Original Article

High dietary ratio of omega-6 to omega-3 polyunsaturated acids during pregnancy and prevalence of post-partum depression

Camilla M.M. da Rocha* and Gilberto Kac*†

*Graduate Program in Nutrition, Institute of Nutrition Josué de Castro, Federal University of Rio de Janeiro, Rio de Janeiro, RJ, 21941-590, Brazil, and

†Department of Applied and Social Nutrition, Institute of Nutrition Josué de Castro, Federal University of Rio de Janeiro, Rio de Janeiro, RJ, 21941-590, Brazil

Abstract

Observational studies suggest association between low concentrations of omega-3 fatty acids and greater risk for post-partum depression (PPD). The objective was to investigate the effect of unbalanced dietary intake of omega-6/omega-3 ratio >9:1 in the prevalence for PPD. The study comprises a prospective cohort with four waves of follow-up during pregnancy and one following delivery. PPD was evaluated according to the Edinburgh Post-partum Depression Scale (PPD ≥ 11) in 106 puerperae between 2005 and 2007, in Rio de Janeiro, Brazil. Independent variables included socio-demographic, obstetric, pre-pregnancy body mass index (BMI) and dietary intake data, which were obtained by means of a food frequency questionnaire in the first trimester of pregnancy. Statistical analysis involved calculation of PPD prevalence and multivariate Poisson regression with robust variance. PPD prevalence amounted to 26.4% [$n = 28$; confidence interval (CI) 95%: 18.0–34.8], and higher prevalences of PPD were observed in women who consumed an omega-6/omega-3 ratio >9:1 (60.0%) and in those with pre-pregnancy BMI <18.5 kg/m² (66.7%). These variables held as factors associated to PPD in the multivariate model, elevating the chances of occurrence of the outcome in 2.50 (CI 95%: 1.21–5.14) and 4.01 times (CI 95%: 1.96–8.20), respectively. Analyses were adjusted for age, schooling, pre-pregnancy BMI, lipids consumption and time elapsed since delivery. It verified an association between omega-6/omega-3 ratio above 9:1, the levels recommended by the Institute of Medicine, and the prevalence of PPD. These results add to the evidence regarding the importance of omega-6 and omega-3 fatty acids in the regulation of mental health mechanisms.

Keywords: depression, post-partum, pregnancy, omega-3, schooling, body mass index.

Correspondence: Professor Gilberto Kac, Department of Applied Social Nutrition, Institute of Nutrition Josué de Castro, Federal University Rio de Janeiro, Avenida Brigadeiro Trompowsky, s/n°, CCS – Bloco J – 2° andar, sala 29, Cidade Universitária – Ilha do Fundão, Rio de Janeiro, RJ, 21941-590, Brazil. E-mail: kacetal@gmail.com or gkac@nutricao.ufrj.br

Introduction

Post-partum depression (PPD) is a serious public health problem (Cruz *et al.* 2005). Among the most commonly observed symptoms are intense sadness, frequent crying, lack of motivation, lowered interest for eating or for self-care, lack of concentration and a low interest for the newborn (Baker *et al.* 2005).

Children of depressed mothers bear greater risks of developing psychopathologies, behavioural and developmental problems, delay in the cognitive and emotional development (Tam *et al.* 2002; Zinga *et al.* 2005).

It is often observed that PPD symptoms are neglected by the woman, producing an underestimation of the prevalence, that makes it harder to track

and treat the disease adequately (Baker *et al.* 2005; Zinga *et al.* 2005). In Brazil, PPD prevalence varies between 13.4% (Santos *et al.* 1999) and 37.1% (Cruz *et al.* 2005), while results from international studies revealed prevalences between 10 and 15% (Boyce & Hickey 2005; Freeman *et al.* 2006).

Recent evidence from observational studies and clinical trials have evaluated the possible role of omega fatty acids consumption in the aetiology of PPD and suggested an association between the low level of an essential long-chain fatty acid of the omega-3 family, precursor to the docosahexaenoic acid (DHA), following pregnancy and the occurrence of PPD (Freeman *et al.* 2006; Freeman *et al.* 2008; Golding *et al.* 2009).

A conceptual framework in which polyunsaturated fatty acids (PUFAs) are thought to influence depression follows a bio-psychosocial model of depression. This model is encompassed within the class of the diathesis-stress model, and is based on the hypothesis that certain biological characteristics (genetic traits or disturbances in the biochemical, neuroendocrine or immune systems), interact with psychological characteristics, such as cognitive style, that make people vulnerable to depression upon exposure to negative life events or stressful experience (Schotte *et al.* 2006; Sontrop 2007).

According to this model, the experience of depression does not result from a single cause but from the culmination of events originating from a variety of causal pathways. Support for this model comes from experimental evidence demonstrating that cognitive-behavioural therapy combined with antidepressant treatment is more effective at treating depression than either form of treatment alone (Arnow & Constantino 2003). It is important to recognize that the hypothesis that PUFAs may be a contributory

factor in the pathophysiology or pathogenesis of depression represents part of a complex bio-psychosocial framework (Sontrop 2007).

Few are the studies regarding dietary consumption in PPD. Thus, the main objective of this study is to evaluate the association between an unbalanced dietary intake ratio between the omega-6 and the omega-3 fatty acids above 9 in the first trimester of pregnancy and the prevalence of PPD.

Methods

This investigation originated from a study with a prospective cohort design performed in the state of Rio de Janeiro, Brazil. Enrolment of pregnant women in the cohort was open during 20 months (July 2005–March 2007). The study comprised five waves of follow-up: on the 8th–13th, 19th–21st, 26th–28th and 36th–40th gestational week, and with at least 30 days post-partum. At those times, interviews were conducted with collection of socio-economic, food consumption, obstetric, lifestyle and anthropometric data. The interviews were conducted during appointment days at a public health centre of the Brazilian Unified Health System. The interviewers were trained for administering the questionnaires. The women were weighed on a digital scale (Filizzola PL 150, Filizzola LTDA, São Paulo, Brazil) and stature was measured with a portable stadiometer (Harpender Inc., England) by trained interviewers, following standardized criteria (Lohman *et al.* 1988). The pre-gestational nutritional status was assessed by pre-gestational body mass index ($\text{BMI} = \text{weight}/\text{stature}^2$), which was measured at the first wave of follow-up, time limit for the definition of the pre-gestational nutritional diagnosis with measured weight (Institute of Medicine 2009).

Key messages

- Post-partum depression (PPD) is a serious health problem for underprivileged Brazilian women.
- Low pre-pregnancy body mass index may act as a risk factor for PPD.
- A high dietary ratio of omega-6 to omega-3 polyunsaturated acids during the first pregnancy trimester increased the prevalence of PPD.

Only women who met the following eligibility criteria at the time of enrolment were selected to participate in the study: (1) being between the 8th and 13th week of gestation; (2) being between 18 and 40 years of age; (3) being free from any chronic diseases such as hypertension and diabetes; and (4) not presenting twin pregnancy.

Two hundred fifty-five women receiving prenatal care at the public health centre were recruited to participate in the study. In the present investigation were included data of PPD from 106 women who completed the follow-up. From these 106, 5 were considered outliers (values of energy intake outside the range ± 3 SD), and were not included in the analyses regarding PPD prevalence according to dietary data and in the unadjusted and adjusted models (final $n = 101$). Some variables presented missing values in baseline (8th–13th weeks of gestation) as follows: monthly income ($n = 1$), skin colour ($n = 3$), menarche age ($n = 1$) and dietary data ($n = 21$). Some variables were collected in other follow-up waves, moments when some losses of follow-up were already present, like stressful events (available number of observations = 88) and marital problems during pregnancy (available number of observations = 67).

With the objective of evaluating the presence of selective losses in the final follow-up, comparisons regarding the distribution of monthly income, age, schooling, self-reported skin colour, marital status, smoking status, alcohol consumption, menarche age, parity, pre-gestational BMI, energy intake adequacy and omega-6/omega-3 ratio variables were made between the women who completed follow-up and those who did not participate in the fifth wave of follow-up. Proportions were compared using chi-squared test. For dichotomous variables, Fisher exact test was employed, and Yates corrected otherwise.

PPD was considered as a dependent variable and its evaluation was performed by means of the Edinburgh Post-partum Depression Scale (EPDS). This scale consists of a self-report instrument composed of 10 items, with options for scoring between 0 and 3 according to the presence and the intensity of the depressive symptom (Cox *et al.* 1987). Several studies have already employed the EPDS as this is an easy scale to understand and apply, not to mention its

effectiveness in tracking PPD (Tam *et al.* 2002; Otto *et al.* 2003; Boyce & Hickey 2005; Cruz *et al.* 2005; Moraes *et al.* 2006; Flores-Quijano *et al.* 2008; Freeman *et al.* 2008; Gausia *et al.* 2008). In a study conducted in Brazil for the validation of the Portuguese version of EPDS, the instrument presented an internal consistency with a Cronbach's alpha coefficient of 0.80 (Santos *et al.* 1999).

EPDS was applied in the fifth wave of follow-up, at least 30 days following delivery. The participants were encouraged to complete the questionnaire by themselves, but they had access to the help of a trained interviewer in case any explanation was necessary or to assist them in reading the items and filling out the answers in case any of the women were not able to do so independently. Studies within the Brazilian population revealed that scores ≥ 11 presents a better predicting power, combining higher sensitivity and specificity (Santos *et al.* 1999). In a recent validation study of EPDS for the Brazilian population, Santos *et al.* (2007) have also shown that scores ≥ 11 had higher sensitivity (83.8%) and specificity (74.7%) for screening moderate and severe PPD, in comparison with scores ≥ 10 , which presented 82.6% and 65.4% of sensitivity and specificity, respectively. For this reason scores ≥ 11 was adopted in the present investigation.

The main exposure investigated in this study was the dietary intake in the first trimester of pregnancy, which was assessed by means of a Food Frequency Questionnaire (FFQ). The previously validated FFQ employed encompasses a list with 81 items and 8 frequency options. It is a robust method and largely accepted in epidemiological studies (Willett 1994; Sichieri & Everhart 1998). An FFQ questionnaire was applied in the second and third trimester, but losses of follow-up constrained its use.

The pregnant women's dietary intake was converted into weight or volume according to each food type. Subsequently, total energy intake and diet composition were analysed based on a worksheet developed and adapted for the present study in MICROSOFT® OFFICE EXCEL 2003 (Microsoft Corporation, Richmond, VA, USA). This worksheet was based on data contained in the Brazilian Food Composition Table (Tabela Brasileira de Composição de Alimentos 2004) and on the United States Development

Agency foods composition table (United States Department of Agriculture 2006). The consumption of daily macro- and micronutrients in g was estimated, as well as the ratio omega-6/omega-3.

The following variables were considered in the analyses: time elapsed since delivery (defined as the number of days between delivery and measurement of the EPDS); socio-economic – monthly income (in quintiles of American dollars); socio-demographic – age (18.0–19.9; 20.0–29.9; 30.0–41.0 years), schooling (≤ 9 ; > 9 years), self-reported skin colour (white, mulatto, black) and marital status (married or stable partnership, single); lifestyle – smoking status (yes, no) and alcohol consumption (yes, no); obstetric – age at menarche (≤ 13 , > 13 years), type of delivery (vaginal, caesarean) and parity (zero, 1–2, ≥ 3); infant outcomes – prematurity (gestational age measured through last menstrual cycle < 37 weeks) and low birthweight (birthweight < 2500 g); pre-gestational nutritional status classified based on the BMI according to the American Institute of Medicine, as follows: underweight < 18.5 kg/m², normal weight 18.5–24.9 kg/m², overweight 25.0–29.9 kg/m² and obese ≥ 30.0 kg/m² (Institute of Medicine 2009); and dietary intake in the first pregnancy trimester: energy intake adequacy – per cent (< 80 ; 80–120; > 120), lipids consumption – g (≤ 92.0 , > 92.0) and omega-6/omega-3 ratio intake ($\leq 9:1$, $> 9:1$). This ratio was employed based on the isolated recommendations for omega-6 and omega-3 from Institute of Medicine (2004), which are 13.0 g and 1.4 g, respectively. The food intake energy adequacy was calculated according to the recommended energy for age, weight and estimated level of physical activity, considering an adequate gestational weight gain (Institute of Medicine 2009).

Additionally, possible confounding factors in the relationship between consumption of omega-6/omega-3 and PPD were included in the analysis: problems in the marital relationship during pregnancy (yes, no) and occurrence of stressful events during pregnancy (yes, no). This information was obtained through the question, 'Did you suffer any stressful event during pregnancy?', evaluated according to the women's perception. Some examples reported include relationship problems with husband and lack of money to buy food items.

Statistical methods

Double typing in the EPI-INFO® version 6.04b (Center for Disease Control and Prevention, Atlanta, GA, USA) was performed. Analyses were conducted employing STATA version 9.2 (Stata Corporation, College Station, TX, USA). Initially, the distribution of each co-variable of the sample was investigated with the objective of defining the best categories for the calculation of PPD prevalence. The prevalences were compared by means of the chi-squared test for proportions. Continuous variables were compared using student *t*-test whenever the variables had normal distribution and Mann–Whitney for those with skewed distributions, stratifying according to the presence or not of PPD. In the bivariate analysis, unadjusted prevalence ratio (PR) was used as effect measure, with a confidence interval of 95% (CI 95%), and the Wald test was employed to verify the association. As the outcome presents a binary distribution and prevalences above 10%, the procedure of multivariate analysis chosen was the Poisson regression with robust variance (Zou 2004). The variables were selected for multivariate analysis based either on *P*-values < 0.20 in the bivariate analysis or when defined as part of a previous established theoretical model. The implementation of this strategy avoids the exclusion of potentially important variables and also controls for residual confounding (Rothman *et al.* 2008). In the present analysis, variables such as age, schooling, time elapsed since delivery and lipid consumption were forced into the model as they were considered to be part of our theoretical model and thus adjust variables. The association was evaluated with the Wald test and for the quality of the adjustment of the final model of Poisson regression, the goodness-of-fit test was employed.

Results

From the 255 pregnant women who enrolled the cohort, 106 finished the follow-up and, thus, have data regarding PPD. The final follow-up rate was 41.6% (106/255). The comparisons performed between losses to follow-up and those that completed the study revealed that there are no significant differ-

ences in the distribution of variables such as monthly income, age, schooling, self-reported skin colour, alcohol consumption, parity, pre-pregnancy BMI, dietary intake adequacy and in the omega-6/omega-3 ratio. Smokers present lower follow-up rate, as well as women who were married or had a stable partnership (Table 1).

The prevalence of PPD observed in the sample was 26.4% ($n = 28$; CI 95%: 18.0–34.8). The greater prevalences of PPD were observed in women with pre-pregnancy BMI $<18.5 \text{ kg/m}^2$ (66.7%), in women with an unbalanced dietary intake in the first trimester regarding the omega-6/omega-3 ratio (60.0%) and in those with schooling ≤ 9 years (36.2%) (Table 2).

The median energy intake in the first trimester of pregnancy was 3423 kcal/day, of which 512.8 g were carbohydrates, 94.2 g were lipids and 139.1 g were proteins. The medians of consumption for linoleic and linolenic acids were 15.4 and 2.1 g, respectively, with a ratio between them of 7.5 g (Table 3). The major dietary sources that contributed to omega-6 and omega-3 PUFAs intake were crackers, fried potato, sausage and chicken and rice, beans and low fat cow meat, respectively (results not shown). The mean pre-pregnancy BMI was 23.8 kg/m^2 . The women from the sample presented a mean age of 26.1 years, income of \$511.40 (in American dollars), and schooling of 9.3 years (Table 3).

In the bivariate analysis, greater prevalences ratio of PPD were observed in women with ≤ 9 years of schooling (PR = 1.94; CI 95%: 1.00–3.74), pre-pregnancy BMI $<18.5 \text{ kg/m}^2$ (PR = 3.07; CI 95%: 1.48–6.33) and with food intake in the first trimester for the omega-6/omega-3 ratio $>9:1$ (PR = 2.73; CI 95%: 1.44–5.18) (Table 4). The variables stress during the pregnancy and consumption of lipids in the first trimester of pregnancy presented a P -value less than 0.20, and followed to the multivariate model. Lipids consumption in the first trimester of pregnancy lost significance but was kept in the model because it was considered an important variable in the theoretical model once it interferes directly in the consumption of omega-6 and omega-3. Stress during pregnancy was removed from the model because it has excessive missing values, constraining the potentiality of the final model.

It was observed that, of the variables studied, the dietary intake in the first trimester for the omega-6/omega-3 ratio $>9:1$ and the pre-pregnancy BMI below 18.5 kg/m^2 remained as factors associated with PPD, increasing the chances for occurrence of the outcome for women 2.50 times (CI 95%: 1.21–5.14) and 4.01 (CI 95%: 1.96–8.20), respectively. The estimations were adjusted for age, schooling, time elapsed since delivery and lipid consumption (Table 5). The final sample size in the multivariate analysis was 101 subjects.

Discussion

The prevalence of PPD was 2.5 times greater among Brazilian women whose dietary ratio of omega-6/omega-3 PUFAs in the first trimester of pregnancy was greater than 9 : 1. This ratio represents the division between the specific recommendations of the Institute of Medicine (2004) for omega-6 and omega-3, which are, respectively, 13.0 and 1.4. The results remained statistically significant even when the analysis were adjusted for the effect of several confounding factors such as age, schooling, pre-pregnancy BMI, lipid consumption and time elapsed since delivery. These results corroborate the data from an observational study where the increase in DHA concentration in the post-partum, was significantly lower in women with PPD (Otto *et al.* 2003).

In this study, we investigated the median difference in the consumption of omega-6 and omega-3, and the ratio between these nutrients, according to presence of PPD. None of the nutrients evaluated separately showed association with PPD. However, upon evaluating the omega-6 and omega-3 family fatty acids ratio, we verified that the median of the omega-6/omega-3 ratio consumed in the first trimester of pregnancy was significantly higher ($P = 0.040$) for women with PPD. Jacka *et al.* (2004) did not observe any significant difference for the means of omega-3 fatty acid consumption between depressed and non-depressed in a sample of Australian women and Sontrop *et al.* (2008) revealed an inverse relationship between omega-3 family fatty acids intake and depressive symptoms in single and smoker pregnant women. More recently, Golding *et al.* (2009) observed associa-

Table 1. Frequency distribution for selected variables between losses and complete follow-up and final follow-up rate for Brazilian women aged 18–41 years in Rio de Janeiro, 2005–2007

Variables	Initial observations (<i>n</i>)	Losses to follow-up (<i>n</i>)	Complete follow-up (<i>n</i>)	Final follow-up rate (%)	<i>P</i> -value*
Monthly income (dollars) [†]					
<205.00	51	33	18	35.3	0.711
205.00–335.00	62	39	23	37.1	
335.00–442.00	38	21	17	44.7	
442.00–670.00	50	25	25	50.0	
≥670.00	53	31	22	41.5	
Age (in years)					
18.0–19.9	38	24	14	36.8	0.388
20.0–29.9	155	94	61	39.4	
30.0–41.0	62	31	31	50.0	
Schooling (years)					
≤9	125	78	47	37.6	0.253
>9	130	71	59	45.4	
Skin colour (self-reported) [‡]					
White	64	35	29	45.3	0.647
Mulatto	152	93	59	38.8	
Black	36	19	17	47.2	
Marital status					
Married or stable partnership	198	125	73	36.9	0.006
Single	57	24	33	57.9	
Smoking status					
Yes	30	23	7	23.3	0.032
No	225	126	99	44.0	
Alcohol consumption					
Yes	31	22	9	29.0	0.173
No	224	127	97	43.3	
Menarche age (in years) [§]					
≤13	180	107	73	40.5	0.577
>13	74	41	33	44.6	
Parity (number of birth)					
0	128	66	62	48.4	0.101
1–2	111	71	40	36.0	
≥3	16	12	4	25.0	
Pre-pregnancy BMI (kg/m ²) [¶]					
<18.5	14	8	6	42.8	0.579
18.5–24.9	156	87	69	44.2	
≥25.0	85	54	31	36.5	
Energy intake adequacy (%)**††‡‡					
>80	13	7	6	46.2	0.907
80–120	22	14	8	36.4	
>120	199	112	87	43.7	
Omega-6/omega-3 ratio intake**††‡‡					
≤9:1	208	117	91	43.8	0.678
>9:1	26	16	10	38.5	

*Fisher exact test *P*-value refers to chi-square for proportions for all dichotomous variables. For non-dichotomous variables, Yates correction was applied. [†]One missing value for monthly income. [‡]Three missing values for skin colour in baseline and one with complete follow-up. [§]One missing value for menarche age in baseline. [¶]Body mass index (BMI) classification according to the American Institute of Medicine 2009 (2009). ^{**}Data from Food Frequency Questionnaire regarding the first trimester of pregnancy. ^{††}Twenty-one missing values for dietary variables in baseline. ^{‡‡}Five outliers for the dietary variables (values for energy intake outside the range ± 3 SD).

Table 2. Number of cases (*n*) and prevalence of post-partum depression (PPD)

Variable	<i>N</i>	<i>n</i>	Prevalence of PPD (%)	<i>P</i> -value*
Monthly income (dollars) [†]				
<205.00	18	5	27.8	0.980
205.00–335.00	23	5	21.7	
335.00–442.00	17	6	35.3	
442.00–670.00	25	6	24.0	
≥670.00	22	6	27.3	
Age (years)				
18.0–19.9	14	3	21.4	0.880
20.0–29.9	61	18	29.5	
30.0–41.0	31	7	22.6	
Schooling (years)				
≤9	47	17	36.2	0.049
>9	59	11	18.6	
Skin colour (self-reported) [‡]				
White	29	8	27.6	0.885
Mulatto	59	16	27.1	
Black	17	3	17.6	
Marital status				
Married or stable partnership	73	19	26.0	0.999
Single	33	9	27.3	
Smoking status				
Yes	7	2	28.6	0.999
No	99	26	26.3	
Alcohol consumption				
Yes	9	2	22.2	0.999
No	97	26	26.8	
Menarche age (in years)				
≤13	73	19	26.0	0.999
>13	33	9	27.3	
Type of delivery				
Vaginal	60	14	23.3	0.506
Caesarean	46	14	30.4	
Parity (number of birth)				
0	62	17	27.4	0.880
1–2	40	10	25.0	
≥3	4	1	25.0	
Prematurity (gestational age < 37 weeks) [§]				
Yes	10	3	30.0	0.724
No	95	25	26.3	
Low birthweight (birthweight < 2500 g) [§]				
Yes	6	1	16.7	0.999
No	99	27	27.3	
Marital problems during pregnancy [¶]				
Yes	11	4	36.4	0.719
No	57	16	28.1	
Stress during pregnancy ^{**}				
Yes	66	21	31.8	0.167
No	20	3	15.0	
Pre-pregnancy BMI (kg/m ²) ^{††}				
<18.5	6	4	66.7	0.156
18.5–24.9	69	15	21.7	
≥25.0	31	9	29.0	
Energy intake adequacy (%) ^{‡‡§§}				
>80	6	2	33.3	0.902
80–120	8	1	12.5	
>120	87	23	26.4	
Lipids consumption (g) ^{‡‡§§}				
≤92.0	52	10	19.2	0.172
>92.0	49	16	32.6	
Omega-6/omega-3 ratio intake ^{‡‡§§}				
≤9:1	91	20	22.0	0.017
>9:1	10	6	60.0	

*Fisher exact test *P*-value refers to chi-square for proportions for all dichotomous variables. For non-dichotomous variables, Yates correction was applied. [†]One missing value for monthly income. [‡]One missing value for skin colour. [§]One missing value for prematurity and low birthweight. [¶]Thirty-eight missing values for marital problems during pregnancy (variable collected in the fifth follow-up wave). ^{**}Twenty missing values for stress during pregnancy (variable collected in the fifth follow-up wave). ^{††}Body mass index (BMI) classification according to the American Institute of Medicine (2009). ^{‡‡}Data from Food Frequency Questionnaire regarding the first trimester of pregnancy. ^{§§}Five outliers for the dietary variables (values for energy intake outside the range ± 3 SD).

Table 3. Medians [interquartile range (IQR)] and means ($\pm$ SD) of dietary daily intake and selected variables according to presence of post-partum depression

Variable*	n	Medians (IQR) or means (±SD [†])	Post-partum depression				P-value
			Yes		No		
			n	Medians (IQR)or means (±SD)	n	Medians (IQR) or means (±SD)	
Energy (kcal) ^{‡§}	101	3423.6 (2621.9–4252.0)	26	3379.3 (2393.6–4741.8)	75	3423.6 (2656.6–4242.8)	0.950
Carbohydrates (g) ^{‡§}	101	512.8 (384.7–597.1)	26	466.4 (334.1–588.3)	75	506.0 (392.1–599.1)	0.494
Lipids (g) ^{‡§}	101	94.2 (68.4–116.7)	26	97.9 (68.2–128.5)	75	88.8 (68.4–109.5)	0.207
Proteins (g) ^{‡§}	101	139.1 (100.7–185.2)	26	149.9 (102.8–190.3)	75	138.0 (98.9–179.9)	0.822
Omega-6 family fatty acids (18:2) (g) ^{‡§}	101	15.4 (11.1–18.6)	26	16.1 (10.6–19.0)	75	14.3 (11.1–18.4)	0.492
Omega-3 family fatty acids (18:3) (g) ^{‡§}	101	2.1 (1.4–2.6)	26	2.0 (1.2–2.6)	75	2.0 (1.4–2.6)	0.792
Omega-6/omega-3 ratio ^{‡§}	101	7.5 (6.7–8.2)	26	8.0 (6.9–8.8)	75	7.4 (6.6–8.1)	0.040
Age (years)	106	26.1 (5.7)	28	25.8 (5.6)	78	26.2 (5.8)	0.767
Monthly income (dollars) [¶]	105	511.4 (421.7)	28	534.8 (405.7)	77	502.9 (429.6)	0.733
Schooling (years)	106	9.3 (3.0)	28	8.8 (3.0)	78	9.4 (3.0)	0.294
Pre-pregnancy BMI (kg/m ²)	106	23.8 (4.3)	28	23.9 (5.2)	78	23.7 (3.9)	0.923
Time elapsed since delivery (days)	106	42.8 (20.4)	28	41.2 (20.1)	78	43.4 (20.6)	0.852

*Median values and *P*-value according to Mann–Whitney test for the variables: energy, carbohydrates, lipids, proteins, omega-6 family fatty acids, omega-3 family fatty acids and omega-6/omega-3 ratio; and mean values and *t*-test for the variables: monthly income, schooling, pre-gestational body mass index (BMI) and time elapsed since delivery. [†]SD, standard deviation. [‡]Data from the Food Frequency Questionnaire regarding the first trimester of pregnancy. [§]Five outliers for the dietary variables (values for energy intake outside the range $\pm$ 3 SD). [¶]One missing value for monthly income.

tion between low omega-3 fatty acid intake and high levels of depressive symptoms during pregnancy.

The evidence of the omega intake effect during pregnancy in PPD prevention are still scanty, although some studies sustain the hypothesis that there is a causal relationship between DHA deficiency and the occurrence of depressive episodes (Otto *et al.* 2003; Sontrop & Campbell 2006). Fatty acids of the omega-3 family, especially the linolenic acid (ALA), precursor of the DHA (Sontrop & Campbell 2006), are utilized in the neuronal development of the fetus, a process that poses a high demand of this fatty acid. Thus, its levels decreased gradually throughout the pregnancy, especially in the last trimester, and remain low until the puerperium because of the release of DHA through the maternal milk (Otto *et al.* 2003; Freeman *et al.* 2006). The reduction in DHA levels in the maternal organism is even higher when associated to the low consumption of fish, such as sardines, salmon, mackerel and tuna – its main sources – as humans' conversion capacity from

ALA to DHA is limited (Sontrop & Campbell 2006). The maternal nervous system might become unprotected because, in these conditions, there is a greater production of docosapentaenoic acid-omega-6 [synthesized from the linoleic acid (LA)], and the DHA-omega-3 is substituted by the former in the neuron's myelin sheath, yet without the same efficiency, altering the patterns of synapses and maybe causing PPD (Simopoulos 2002; Otto *et al.* 2003).

PPD consists of a public health concern. The prevalence of PPD in the present study was 26.4%, lower than the one reported by Cruz *et al.* (2005) in a study with women monitored by the Family Health Program of the Brazilian government (37.1%), greater than the one observed by Moraes *et al.* (2006) – 19.1% and similar to the one observed by Tannous *et al.* (2008) – 20.7% – in women residing in Porto Alegre, a metropolis in the south of Brazil. The prevalences observed in the present study and in other Brazilian samples were similar to the ones observed in samples of puerperae from other countries such as

Table 4. Unadjusted prevalence ratio and 95% confidence intervals (CI 95%) for post-partum depression*

Variable	Prevalence ratio	CI 95%	P-value
Monthly income (dollars)			
<205.00	1.00		
205.00–335.00	0.78	0.26–2.30	0.657
335.00–442.00	1.27	0.47–3.42	0.635
442.00–670.00	0.86	0.31–2.41	0.780
≥670.00	0.98	0.36–2.71	0.972
Age (years)			
18.0–19.9	1.00		
20.0–29.9	1.38	0.47–4.06	0.562
30.0–41.0	1.05	0.32–3.50	0.932
Schooling (years)			
≤9	1.94	1.00–3.74	0.048
>9	1.00		
Skin colour (self-reported)			
White	1.00		
Mulatto	0.98	0.48–2.03	0.963
Black	0.64	0.19–2.10	0.462
Marital status			
Married or stable partnership	1.00		
Single	1.05	0.53–2.07	0.893
Smoking status			
Yes	1.09	0.32–3.69	0.893
No	1.00		
Alcohol consumption			
Yes	0.83	0.23–2.96	0.773
No	1.00		
Menarche age (in years)			
≤13	1.00		
>13	1.05	0.53–2.07	0.893
Delivery type			
Vaginal	1.00		
Caesarean	1.30	0.69–2.46	0.413
Parity (number of birth)			
0	1.10	0.19–6.33	0.918
1–2	1.00	0.17–5.98	0.999
≥3	1.00		
Prematurity (gestational age < 37 weeks)			
Yes	1.14	0.41–3.13	0.597
No	1.00		
Low birthweight (birthweight < 2500 g)			
Yes	0.53	0.06–4.78	0.533
No	1.00		
Marital problems during pregnancy			
Yes	1.30	0.53–3.16	0.569
No	1.00		
Stress during pregnancy			
Yes	2.12	0.70–6.42	0.183
No	1.00		
Pre-pregnancy BMI (kg/m ²) [†]			
<18.5	3.07	1.48–6.33	0.002
18.5–24.9	1.00		
≥25.0	1.34	0.65–2.72	0.426
Time elapsed since delivery (days)	0.99	0.98–1.01	0.518
Energy intake adequacy (%) ^{‡§}			
>80	2.67	0.30–23.24	0.375
80–120	1.00		
>120	2.11	0.32–13.80	0.434
Lipids consumption (g) ^{§§}			
≤92.0	1.00		
>92.0	1.70	0.85–3.39	0.133
Omega-6/omega-3 ratio intake ^{§§}			
≤9:1	1.00		
>9:1	2.73	1.44–5.18	0.002

*Prevalence ratio and 95% CI were estimated through Poisson regression. P-value for Wald test. [†]Body mass index (BMI) classification according to the American Institute of Medicine (2009). [‡]Data from the Food Frequency Questionnaire regarding the first trimester of pregnancy.

[§]Five outliers for the dietary variables (values for energy intake outside the range ± 3 SD).

Table 5. Multivariate Poisson model for factors associated to post-partum depression* ($n = 101$)

Variable	Unadjusted prevalence ratio	Adjusted prevalence ratio	CI 95%	P-value
Age (in years)				
18.0–19.9	1.00	1.00		
20.0–29.9	1.38	1.21	0.40–3.65	0.730
30.0–41.0	1.05	1.03	0.31–3.38	0.961
Schooling (in years)				
≤9	1.94	1.80	0.89–3.65	0.102
>9	1.00	1.00		
Pre-pregnancy BMI (kg/m ²) [†]				
<18.5	3.07	4.01	1.96–8.21	<0.001
18.5–24.9	1.00	1.00		
≥25.0	1.33	1.23	0.57–2.65	0.602
Time elapsed since delivery (days) [‡]	0.99	1.00	0.98–1.02	0.969
Lipids consumption (g) ^{§¶}				
≤92.0	1.00	1.00		
>92.0	1.70	1.68	0.88–3.20	0.112
Omega-6/omega-3 ratio intake ^{§¶}				
≤9:1	1.00	1.00		
>9:1	2.73	2.50	1.21–5.14	0.013

*Prevalence ratio and 95% confidence intervals (CIs) were estimated through Poisson regression. *P*-value for Wald test. [†]Body mass index (BMI) classification according to the American Institute of Medicine (2009). [‡]Continuous variable included on the final model. [§]Data from the Food Frequency Questionnaire concerning the first trimester of pregnancy. [¶]Five outliers for the dietary variables (values for energy intake outside the range ± 3 SD). In the multivariate model all variables are adjusted for each other.

Bangladesh (Gausia *et al.* 2008) – 22%, and Mexico (Flores-Quijano *et al.* 2008) – 24.5%, and greater than those observed in studies in developed countries (Boyce & Hickey 2005; Freeman *et al.* 2006). Despite having a frequency 5–10 times greater than that of gestational diabetes and being as frequent as hypertension during pregnancy, the early detection of PPD is not part of the routine in most health institutions (Troppil *et al.* 2005).

It is important to link the high prevalences of PPD with one of the main characteristics of nutritional transition, in regard to changes in eating habits (Bermudez & Tucker 2003). In general, diets flow from a healthier pattern to a high consumption of industrialized foods, with higher proportions of LA in relation to the ALA (Martin *et al.* 2006). It is known, however, that before the phenomenon of nutritional transition, this ratio was much lower (around 1:1 or 2:1), with a higher consumption of fatty acids from the omega-3 family. Several studies have already described this ratio in the population's diet, and the values from 10:1 to 20:1 were observed (Simopoulos 2002; Martin *et al.* 2006).

Recent studies based on randomized clinical trials (RCT) revealed the potential effect of the omega supplementation in the prevention of PPD and have already evaluated the effectiveness of supplementation from the omega-6 and omega-3 fatty acids family, during pregnancy, in the attempt of improving the concentrations of DHA in the mothers and in the umbilical cord of their children (Su *et al.* 2003; Groot *et al.* 2004; Freeman *et al.* 2008; Doornbos *et al.* 2009). The effect of an unbalanced dietary intake in the omega-6/omega-3 ratio in increasing the risk of PPD is in a similar line of evidence as the studies cited above, although we are aware that RCT are much less prone to confounding as our observational study, so, less importance should be given to observational studies rather than to RCT. The results from RCT were inconclusive and given the seriousness of PPD and the availability of proven treatment, it is very important to state, that at this moment, there are no evidence that PUFAs supplementation will alleviate PPD. This put the issue as a field of study that deserves to be further investigated. Until recently, the strongest evidence supporting a protective effect of

omega-3 PUFAs on depression came from RCTs where participants were administered omega-3 PUFAs concurrently to antidepressants (Sontrop & Campbell 2006). However, this is refuted by a trial by Carney *et al.* (2009) demonstrating no effect of omega-3 PUFAs in combination with sertraline on depression in patients with coronary heart disease. It is also important to consider that negative results may be less likely to be published, which may lead to a positive-result publication bias.

Women with BMI below 18.5 kg/m² presented four times greater PPD prevalences. We might hypothesize that women with low BMI may present a dietary composition different from that of the rest of the sample, poorer in fatty acids, leaving them unprotected from PPD. A study conducted in Pakistan to evaluate the persistence of prenatal depression during the first year of post-partum did not find associations between low BMI and the continuance of depressive symptoms (Rahman & Creed 2007).

We observed in our data a slightly higher energy intake when compared with other studies (Siega-Riz *et al.* 2002; Lacerda *et al.* 2007). This result might be part of a drawback of the FFQ, which consists in the potential for overestimation. We opted to employ an FFQ during the first pregnancy trimester because it comprises a group with very scarce information. This procedure can estimate individual's usual intake (Willett 1994), recent intake (Castro *et al.* 2006), past intake (Bunin *et al.* 2001) and intake from long (Sichieri & Everhart 1998) or short intervals (Bunin *et al.* 2001).

This study adds to a body of research suggesting a relationship between PUFAs and depression but have some limitations. The first one consists in the lack of dietary data in reasonable number of women for the second and third pregnancy trimesters. The reduced size of the sample due to a high loss to follow-up is another limitation. Although the losses were excessive, significant differences were not observed between women who completed the follow-up and those regarded as losses, except for those who smoke and for women married or with stable partnership. The fact that the study could not exclude women with pre-existing depression during pregnancy is another limitation. In this regard, we need to be careful

in drawing conclusions based on temporality and causation.

A greater prevalence of PPD was observed in Brazilian women with an unbalance in the dietary intake of the omega-6 and omega-3 ratio in the first trimester of pregnancy, even when this relationship was adjusted for confounding factors. PPD is a serious public health concern, both in developed and in developing countries such as Brazil, and multi-professional preventive approaches are needed.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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