35	0·33	0·012
Mn (mg/d)	4·83	7·53	3·55	6·33	0·02	0·463
Na (mg/d)	5074·23	2376·10	3955·30	1919·43	0·43	0·001
Cholesterol (mg/d)	695·27	459·59	592·48	361·55	0·45	0·001
Saturated fat (g/d)	46·08	27·47	36·89	28·46	0·40	0·009
Polyunsaturated fat (g/d)	33·79	21·88	24·87	12·82	0·30	0·029
Monounsaturated fat (g/d)	36·61	19·36	28·98	15·24	0·44	0·001
Fibres (g/d)	36·66	17·87	27·72	10·35	0·40	0·004

ICC, intraclass correlation coefficient.
$^*P < 0{\cdot}05$.

was also reported in other FFQ validation studies that have used the same survey as reference method[31–33]. Research focused on evaluating the validation and reproducibility of a FFQ adapted to the adult Moroccan population and a study aimed at applying a FFQ developed for Lebanese pregnant women have also identified the overestimation of the instrument in comparison to the 24 hR[34,35]. Overestimation can be justified by the exorbitant description of intake frequency, increased portion size or lack of intake of some food items in the 24 hR. Therefore, overestimation is not an issue in epidemiological studies, since individuals are classified based on food intake levels[36,37]. Because FFQ1 presented higher mean values than FFQ2, results found in other studies were similar to ours. This outcome can be explained by pregnant women's likely adaptation to the applied instrument, as well as by their greater involvement and attention at the time to complete the questionnaire[35,38].

The mean recorded for the unadjusted correlation coefficients between FFQ1 and 24 hR was 0·42–14 nutrients, which were considered valid for women's food intake assessment ($r \geq 0{\cdot}4$)[12]. These values were higher than, or similar to, those reported in other studies conducted with pregnant women, such as the one carried out with Lebanese pregnant women, whose correlation coefficients ranged from 0·29 (Fe) to 0·76 (energy)[34], as well as the study by Ogawa *et al.*[39], who reported correlation coefficients ranging from 0·09 to 0·40 (nutrients) in Japanese women at early pregnancy stage.

Energy-based adjusted correlation coefficients recorded decreased values for almost all nutrients, which may indicate high food intake variation among pregnant women. The mean of coefficients increased from 0·42 to 0·45 after dilution (i.e., after the effects of intrapersonal variance were eliminated) – these values were higher than that reported (0·35) in a study conducted with Brazilian pregnant women living in Ribeirão Preto County/SP[40].

Higher correlation coefficients were observed for phosphorus and monounsaturated fat intake, whose values ranged from 0·92 to 0·87. This finding can be associated with the fact that some food items contributing to the intake of these nutrients were consumed more often or by a larger number of pregnant women.

Results in the current study have indicated FFQ reproducibility for 19/25 (76·0 %) of the evaluated nutrients – ICC ranged from 0·07 (vitamin B_{12}) to 0·72 (Mg). Li *et al.*[41] have investigated healthy pregnant women living in rural China and found similar ICC, according to which fourteen of the eighteen evaluated nutrients presented correlation coefficient ≥0·40 - values ranged from 0·27 to 0·79.

The interval between FFQ applications is extremely important to assure its reproducibility[11]. Thus, FFQ applied at short intervals may have their reproducibility overestimated, since participants can recall previous responses. Conversely, FFQ are expected to present lower reliability in applications carried out over long periods of time, since participants' diet can face sudden changes[11,12]. The current

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study respected the 1-month interval between FFQ applications 1 and 2, as recommended[11].

The following aspects prevailed among pregnant women evaluated in the current study: middle age, complete high school, monthly family income greater than, or equal to, one minimum wage and adequate nutritional status (eutrophy) in the pre-gestational and gestational periods. Changes in these variables represent risk factors for gestational complications[42,43]. It should be noticed that gestational complications were not identified in the evaluated women, as well as that the previous limitation in the selection of pregnant women with non-communicable diseases allowed reducing factors capable of changing participants' food intake.

Limitations observed in 24 hR comprised memory bias; collaboration by interviewees, depending on their ability, psychological conditions and cognitive level; a single recall cannot estimate the usual nutrient intake and difficulty in estimating portion size[30]. The 24 hR is widely used in epidemiological research, since it is a low-cost method that does not affect participants' food intake and can be applied to any age group regardless of educational or socio-economic level[44,45].

It is important highlighting some limitations observed in the current study. It was not possible using more precise methods such as the real Food Register and/or biochemical analyses in order to validate the FFQ; thus, we chose to use 24 hR because it was the most technically feasible method. The mean recorded for three 24 hR (a considerable number of days to assess participants' usual intake) was used to minimise this limitation and to adjust nutrients based on energy in order to minimise correlated errors between the two methods. In addition, it was not possible performing random sampling.

In addition to the limitations observed for the 24 hR, FFQ has method-inherent limitations such as memory bias and response overestimation. However, techniques such as detailed description and review have been adopted to minimise these limitations.

One cannot ignore the fact that one-fourth of the current sample comprised pregnant teenagers. Some studies that brought this population together with groups of children and elderly individuals have shown some difficulty in understanding the elaborated FFQ,[24] which could make these studies viable. The current research has taken some precautions to avoid this type of situation; among them, one finds: illiterate pregnant women were not included in the survey; the questionnaire was prepared in vertical form, which included frequency categories and portion sizes; the instrument was applied by the researcher; and food photo album using.

The current study differs from research already carried out in Brazil because the herein adopted instrument was specifically developed for pregnant women living in a capital city in Northeastern Brazil, which is a region that lacks studies, mainly in the food intake field.

In addition, the elaborated FFQ presented satisfactory validation for energy, carbohydrate, vitamins B_2, B_5, E, B_{12}, phosphorus, Mg, Se, cholesterol, saturated, polyunsaturated and monounsaturated fats, and fibres. Similarly, it has shown satisfactory reproducibility for energy, protein, carbohydrate, lipid, vitamins A, B_3, B_5, B_6 and E, folate, phosphorus, Mg, Fe, Zn, Na, cholesterol, saturated and monounsaturated fats, and fibres.

Therefore, the herein developed FFQ is a potentially useful tool to be used in research context to help determining the routine dietary intake of pregnant women living in Northeastern Brazil.

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