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Determinant factors of insufficient and excessive gestational weight gain and maternal–child adverse outcomes

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ABSTRACT

Objective: To estimate the magnitude and determinant factors of insufficient and excessive gestational weight gain (GWG) and its relation with maternal–child adverse outcomes.
Methods: This was a prospective study with 173 pregnant women and their newborns monitored at a primary health care facility in Rio de Janeiro. Multinomial regression models were employed, having as the outcome the adequacy of GWG (insufficient, adequate, or excessive). Covariables were classified as biological, socioeconomic, reproductive, behavioral, and nutritional.
Results: Forty-one percent of pregnant women had insufficient GWG and 22.0% had excessive GWG. Pregestational overweight was associated with insufficient GWG (odds ratio [OR] 0.19, 95% confidence interval [CI] 0.05–0.78), and pregestational obesity was associated with excessive GWG (OR 4.66, 95% CI 1.34–19.08). Also associated with insufficient GWG were a stature <157 cm (OR 2.25, 95% CI 1.03–4.93) and ages 25–29 y (OR 3.70, 95% CI 1.26–10.84) and ≥30 y (OR 2.88, 95% CI 1.13–7.35) compared with the reference group (18–24 y). Age <12 y at menarche (OR 4.97, 95% CI 1.51–16.30) and being a former smoker (OR 5.18, 95% CI 1.62–16.52) demonstrated an association with excessive GWG compared with non-smokers (reference group). Sixty percent of pregnant women with excessive GWG delivered by cesarean section compared with 39.8% with adequate or insufficient GWG ($P < 0.05$). Prevalence of macrosomia in the excessive GWG group was 23.5% compared with 4.5% for pregnant women with insufficient GWG ($P < 0.001$).
Conclusion: Different determinant factors related to insufficient and excessive GWG were observed, which can be identified in the beginning of pregnancy, thus predicting unfavorable gestational outcomes. An increased percentage of women presented GWGs outside recommended levels.

Introduction

Pregestational body mass index (BMI) and gestational weight gain (GWG) constitute the most important anthropometric indicators employed during pregnancy [1,2], because these are not only low-cost procedures but also reflective of maternal nutritional status before and after pregnancy [3].

The recommendation recognized worldwide [1,4] instructs that weight gain during pregnancy should be differentiated in accordance with the pregestational nutritional status, being defined by BMI (weight in kilograms divided by height in meters squared). Women with pregestational underweight, normal weight, overweight, and obesity should gain 12.5 to 18.0, 11.5 to 16.0, 7.0 to 11.5, and 7.0 kg, respectively [4,5]. This recommendation has as its objective restoring body fat storage levels in low-weight women and minimizing fat gain in overweight and obese women [1,6]. However, most pregnant women have weight gains during pregnancy outside the recommended levels [1,2].

Gestational weight gain within the recommended levels has a decisive function in favorable gestational outcomes. The scientific literature has demonstrated that inadequate GWG results in implications at the short, mid, and long terms to maternal and pediatric health [2,3,6]. Insufficient GWG is considered a risk factor for gestational complications and

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adverse outcomes, especially low birth weight, intrauterine growth restriction, and prematurity [7–12]. Conversely, excessive GWG, aside from contributing to postpartum weight retention and risks of future obesity, is associated with several complications, among which are cesarean section delivery, hemorrhages, hypertensive syndromes in pregnancy, fetal macrosomia, and even low birth weight [7–9,13–17].

Pregestational, gestational, and modifiable maternal behaviors contribute in different ways to GWG. Studies have identified several demographic, socioeconomic, biological, dietetic, psychological, and behavioral characteristics and health conditions during gestation and inadequate prenatal monitoring as risk factors for insufficient and excessive GWG [18–24]. Attempts to understand how each factor operates have become essential to adequately intervene ahead of time, due to the multi-causality of GWG deviations. The objective of this study was to estimate the magnitude and determinant factors of insufficient and excessive GWG and its relation to maternal–child adverse outcomes in a cohort of women monitored at a public primary health care clinic in the city of Rio de Janeiro, Brazil.

Materials and methods

This investigation inserts itself in a prospective study, Deviations in Gestational Weight Gain and the Effect in Reproductive Health Outcomes, with a dynamic sample composed of pregnant women monitored at a primary health care clinic that is part of the public services of the city of Rio de Janeiro, Brazil. Enrollment was free during 22 mo (June 2005 to April 2007). The monitoring protocol of the main study consisted of conducting individual interviews in five waves of follow-up: gestational weeks 8–13 (baseline), 19–21, 26–28, and 36–40 and 1–3 mo postpartum, when anthropometric measurements were performed, blood samples were taken, and previously tested questionnaires were applied. Other details regarding the study protocol can be obtained elsewhere [25].

Two hundred ninety-two pregnant women who met the eligibility criteria were included. Of those, 255 agreed to participate and began the monitoring phase, and 173 of them had their weight gain evaluated at the fourth wave of follow-up. This therefore was the sample for this analysis. The women's profile was defined to not differ from any other average pregnant women recruited from any Brazilian public health care center in age, income, and nutritional status, meaning that they were representative in the external validity of a potential target Brazilian child-bearing age group.

The outcome variable was the adequacy of GWG (insufficient, adequate, or excessive) measured on an individual basis. To classify the outcome, we calculated the difference between measurements of body weight assessed at the fourth follow-up wave and women's pregestational weight. We employed the recommendations proposed by the Institute of Medicine (IOM) [4] and endorsed by the Brazilian Ministry of Health [5] to evaluate total GWG according to their upper and lower limits. That way, values above the IOM recommendations were considered excessive GWG, values below, insufficient, and those within the guidelines, adequate GWG. The same GWG intervals to evaluate the adequacy of women with pregestational overweight and obesity were employed [1,6].

All exploratory variables were grouped in blocks.

Biological and socioeconomic variables were age (18–24, 25–29, 30–40 y), stature (<157, ≥157 cm), age at menarche (<12, ≥12 y), self-reported skin color (white, brown, black), marital status (married, living together, single), education, (≤4, 5–8, ≥9 y), per-capita family income (≤0.5, 0.5–1.0, >1.0 Brazilian minimum wage, about US $260/mo), and working outside the home (yes, no).

Reproductive history variables were parity (0, 1, ≥2 childbirths), intergestational interval (≤2, 3–5, ≥6 y), and gestational age (33–37, 38–41 wk).

The gestational age of the woman (based on last menstrual period) at the fourth wave of follow-up was included in the analysis as a confounder, due primarily to the form of obtaining a pregnant woman's weight at this wave (measured versus retrieved from medical files). The unique information obtained from medical files was the weight measurements of 78 pregnant women (45.1% from total sample) at the fourth wave of follow-up. With regard to the form of obtaining a pregnant woman's weight, no differences were found in mean total GWG (11.9 versus 11.5 kg) between measured and retrieved data. The same situation was observed when total GWG was stratified by gestational age stratus (11.3 versus 12.2 kg). Otherwise we found a significant difference between the mean gestational age of measured and retrieved weights (36.7 ± 1.3 versus 38.6 ± 1.8, $P < 0.001$), which is the reason this variable was included in all models.

Behavioral variables were smoking (non-smoker, former smoker, smoker), consumption of alcoholic beverages (non-consumer, former consumer, consumer), and intensity of physical activities (sedentary, light/moderate). These variables refer to the first wave of follow-up.

Nutritional variables were pregestational BMI (underweight, normal weight, overweight, obesity) and adequacy of energy intake (below, adequate, above).

The women were weighed on a digital scale (Filizzola PL 150, Filizzola Ltda., São Paulo, Brazil) and stature was measured with a portable stadiometer (Harpenden Inc., Crosswell, Crymych, Pembs, England, UK) by trained interviewers according to standardized criteria [26]. Pregestational nutritional status was assessed by pregestational BMI, which was obtained at the first wave of follow-up, the time limit for the definition of a pregestational nutritional diagnosis with measured weight [1,5,6]. We considered the BMI cutoff points proposed by the IOM [1].

Statistical analyses

All statistical analyses were performed with SPSS 16.0 (SPSS Inc., Chicago, IL, USA). First, a distribution of the sample according to the categorized explanatory variables was made, considering the adequacy of GWG. For that, Pearson's chi-square test was performed to ascertain the existence of differences between the proportions of GWG for each categorical variable.

Models of multinomial logistic regression were implemented to estimate measurements of odds ratios (ORs) with 95% confidence intervals. Such regression models allow for the outcome variable to have three or more categories [27]. In this study, women who had insufficient and excessive GWG were compared with the reference category, those with adequate GWG.

Individual analyses were performed for each of the explanatory variables, adjusted for gestational age, and those variables that presented an association with GWG to a 20% significance level on Wald's test were selected for the multiple multinomial logistic model. All selected variables were included in the saturated model and later removed one by one (backward elimination), with gestational age kept as the control variable. The selection criterion to keep variables in the final model was the likelihood ratio test, removing from the saturated model variables that presented the highest P value. The final model included those variables that presented an association with insufficient or excessive GWG to a significance level of 5%.

The prevalence of maternal–child adverse outcomes, defined as preterm delivery (gestational age at birth <37 wk), low birth weight (birth weight <2500 g), fetal macrosomia (birth weight ≥4000 g), and cesarean section delivery, was estimated as having a GWG status, insufficient or excessive, as exposure. Prevalences were compared with Pearson's chi-square test for proportions.

The study was approved by the research ethics committee of the Institute of Puericulture and Pediatrics Martagão Gesteira of the Federal University of Rio de Janeiro. All participants signed a term of consent, which was obtained freely and spontaneously, after all necessary clarifications had been provided.

Results

The losses to follow-up that took place during the study amounted to 32.1% and did not differ between dropouts and completers according to several variables such as age, marital status, education, pregestational BMI, and family income. The 292 pregnant women who met the criteria presented a similar profile to those 255 women who were enrolled in the cohort and to the 173 women analyzed in this study regarding the above-mentioned variables (results not shown).

The distribution of GWG according to selected variables is presented in Tables 1 and 2. According to pregestational nutritional status, 20.2% presented underweight and 12.1% and 16.8% overweight and obesity, respectively. Prevalences of insufficient and excessive GWG were 41.6% and 22%, respectively. Insufficient GWG was greater for pregnant women older than 25 y, with a stature shorter than 157 cm and a pregestational status of underweight. In turn, excessive GWG presented a higher prevalence among pregnant women who were 18 to 24 y old, had menarche before 12 y of age, former smokers, with a gestational age older than 38 wk, and obese at the beginning of pregnancy (Tables 1 and 2). Mean ± SD GWG measurements were 12.44 ± 3.51, 12.08 ± 4.44, 10.88 ± 6.20, and 10.21 ± 5.09 kg for the pregestational statuses of underweight, normal weight, overweight, and obesity, respectively, with a linear tendency ($P = 0.029$; data not shown in tables).

Table 1
Distribution of gestational weight gain adequacy according to biological and socioeconomic characteristics in a cohort of women attending a prenatal clinic in Rio de Janeiro, Brazil, 2005–2007

Variables	Total, percentage (n)	Gestational weight gain, percentage (n)*			P†
		Insufficient	Adequate	Excessive	
Age (y)					
18–24	56.1 (97)	32.0 (31)	44.3 (43)	23.7 (23)	
25–29	18.5 (32)	56.2 (18)	21.9 (7)	21.9 (7)	
30–40	25.4 (44)	52.3 (23)	29.5 (13)	18.2 (8)	0.049
Stature (cm)					
<157	33.5 (58)	60.3 (35)	31.0 (18)	8.6 (5)	
≥157	66.5 (115)	32.2 (37)	39.1 (45)	28.7 (33)	0.001
Age at menarche (y)‡					
<12	23.3 (40)	40.0 (16)	20.0 (8)	40.0 (16)	
≥12	76.7 (132)	41.7 (55)	41.7 (55)	16.6 (22)	0.003
Self-reported skin color‡					
White	26.9 (46)	39.1 (18)	37.0 (17)	23.9 (11)	
Brown	60.8 (104)	41.3 (43)	37.5 (39)	21.2 (22)	
Black	12.3 (21)	52.4 (11)	28.6 (6)	19.0 (4)	0.875
Per-capita family income (minimum wage)§					
≤0.5	24.9 (43)	48.8 (21)	39.5 (17)	11.7 (5)	
0.5–1.0	34.1 (59)	45.8 (27)	30.5 (18)	23.7 (14)	
>1.0	41.0 (71)	33.8 (24)	39.4 (28)	26.8 (19)	0.231
Education (y)					
≤4	17.3 (30)	40.0 (12)	33.3 (10)	26.7 (8)	
5–8	34.1 (59)	47.4 (28)	39.0 (23)	13.4 (8)	
≥9	48.6 (84)	38.1 (32)	35.7 (30)	26.2 (22)	0.429
Working outside the home					
No	41.6 (72)	34.7 (25)	44.5 (32)	20.8 (15)	
Yes	58.4 (101)	46.5 (47)	30.7 (31)	22.8 (23)	0.160
Marital status					
Single	20.8 (36)	55.5 (20)	27.8 (10)	16.7 (6)	
Living together	55.5 (96)	36.5 (35)	40.6 (39)	22.9 (22)	
Married	23.7 (41)	41.5 (17)	34.1 (14)	24.4 (10)	0.384
Total	100 (173)	41.6 (72)	36.4 (63)	22.0 (38)	—

* Classification of gestational weight gain adequacy according to the Institute of Medicine [4].
† Pearson's chi-square test for proportions of gestational weight gain.
‡ Variable with losses <1% due to absence of information.
§ Brazilian minimum wage about US $260/mo.

Table 2
Distribution of gestational weight gain adequacy according to reproductive history and behavioral and nutritional characteristics in a cohort of women attending a prenatal clinic in Rio de Janeiro, Brazil, 2005–2007

Variables	Total, percentage (n)	Gestational weight gain, percentage (n)*			P†
		Insufficient	Adequate	Excessive	
Parity (no. of childbirths)					
0	48.6 (84)	39.3 (33)	40.5 (34)	20.2 (17)	
1	35.3 (61)	39.3 (24)	37.7 (23)	23.0 (14)	
≥2	16.2 (28)	53.6 (15)	21.4 (6)	25.0 (7)	0.472
Intergestational interval (y)‡					
≤2	25.8 (23)	30.4 (7)	39.2 (9)	30.4 (7)	
3–5	27.0 (24)	41.7 (10)	37.5 (9)	20.8 (5)	
≥6	47.2 (42)	52.4 (22)	26.2 (11)	21.4 (9)	0.510
Gestational age (wk)§					
33–37	54.2 (91)	47.3 (43)	40.7 (37)	12.1 (11)	
38–41	45.8 (77)	35.0 (27)	32.5 (25)	32.5 (25)	0.006
Smoking					
Non-smoker	65.9 (114)	47.4 (54)	37.7 (43)	14.9 (17)	
Former smoker	24.9 (43)	27.9 (12)	30.2 (13)	41.9 (18)	
Smoker	9.2 (16)	37.5 (6)	43.8 (7)	18.8 (3)	0.007
Alcohol consumption					
Non-consumer	37.0 (64)	42.2 (27)	43.7 (28)	14.1 (9)	
Former consumer	51.4 (89)	42.7 (38)	30.3 (27)	27.0 (24)	
Consumer	11.6 (20)	35.0 (7)	40.0 (8)	25.0 (5)	0.280
Intensity of physical activities					
Sedentary	17.3 (30)	33.3 (10)	43.3 (13)	23.3 (7)	
Light/moderate	82.7 (143)	43.4 (62)	35.0 (50)	21.7 (31)	0.575
Adequacy of energy intake (%)§					
Below (<90)	35.8 (54)	44.4 (24)	31.5 (17)	24.1 (13)	
Adequate (90–110)	15.2 (23)	34.8 (8)	47.8 (11)	17.4 (4)	
Above (>110)	49.0 (74)	41.9 (31)	35.1 (26)	23.0 (17)	0.751
Pregestational BMI (kg/m^2)					
Underweight (<19.8)	20.2 (35)	48.6 (17)	48.6 (17)	2.8 (1)	
Normal (19.8–25.9)	50.9 (88)	46.6 (41)	36.4 (32)	17.0 (15)	
Overweight (26.0–28.9)	12.1 (21)	23.8 (5)	42.9 (9)	33.3 (7)	
Obesity (≥29.0)	16.8 (29)	31.0 (9)	17.3 (5)	51.7 (15)	0.001
Total	100 (173)	41.6 (72)	36.4 (63)	22.0 (38)	—

BMI, body mass index
* Classification of gestational weight gain adequacy according to the Institute of Medicine [4].
† Pearson's chi-square test for proportions of gestational weight gain.
‡ *N* refers to the number of non-primiparous pregnant women.
§ Variable with losses <10% due to absence of information.

A greater OR of pregnant women presenting insufficient GWG was observed in the more advanced age strata and a stature shorter than 157 cm. As for the associations with excessive GWG, greater ORs were observed for pregnant women with menarche before 12 y of age, former smokers, and those who were obese before becoming pregnant. Gestational age at 33 to 37 wk was inversely associated with excessive GWG (Table 3). In the final model insufficient GWG was associated with women older than 25 y (25–29 y, OR 3.70; 30–40 y, OR 2.88), stature shorter than 157 cm (OR 2.25), and pregestational overweight nutritional status (OR 0.19). For excessive GWG, women who presented greater chances were those with menarche before age 12 y (OR 4.97), former smokers (OR 5.18), and those presenting pregestational obesity, which increased the chance to greater than four times (OR 4.66; Table 4).

Prevalences of preterm delivery, low birth weight, fetal macrosomia, and cesarean delivery in the present study were 6.2%, 1.9%, 7.7%, and 44.2%, respectively. The prevalence of fetal macrosomia in the excessive GWG group was 23.5% compared with 4.5% for pregnant women with insufficient GWG ($P < 0.001$). Sixty percent of women with excessive GWG delivered by cesarean section, 40.0% of women with adequate GWG compared with 39.7% of pregnant women with insufficient GWG ($P = 0.144$). When insufficient and adequate GWG were combined and compared against excessive GWG, the results were significant ($P = 0.049$; Table 5). Cesarean delivery was reported in 56.7%, 47.8%, 37.9%, and 26.7% for women with a pregestational nutritional status of obesity, overweight, normal weight, and underweight, respectively (results not shown).

Discussion

Previous analyses with the same dataset aiming mainly to estimate GWG velocity were conducted employing a mixed-

Table 3
Individual analyses of explanatory variables for gestational weight gain adequacy, odds ratios, and 95% confidence intervals in a cohort of women attending a prenatal clinic in Rio de Janeiro, Brazil, 2005–2007

Variables	Gestational weight gain*			
	Insufficient		Excessive	
	OR† (95% CI)	P‡	OR† (95% CI)	P‡
Age (y)				
18–24	1		1	
25–29	3.61 (1.34–9.71)	0.011	1.72 (0.53–5.64)	0.369
30–40	2.45 (1.08–5.59)	0.032	1.15 (0.41–3.23)	0.796
Stature (cm)				
<157	2.36 (1.15–4.83)	0.019	0.41 (0.14–1.23)	0.113
≥157	1		1	
Age at menarche (y)				
<12	2.00 (0.79–5.07)	0.142	4.86 (1.78–13.26)	0.002
≥12	1		1	
Self-reported skin color				
White	1		1	
Brown	1.04 (0.47–2.31)	0.913	0.84 (0.33–2.16)	0.715
Black	1.72 (0.52–5.70)	0.372	1.07 (0.24–4.86)	0.927
Per-capita family income (minimum wage)				
≤0.5	1.46 (0.63–3.39)	0.379	0.39 (0.12–1.27)	0.118
0.5–1.0	1.77 (0.79–3.98)	0.168	1.05 (0.41–2.67)	0.920
>1.0	1		1	
Education (y)				
≤4	1.14 (0.43–3.02)	0.796	0.97 (0.32–2.97)	0.961
5–8	1.17 (0.55–2.49)	0.683	0.37 (0.13–1.02)	0.056
≥9	1		1	
Working outside the home				
No	0.52 (0.26–1.04)	0.064	0.55 (0.24–1.28)	0.164
Yes	1		1	
Marital status				
Single	1.64 (0.58–4.64)	0.353	0.99 (0.26–3.72)	0.983
Living together	0.74 (0.32–1.71)	0.482	0.79 (0.29–2.12)	0.637
Married	1		1	
Parity (no. of childbirths)				
0	1		1	
1	1.10 (0.52–2.36)	0.796	0.99 (0.40–2.48)	0.987
≥2	2.63 (0.91–7.64)	0.075	1.98 (0.56–7.02)	0.288
Intergestational interval (y)				
≤2	0.39 (0.11–1.32)	0.129	0.99 (0.25–3.95)	0.990
3–5	0.54 (0.17–1.75)	0.306	0.86 (0.20–3.76)	0.862
≥6	1		1	
Gestational age (wk)§				
33–37	1.11 (0.56–2.21)	0.762	0.31 (0.13–0.72)	0.007
38–41	1		1	
Smoking				
Non-smoker	1		1	
Former smoker	0.73 (0.30–1.77)	0.486	3.77 (1.47–9.68)	0.006
Smoker	0.69 (0.22–2.23)	0.539	0.90 (0.20–4.02)	0.890
Alcohol consumption				
Non-consumer	1		1	
Former consumer	1.465(0.70–3.00)	0.320	3.36 (1.28–8.83)	0.014
Consumer	0.91 (0.29–2.85)	0.867	1.98 (0.50–7.89)	0.332
Intensity of physical activities				
Sedentary	0.61 (0.25–1.52)	0.294	0.94 (0.33–2.68)	0.906
Light/moderate	1		1	
Adequacy of energy intake (%)‖				
Below (<90)	1.96 (0.65–5.91)	0.233	2.01 (0.51–7.98)	0.321
Adequate (90–110)	1		1	
Above (>110)	1.61 (0.56–4.61)	0.377	1.99 (0.53–7.52)	0.308
Pregestational BMI (kg/m^2)				
Underweight (<19.8)	0.77 (0.34–1.75)	0.531	0.13 (0.02–1.12)	0.064
Normal (19.8–25.9)	1		1	
Overweight (26.0–28.9)	0.43 (0.13–1.42)	0.166	1.69 (0.52–5.52)	0.383
Obesity (≥29.0)	1.46 (0.44–4.82)	0.538	5.40 (1.62–17.97)	0.006

BMI, body mass index; CI, confidence interval; OR, odds ratio
* Classification of gestational weight gain adequacy according to the Institute of Medicine [4].
† Adjusted analyses according gestational age at the fourth wave.
‡ Wald's test.
§ Variable without adjusted analyses according gestational age at last follow-up wave.
‖ Variable with losses <10% due to absence of information.

Table 4
Final model of multinomial logistic regression for gestational weight gain adequacy in a cohort of women attending a prenatal clinic in Rio de Janeiro, Brazil, 2005–2007

Variables	Gestational weight gain*			
	Insufficient		Excessive	
	OR† (95% CI)	P‡	OR† (95% CI)	P‡
Age (y)				
18–24	1		1	
25–29	3.70 (1.26–10.84)	0.017	1.19 (0.27–5.34)	0.816
30–40	2.88 (1.13–7.35)	0.027	0.49 (0.13–1.82)	0.285
Stature (cm)				
<157	2.25 (1.03–4.93)	0.043	0.30 (0.08–1.14)	0.077
≥157	1		1	
Age at menarche (y)				
<12	2.61 (0.95–7.16)	0.062	4.97 (1.51–16.30)	0.008
≥12	1		1	
Smoking				
Non-smoker	1		1	
Former smoker	0.91 (0.34–2.40)	0.844	5.18 (1.62–16.52)	0.005
Smoker	0.57 (0.15–2.13)	0.402	1.16 (0.19–7.10)	0.874
Education (y)				
≤4	1.15 (0.38–3.52)	0.802	1.81 (0.46–7.13)	0.395
5–8	1.27 (0.54–2.98)	0.580	0.27 (0.07–0.98)	0.047
≥9	1		1	
Pregestational BMI (kg/m^2)				
Underweight (<19.8)	0.96 (0.39–2.37)	0.933	0.163 (0.02–1.49)	0.109
Normal (19.8–25.9)	1		1	
Overweight (26.0–28.9)	0.19 (0.05–0.78)	0.021	1.99 (0.47–8.46)	0.353
Obesity (≥29.0)	0.96 (0.26–3.50)	0.947	4.66 (1.34–19.08)	0.032
Model P value	<0.001			

BMI, body mass index; CI, confidence interval; OR, odds ratio
* Classification of gestational weight gain adequacy according to the Institute of Medicine [4].
† Adjusted analyses according gestational age at the fourth wave.
‡ Wald's test.

effects linear longitudinal regression model. Mean weekly gestational weight gain was 0.413 kg, consistent with IOM recommendations [1,4]. According to the longitudinal model, triacylglycerols, blood glucose, adequacy of energy intake, maternal age, and onset of menarche were associated with GWG velocity [25].

In the current study, we presented a different aim and analytical approach, more focused on the identification of subgroups at risk of developing deviations in GWG, target groups for preventive care, and interventions. Results published previously had a prospective/longitudinal perspective, whereas those from the present investigation have a population at-risk approach. Pregestational nutritional status was associated with both GWG outcomes (insufficient or excessive). Stature and age of the pregnant women demonstrated an association with insufficient GWG, whereas age at menarche and smoking were associated with excessive GWG. Previous results [25] have shown the effect of biochemical variables such as triacylglycerols and blood glucose and energy intake during pregnancy in GWG. The present results confirm the effect of known variables on GWG such as age and pregestational nutritional status measured by BMI, but also revealed some new evidence regarding the effect of early menarche and short stature, two measurements of early life nutritional conditions, and new data on smoking, a known controversial effect.

Our results suggest that women of shorter stature (<157 cm) are more than two times likely to present insufficient GWG. It is well documented that short stature may act as a marker of early life nutritional deficiency and pregnancy is an important period of insults. It was verified in a prospective study that having short stature was an independent risk of insufficient GWG for underweight or normal-weight pregestational women [28]. Despite IOM recommendations in 1990, which restricted GWG for women of short stature to the minimum stratum, data regarding the effects of stature on GWG are still limited, and interactions between pregestational BMI and stature deserve further investigations [6]. The high magnitude of short stature and insufficient GWG observed in this Brazilian sample of pregnant women may represent an increase in the risk of several maternal–child adverse outcomes as low birth weight, although this association was not observed in our data, probably due to sample size limitations.

In the present study pregnant women who declared starting menarche before age 12 y presented an almost five times greater chance of excessive GWG. Previous studies have verified that women who started menarche before age 12 y presented a greater chance of developing postpartum overweight [29] and obesity during the reproductive cycle [30]. Despite the association indicating that an early menarche is related to excessive GWG, some studies [31,32] have shown that other factors may be involved in the regulation of menarche age, such as excess of adipose tissue due to the influence of childhood obesity.

Some studies have shown that smoking may be associated with low GWG [6,19,22,24,33], although the mechanism that affects GWG is not clear. It is suggested that smoking would induce an acute reaction in the metabolic rate, which would influence the reduction of digestion of foods when compared with the non-smokers. In line with other studies [34,35], women who declared themselves to be former smokers in the beginning

Table 5
Distribution of maternal–child adverse outcomes according to gestational weight gain adequacy in a cohort of women attending a prenatal clinic in Rio de Janeiro, Brazil, 2005–2007

Gestational weight gain*	Preterm delivery†			Low birth weight‡			Macrosomia§			Cesarean delivery		
	N (n)	Percentage	P‖	N (n)	Percentage	P‖	N (n)	Percentage	P‖	N (n)	Percentage	P‖,¶
Insufficient	62 (5)	8.1		67 (2)	3.0		67 (3)	4.5		58 (23)	39.7	
Adequate	53 (4)	7.5		55 (1)	1.8		55 (1)	1.8		50 (20)	40.0	
Excessive	31 (0)	0	0.273	34 (0)	0	0.586	34 (8)	23.5	<0.001	30 (18)	60.0	0.144
Total	146 (9)	6.2		156 (3)	1.9		156 (12)	7.7		138 (61)	44.2	

n, number of positive cases for each maternal–child outcome
* Classification of gestational weight gain adequacy according to Institute of Medicine [4].
† Preterm delivery (gestational age at birth <37 wk), variable with losses <15% due to absence of information.
‡ Low birth weight (birth weight <2500 g), variable with losses <10% due to absence of information.
§ Fetal macrosomia (birth weight ≥4000 g), variable with losses <10% due to absence of information.
‖ Pearson's chi-square test for proportions.
¶ Pearson's chi-square test for proportions = 0.049 when insufficient and adequate where mixed and compared against excessive gestational weight gain.

of their pregnancy presented a greater chance of having excessive GWG compared with non-smokers, although no effect was verified regarding insufficient GWG in the present study, as several previous studies have [19,22,24,33]. Favaretto et al. [35] verified that former smokers gained 1.03 kg more than those reporting never smoking, and 1.54 kg more when compared with those who reported quitting smoking during the pregnancy. It is important to mention that smoking was self-reported and our results did not consider the number and frequency of smoked cigarettes.

Similarly to our results, Siega-Riz and Hobel [28] verified that insufficient GWG was greater in older women. Chasan-Taber et al. [36] verified that being older than 30 y represented a greater chance of having a GWG above IOM recommendations compared with ages 20 to 24 y. For pregnant women residing in the city of São Paulo, [18] having an education equivalent to a primary education and having completed high school or college was a risk factor for excessive GWG in the second trimester of gestation, as in pregnant women in Recife [20]. In our study having education of 5–8 y represented a lower chance of developing excessive GWG, although the small number of subjects in the analyses prevents any conclusion.

High prevalences of insufficient and excessive GWG were observed in this sample. Consequently, only 36.4% of the women studied found themselves within the IOM recommended levels of GWG. This proportion is similar to that described in the literature, and varies from 30% to 40% in Brazilian [37,38] and international [8,11,19,21,22,36,39,40] studies. The small proportion of women whose GWG was within the IOM guidelines requires attention. GWG is a modifiable factor that can be controlled when adequate prenatal nutritional counseling is provided. Thus, women whose GWG is outside the guidelines are target groups for prevention and interventions. However, different from the present results, most studies have indicated that excessive GWG is more prevalent than insufficient GWG, results that can be partly explained by the high prevalence (35%) of short stature (<157 cm) and precocious assessment of body weight at the fourth interview.

The effect of deviations in GWG in maternal–child adverse outcomes was addressed in the present study as our secondary aim. The results concerning medical complications such as cesarean section and prevalence of fetal macrosomia were similar to those reported in the literature [7,9,15,16,41,42]. Excessive GWG was responsible for a greater prevalence of cesarean section and macrosomia. The consequences of deviations in GWG in maternal–child adverse outcomes are well known and involve higher risks of postpartum weight retention, later child obesity, lower breast-feeding initiation, among others [7,9,11]. Although there are clear evidences between GWG and these outcomes, the small number of cases prevents the study to draw decisive conclusions. In any case, it is important that health professionals be conscious of the public health costs of this problem. Effective interventions with the objective of preventing or attenuating GWG deviations, derived from clinical trial evidences, with appropriate nutritional counseling toward adequate GWG have already demonstrated positive results for excessive GWG [43,44].

Among the study limitations, noteworthy are losses that happened during follow-up, due to several causes, such as losing contact and women abandoning the study. However, the percentage (32.1%) was close to that observed in similar studies [18]. Another limitation involves the utilization of different forms of obtaining gestational weight data (face-to-face interview versus consulting medical files), although we managed to show that differences in average GWG obtained in interviews and those obtained by consulting medical files were not statistically significant, suggesting an absence of confounding. GWG calculated based on weight assessed at the fourth interview (36–40 wk of gestation) may cause a sub-estimation of weight gain, and the ideal would be obtaining these measurement moments before delivery. For this reason, we opted to control for gestational age in the individual analysis and in the final multinomial model. It is important to interpret the results cautiously because some of the comparisons were based in strata with quite small samples, which reduces the power to detect some associations.

Our results were similar to and agree with the literature regarding the effect of pregestational nutritional status and age, but provide new evidence of the effect of onset of menarche, stature, and smoking. The results suggest that the women with a heightened risk of insufficient or excessive GWG could be identified at the beginning of pregnancy, predicting possible unfavorable maternal–child outcomes.

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