Rev Saúde Pública 2006;40(3):457-65

Luiz Carlos Seligman

Bruce Bartholow Duncan

Leandro Branchtein

Dea Suzana Miranda Gaio

Sotero Serrate Mengue

Maria Inês Schmidt

Obesity and gestational weight gain: cesarean delivery and labor complications

Obesidade e ganho de peso gestacional: cesariana e complicações de parto

ABSTRACT

OBJECTIVE: To assess the association between pre-gestational obesity and weight gain with cesarean delivery and labor complications.

METHODS: A total of 4,486 women 20-28 weeks pregnant attending general prenatal care clinics of the national health system in Brazil from 1991 to 1995 were enrolled and followed up through birth. Body mass index categories based on prepregnancy weight and total weight gain were calculated. Associations between body mass index categories and labor complications were adjusted through logistic regression analysis.

RESULTS: Obesity was present in 308 (6.9%) patients. Cesarean delivery was performed in 164 (53.2%) obese, 407 (43.1%) pre-obese, 1,045 (35.1%) normal weight and 64 (24.5%) underweight women. The relative risk for cesarean delivery in obese women was 1.8 (95% CI: 1.5-2.0) compared to normal weight women. Greater weight gain was particularly associated with cesarean among the obese (RR 4th *vs* 2nd weight gain quartile 2.2; 95% CI: 1.4-3.2). Increased weight at the beginning of pregnancy was associated with a significantly higher adjusted risk of meconium with vaginal delivery and perinatal death and infection in women submitted to cesarean section. Similarly, greater weight gain during pregnancy increased the risk for meconium and hemorrhage in women submitted to vaginal delivery and for prematurity with cesarean.

CONCLUSIONS: Pre-gestational obesity and greater weight gain independently increase the risk of cesarean delivery, as well as of several adverse outcomes with vaginal delivery. These findings provide further evidence of the negative effects of prepregnancy obesity and greater gestational weight gain on pregnancy outcomes.

KEYWORDS: Cohort studies. Obesity, epidemiology. Weight gain. Pregnancy. Labor, premature, epidemiology. Labor complications, epidemiology. Cesarean section. Postpartum hemorrhage. Meconium. Perinatal mortality.

RESUMO

OBJETIVO: Avaliar a associação de obesidade pré-gestacional e ganho de peso excessivo com cesariana e outras complicações do parto.

MÉTODOS: Um total de 4.486 mulheres com 20-28 semanas de gravidez do pré-natal geral do Sistema Único de Saúde de seis capitais brasileiras foram arroladas entre 1991-1995 e seguidas até o parto. As categorias do índice de massa corporal

Programa de Pós-Graduação em Epidemiologia. Faculdade de Medicina. Universidade Federal do Rio Grande do Sul. Porto Alegre, RS, Brasil

Correspondence:
Luiz Carlos Seligman
Rua Carlos Trein Filho, 1080/201
90450-120 Porto Alegre, RS, Brasil
E-mail: lc.seligman@brturbo.com.br

Received: 7/15/2005 Reviewed: 11/17/2005
Approved: 1/27/2006

e o ganho de peso total foram calculados com base no peso pré-gestacional. Associações entre estas categorias nutricionais e complicações do parto foram ajustadas por regressão logística.

RESULTADOS: A obesidade foi observada em 308 (6,9%) pacientes. As cesarianas ocorreram em 164 (53,2%) obesas, 407 (43,1%) pré-obesas, 1.045 (35,1%) normais e em 64 (24,5%) mulheres de baixo peso. O risco relativo para cesariana na comparação de obesas com grávidas de peso normal foi 1,8 (IC 95%: 1.5-2.0). Ganho de peso excessivo mostrou a maior associação com cesariana entre obesas (RR=2,2; IC 95%: 1,4-3,2) para 4º *vs* 2º quartil. Maior peso pré-gravídico esteve associado com risco ajustado significativamente aumentado para mecônio no parto vaginal e com prematuridade, morte perinatal ou infecção na cesariana. Similarmente, grande ganho de peso aumentou o risco para mecônio e hemorragia materna no parto vaginal e com prematuridade na cesariana.

CONCLUSÕES: A obesidade pré-gestacional e o ganho de peso excessivo aumentaram de forma independente o risco de cesariana e vários resultados adversos durante o parto vaginal. Esses achados oferecem evidências adicionais aos efeitos negativos da obesidade pré-gravídica e do ganho de peso excessivo na gravidez e parto.

DESCRITORES: Estudos de coortes. Obesidade, epidemiologia. Ganho de peso. Gravidez. Trabalho de parto prematuro, epidemiologia. Complicações do trabalho de parto, epidemiologia. Cesárea. Hemorragia pós-parto. Mecônio. Mortalidade perinatal.

INTRODUCTION

The prevalence of overweight and obesity have substantially increased in the last decades, especially in women. Data from 1989 reported that 13.3% of Brazilian women were obese and a national survey conducted in 1996 showed that 10.2% of Brazilian women of reproductive age (20 to 49 years) were obese. Additionally the prevalence of overweight among Brazilian women in this age group was 36.8% in 1996.[13]

Medical complications such as diabetes and hypertension are significantly increased during pregnancy in obese patients. Fetal distress, meconium staining, arrest disorders, hemorrhage, difficult peridural access and operatory time are also increased in obese women. Furthermore, evidence of increased risk for cesarean section, endometritis, prolonged hospital stay, thromboembolic phenomena, anemia, urinary tract infection, prematurity and fetal demise have been described.[23]

Cesarean sections (C-sections) have become more frequent since 1970-80 around the world. Between 1965 and 1986, the rate of cesarean delivery in the United States increased from 4.5 to 24.1%.[21] From 1984 to1993, cesarean delivery was the most frequent major surgical procedure in the United States. Rates then declined slightly to 20.7% in 1996 and, more recently increased again in 2002 reaching 26.1%, the highest rate ever recorded.[12] In a city of southern Brazil, a rate of 30.5% was described in 1993.[2] Usage data from the Brazilian National Health System (Datasus)* show a nationwide cesarean delivery rate of 38% in 1999.

The Brazilian Study of Gestational Diabetes[19] investigated pregnancy outcomes, allowing a detailed examination of the relationship between body mass index (BMI) categories and adverse pregnancy outcomes. The study provides data from a population in a developing country and gives new insights concerning the risks associated with nutritional excess in pregnancy.

Thus, the objective was to assess the associations between pre-gestational obesity and greater weight gain in pregnancy and cesarean delivery and labor complications in pregnant women.

METHODS

The Brazilian Study of Gestational Diabetes was designed primarily to investigate the frequency and risks associated with gestational diabetes. The study methodology has been previously reported.[19] The current investigation is a cohort study comprising 5,564 preg-

*Ministério da Saúde, Datasus. Indicadores de cobertura: proporção de partos cesáreos [dados estatísticos]. Disponível em http://tabnet.datasus.gov.br/cgi/tabcgi.exe?idb2001/f08.def [acesso em 1 jul 2001].

nant women enrolled in general prenatal care clinics of the National Health System in six state capitals of Brazil: Porto Alegre, São Paulo, Rio de Janeiro, Salvador, Fortaleza, and Manaus, from 1991 to 1995.

Daily recruitment in all accredited services initiated before each clinic visit. Eligible participants (20 years of age or older, between 20 and 28 weeks of pregnancy, non-diabetic) were identified through a standardized chart review. All women were interviewed during that clinic visit with a standardized questionnaire. Anthropometric measures were obtained at the same time according to standardized protocols. Clinic supervisors (physicians) and interviewers (medical students, nurses, and health agents) were trained and certified by the Coordinating Center team. Quality control was carried out regularly at each center and by site visits of the Coordinating Center team.[19]

All subjects underwent a standardized 75 g oral glucose tolerance test (OGTT) following the World Health Organization (WHO) recommendations. They were then followed up through delivery and during in-hospital postpartum period via chart review using a common structured protocol.

Fifty-one (0.9%) patients with multiple pregnancies, 17 (0.3%) of Asian origin and 1,010 (18.2%) with missing delivery data were excluded from this study, remaining 4,486 (80.6%) patients in the final sample for analysis of maternal data. An additional 544 (9.8%) subjects lacked data on neonatal outcomes, remaining a total of 3,942 (70.8%) patients for investigation of neonatal complications.

Educational level was assessed by interview and skin color was classified as white, black, mixed or yellow (Asian) by observation. Gestational age at baseline was defined by a hierarchical criteria based on four parameters: ultrasound, estimate of gestational age by physical examination at birth,[5] last menstrual period and uterine height at enrollment – and their compatibility (agreement within two weeks).[19] Data on weight gain, delivery Apgar scores, prenatal intrapartum and postpartum complications such as hemorrhage, infection (wound, endometritis, respiratory or urinary tract), meconium staining and perinatal death were obtained from prenatal and obstetrical records. Pregnancy duration was calculated summing up gestational age at baseline with time from baseline to delivery.

Obesity and other BMI categories were defined according to the 1997 WHO recommendations using self-reported prepregnancy weight as underweight, <18.5 kg/m²; normal weight, 18.5 to 24.9 kg/m²; preobese, 25.0 to 29.9 kg/m² and obese, ≥30.0 kg/m². Total weight gain during pregnancy was calculated as the last recorded weight during pregnancy minus this reported pre-gestational weight, and then adjusted to a 40-week pregnancy.[16] This variable was analyzed in quartiles. Risks associated with greater weight gain in pregnancy are presented comparing risk between women with gains in the 4th *vs* 2nd quartile.

Gestational Diabetes Mellitus (GDM) was defined following the WHO criteria as fasting glucose ≥7.0 mmol/l or a 2-h glucose ≥7.8 mmol/l. Hypertensive disorders related to pregnancy included cases of chronic hypertension, eclampsia or pre-eclampsia, pre-eclampsia superimposed upon chronic hypertension and transient gestational hypertension, consistent with the National High Blood Pressure Education Program working group report on high blood pressure in pregnancy.

Macrosomia was defined as birth weight at or above the gestational age-specific (by week) 90th percentile of the study sample, as previously described.[19] Perinatal death was defined as loss of a fetus >1,000 g or with estimated gestational age ≥28 weeks, or as an early neonatal death (up to seven days); and prematurity as delivery at less than 37 completed weeks of gestation. Reported indications of cesarean delivery were grouped into fetal distress, cephalopelvic disproportion, anomalous presentation, prior cesarean section and others/non-specified.

Statistical analyses were performed using SPSS statistical software and Epi Info 6.04d. A priori sample size calculations were done for the main study objectives, the association of hyperglycemia with macrosomia; no additional sample size calculations were performed prior to this particular study as both its exposure and main outcome were more frequent than those related to the main study objectives.

Descriptive statistics were expressed as means and standard deviations (SD) or as proportions; differences were tested using Student's t-test. Statistical differences in prenatal characteristics across categories of prepregnancy BMI were evaluated with Pearson's chi-square test. Associations of BMI categories and weight gain were adjusted by delivery complications through logistic regression analysis. Selection of potential confounders, age, skin color, education, site, parity, weight gain and length of gestation, was based on their association in the bivariate analysis with the main exposures and outcome, or their having been previously evaluated in similar studies. In most analyses, BMI categories were modeled as indicator variables. However, given

Table 1 - Prenatal characteristics of 4486 women according to pre-pregnancy body mass index categories. Brazilian Study of Gestational Diabetes, 1991-1995.

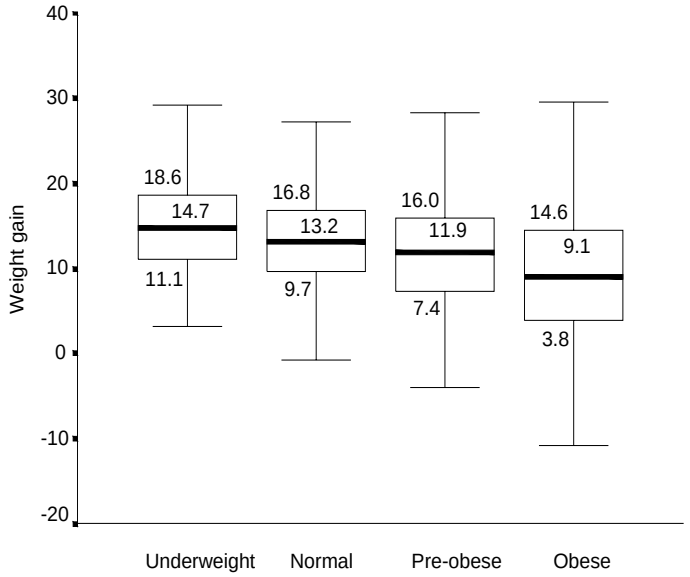
	Underweight		Normal		Pre-obese		Obese		
	N	%	N	%	N	%	N	%	p-value
Education (years)									0.166
<8	123	47.5	1,300	43.8	442	46.9	152	50.0	
8 a 11	120	46.3	1,410	47.5	418	44.3	132	43.4	
>11	16	6.2	258	8.7	83	8.8	20	6.6	
Skin color									0.001
White	100	38.3	1,333	44.8	446	47.3	128	41.6	
Black	31	11.9	370	12.4	146	15.5	55	17.9	
Mixed	130	49.8	1,271	42.7	351	37.2	125	40.6	
Smoking									0.002
Never	172	65.9	1,768	59.1	531	56.3	196	63.6	
Former smoker	51	19.5	668	22.5	237	25.1	67	21.8	
Current smoker	38	14.6	548	18.4	175	18.6	45	14.6	
Length of gestation (weeks)									0.007
<37	55	21.3	489	16.5	112	12.0	48	15.7	
37 a 41	192	74.4	2,346	79.3	781	83.4	243	79.4	
>41	11	4.3	125	4.2	44	4.7	15	4.9	
Total	261	5.8	2,974	66.3	943	21.0	308	6.9	

Small differences in numbers are due to missing values for specific variables.

the linear nature of the associations across categories and in order to increase statistical power, prepregnancy weight and weight gain during pregnancy were modeled as four level ordinal variables in the investigation of their associations with obstetric procedures (oxytocin and forceps), cesarean indications, ruptured membranes and complications of delivery (meconium staining, prematurity, perinatal death, hemorrhage and maternal infection). These latter analyses were additionally stratified by route of delivery. In these analyses risk for obesity and greater weight gain is reported as a two unit change in this ordinal variable. As several outcomes had frequencies of greater than 10%, odds ratios obtained were corrected to relative risks according to Zhang & Yu.[24] The population-attributable fraction was calculated using the following equation:

$$A/M \times (\text{RR} - 1)/\text{RR}$$

where *A* is the number of outcomes among exposed individuals, *M* is the total number of outcomes, and RR is the adjusted odds ratio for the association between exposure and outcome, expressed, after corrected for the outcome prevalence, as a relative risk. As the objectives of this cohort study were to produce results representative of a broad sample of pregnant women sampled without bias (consecutively) at certified clinics, the study estimates did not take into account differences in the proportion of potentially eligible women effectively enrolled in each clinic. The site effect was treated as a confounder in all multivariable analyses.



Note: Solid line = median; box = interquartile range; lines extend from the box to the highest and lowest values = 4th and 1st weight gain quartile, respectively.

Figure - Pregnancy weight gain across BMI categories. Brazilian Study of Gestational Diabetes, 1991-1995.

Faculdade de Medicina of Universidade Federal do Rio Grande do Sul Ethics Committees approved the study protocol, and patients consented to participate after being informed about the nature of the study.

RESULTS

Obesity was found in 308 (6.9%), pre-obesity in 943 (21.0%), normal weight in 2,974 (66.3%) and underweight in 261 (5.8%) patients. Means and SDs of excluded and included patients were similar with respect to age 28.0±(5.4) *vs* 27.7±(5.5) years, years of education 8.0±(4.1) *vs* 7.8±(3.6) and gravidity 1.9±(1.9) *vs* 1.8±(1.9) respectively, these small differences were not statistically significant. Of those studied, mean age was 30.3±(6.0) for obese, 29.2±(5.8) for pre-

Table 2 - Crude and adjusted* risks of cesarean delivery according to body mass index categories and other factors. Brazilian Study of Gestational Diabetes, 1991-1995.

BMI categories	BMI (kg/m²)	Crude		Adjusted	
		RR	95% CI	RR	95% CI
Underweight	<18.5	0.7	0.5-0.9	0.7	0.5-0.9
Normal	18.5-24.9	1.0	-	1.0	-
Pre-obese	25-29.9	1.2	1.1-1.3	1.3	1.1-1.4
Obese	>30	1.5	1.4-1.7	1.8	1.5-2.0

BMI: body mass index
*Adjusted through logistic regression models for age, skin color, education, site, parity, weight gain and length of gestation

obese, 27.2±(5.2) for normal weight and 25.6±(4.8) for underweight women. Higher BMI category was also associated with greater parity: 2.0±(2.0) for the obese, 1.7±(1.7) for the pre-obese, 1.3±(1.5) for those with normal weight and 1.2±(1.5) for those underweight. Table 1 shows prenatal demographic characteristics. Obese patients had the lowest schooling (50% having attained less than 8th grade), were more likely to be black (17.9%) and were least likely to smoke. Gestational length was similar across BMI categories, with the exception of underweight women who had higher prevalence of preterm delivery. Figure shows weight gains across BMI categories. The lowest weight gain was found in obese patients. Median weight gain (interquartile range) was 9.1 kg (3.8-14.6) for obese, 11.9 kg (7.4-16.0) for pre-obese, 13.2 kg (9.7-16.8) for normal weight and 14.7 kg (11.1-18.6) for underweight women.

The overall cesarean rate for all 4,486 patients was 37.4%. Cesarean rates decreased linearly across BMI categories, and they were 53.2% among obese and 43.2% among pre-obese, 35.1% among normal weight and 24.5% among underweight patients. Obese women had an increased rate of cephalopelvic disproportion (11.0%) as an indication for cesarean delivery when compared to 6.2% for the normal weight group. All other reported indications except for anomalous presentation were also higher in obese patients.

With respect to obstetric procedures, higher BMI categories and greater weight gain did not increase the risk of oxytocin or forceps assisted labor. Greater weight gain predicted a slightly increased adjusted risk of ruptured amniotic membranes for more than 12 hours with near borderline significance in adjusted analyses (RR 4th *vs* 2nd weight gain quartile =1.2; 95% CI: 0.98-1.5; p=0.08 for linear trend), higher prepregnancy BMI categories did not (RR obese *vs* normal weight =0.92; 95% CI: 0.66-1.26; p=0.63 for linear trend). Obese women, as well as those with greater weight gain, had increased risk for several reported indications for cesarean delivery. The relative risk of cesarean delivery due to cephalopelvic disproportion was 2.3 (95% CI: 1.6-3.1) when comparing obese with normal weight women (p<0.001 for linear trend across BMI categories categories) and 1.2 (95% CI: 0.91-1.5) when comparing 4th *vs* 2nd weight gain quartile (p=0.19 for linear trend across weight gain categories). No increased risk was seen for cesarean due to fetal distress or anomalous presentation. However, the indication of prior cesarean was more frequent: RR=1.5 (95% CI: 1.2-2.1; p=0.003 for linear trend) and 1.3 (95% CI: 1.0-1.6; p=0.03 for linear trend), with higher BMI categories (obese *vs* normal weight) and greater weight gain (4th *vs* 2nd weight gain quartile), respectively. Also, risk for other/non-specified indication was greater: RR=1.4 (95% CI: 1.1-1.7) for obese *vs* normal weight (p=0.003 for linear trend) and 1.4 (95% CI: 1.2-1.6) for 4th *vs* 2nd weight gain quartile (p<0.001 for linear trend).

Table 2 displays crude and adjusted risk of cesarean delivery. After adjustment for age, skin color, education, site, parity, weight gain and length of gestation, obese women had a 1.8 risk of cesarean delivery (95% CI: 1.5-2.0) compared to normal weight women. Regression models including the potential mediating factors of GDM, pregnancy-related hypertension and macrosomia produced similar results (data not shown).

The adjusted relative risk of cesarean section in those in the 4th *vs* 2nd quartile of weight gain was 1.5 (95% CI: 1.3-1.6). Table 3 shows the adjusted risks of cesarean delivery associated with greater weight gain across BMI categories. Among obese women, the relative risk was 2.2 (95% CI: 1.4-3.2) when comparing women with 4th *vs* 2nd quartile gain. Weight gain according the 1990 Institute of Medicine (IOM) recommendations was also examined across BMI categories. Significant adjusted risk with excessive *vs* rec-

Table 3 - Crude and adjusted risks of cesarean delivery among those having greater weight gain according to body mass index categories (4th *vs* 2nd weight gain quartile). Brazilian Study of Gestational Diabetes, 1991-1995.

BMI categories	Crude		Adjusted*	
	RR	95% CI	RR	95% CI
Underweight	2.1	1.2-3.2	1.5	0.7-2.7
Normal	1.5	1.3-1.7	1.4	1.3-1.6
Pre-obese	1.5	1.2-1.8	1.5	1.1-1.8
Obese	1.9	1.3-2.6	2.2	1.4-3.2

BMI: body mass index
*Adjusted through logistic regression models for age, skin color, education, site, parity and length of gestation

ommended weight gain, defined as over IOM's recommended upper limit, was seen in normal (RR=1.3; 95% CI: 1.1-1.5) and pre-obese subjects (RR=1.5; 95% CI: 1.1-1.9). Underweight women with excess weight gain demonstrated a similar, though not statistically significant, adjusted risk (RR=1.4; 95% CI: 0.72-2.0). For obese women, the same limits for excess gain were adopted as for pre-obese women and it was found increased but not statistically significant risk (RR=1.7; 95% CI: 0.88-2.8). Overall, the relative risk for C-section in those with excess weight gain was 1.3 (95% CI: 1.2-1.5).

As shown in Table 4, the association between BMI categories and maternal complications were often different in those with and without cesarean delivery. Obesity increased the risk of meconium-stained amniotic fluid in vaginal deliveries (RR obese vs. normal weight 1.72; 95% CI: 1.23-2.33), but not in C-sections. Greater weight gain also increased this risk for those patients who had vaginal deliveries (RR 4th *vs* 2nd 1.27; 95% CI: 1.03-1.55), whereas in those having C-sections the observed association was protection (RR=0.70; 95% CI: 0.55-0.89). However, BMI categories and greater weight gain increased the risk for premature delivery in patients who underwent C-section (RR=1.56; 95% CI: 0.97-2.33; p=0.07) and (RR=1.58; 95% CI: 1.07-2.28), respectively. Increased adjusted risk for perinatal death was observed in obese when compared to normal weight women (RR=3.81; 95% CI: 1.18-10.61) undergoing cesarean, but not for vaginal delivery. Greater weight gain was associated with fewer perinatal deaths in vaginal delivery (RR 4th *vs* 2nd 0.45; 95% CI: 0.21-0.95); this association was not seen in cesarean deliveries. Separate analyses of the two components of this outcome, fetal death and early neonatal death, showed associations which were consistent in direction and generally similar in magnitude for vaginal deliveries (data not shown). The rates were too small to allow for such analyses in C-section births. Greater weight gain also predicted a greater adjusted risk for hemorrhage with vaginal delivery (RR 4th *vs* 2nd 3.98; 95% CI: 1.78-8.59) but not with C-section. No statistically significant associations were observed between BMI categories and hemorrhage with vaginal or cesarean delivery. Finally, a higher BMI category entailed a greater adjusted risk for infection (RR=2.41; 95% CI: 1.13-5.01) in the group of cesarean patients, but not in those with vaginal delivery. Additionally, a higher adjusted risk for infection, though without statistical significance (RR 4th *vs* 2nd 3.05; 95% CI: 0.86-9.88) was seen in vaginal delivery patients having greater weight gain.

DISCUSSION

In the present study, cesarean deliveries were considerably more frequent in higher BMI categories and those with greater weight gain during pregnancy.

In spite of the lack of uniformity concerning the defi-

Table 4 - Crude and adjusted* risks of pregnancy complications according to pre-gestational BMI categories (obese *vs* normal) and weight gain (4th *vs* 2nd quartile), by route of delivery. Brazilian Study of Gestational Diabetes, 1991-1995.

Complication		Vaginal delivery (N=2,726)			Cesarean delivery (N=1,648)		
		Events	RR**	95% CI	Events	RR**	95% CI
Meconium		353			313		
BMI categories	Crude		1.51	1.15-1.94		1.22	0.91-1.59
	Adjusted		1.72	1.23-2.33		1.21	0.84-1.68
Weight gain	Crude		1.14	0.93-1.40		0.69	0.55-0.87
	Adjusted		1.27	1.03-1.55		0.70	0.55-0.89
Prematurity		428			276		
BMI categories	Crude		0.59	0.44-0.80		0.87	0.63-1.18
	Adjusted		0.41	0.22-0.75		1.56	0.97-2.33
Weight gain	Crude		0.80	0.58-1.09		1.44	0.99-2.08
	Adjusted		0.75	0.54-1.04		1.58	1.07-2.28
Perinatal death		86			38		
BMI categories	Crude		1.23	0.66-2.28		1.45	0.64-3.24
	Adjusted		0.62	0.17-2.06		3.81	1.18-10.61
Weight gain	Crude		0.47	0.23-0.97		0.73	0.31-1.74
	Adjusted		0.45	0.21-0.95		1.04	0.43-2.52
Hemorrhage		40			22		
BMI categories	Crude		1.58	0.64-3.79		0.86	0.26-2.81
	Adjusted		1.44	0.40-4.95		0.63	0.14-2.68
Weight gain	Crude		3.65	1.64-7.85		0.81	0.34-1.92
	Adjusted		3.98	1.78-8.59		0.89	0.36-2.20
Infection		14			62		
BMI categories	Crude		0.96	0.19-4.65		2.15	1.15-4.00
	Adjusted		1.11	0.13-8.38		2.41	1.13-5.01
Weight gain	Crude		2.81	0.80-9.02		0.80	0.47-1.34
	Adjusted		3.05	0.86-9.88		0.94	0.55-1.60

*Adjusted through logistic regression models for age and education. Pre-pregnancy body mass index (BMI) categories analyses also adjusted for weight gain; weight gain analyses also adjusted for pre-pregnancy BMI categories
**Relative risk for obese *vs* normal weight and 4th *vs* 2nd quartile of weight gain, estimated assuming a linear trend of risk across the 4 BMI categories and weight gain

nition of obesity, many epidemiologic studies have reported increased risk for C-section in obese patients with crude relative risks varying from 1.2 to 3.6.[3,7,8, 23] This risk was evident even when it was examined for just primary cesarean deliveries,[21] and was present across many different practice settings. It has been suggested that obese women are more susceptible to prolonged labor with an increased risk for arrest disorders because of their increased pelvic soft tissues combined with a fixed bone structure resulting in a narrower birth canal.[7] Combining the study data with the literature, especially considering the large, mutually independent associations shown here for prepregnancy BMI and weight gain during pregnancy, suggests that both these nutritional aspects play an important role in this complication.

Increased cesarean rates have been described in obese women in the presence of fetal distress, cephalopelvic disproportion and prior C-section.[3] The study data are consistent with these previous findings, and emphasize the independent additional risk for several reported cesarean indications due to greater weight gain during pregnancy.

Obese women usually gain less weight during pregnancy than other categories. Nonetheless, there is a risk for adverse outcome when large weight gain occurs even in these patients. Studies by Parker & Abrams[18] reported increased incidence of large-for-gestational-age births (>90th percentile of fetal growth standards) of 40% for obese women (BMI >29 kg/m²) and Cogswell et al[6] found that high birth weight almost doubled among obese women who gained ≥13.7 kg compared to those who gained 6.8 to 8.6 kg during pregnancy, entailing an increased risk for cesarean. The study analyses were stratified according to the route of delivery and it was found that obesity and greater weight gain predicted meconium-stained amniotic fluid with vaginal delivery only, greater weight gain was protective against meconium staining with C-section. This difference suggests that cesarean indication in obese women is in fact preventing fetal distress. Johnson et al[9] described increased risk for meconium staining with obesity and weight gain and Bianco et al[3] also reported risk for obesity, but it was not found any previous studies investigating and demonstrating risk with obesity or weight gain when stratified for route of delivery. Large weight gain among obese pregnant women has been shown to be associated with increased risk of perinatal and neonatal mortality, as reported by Naeye.[15] However, in the study analyses stratified according to route of delivery, it was found a protective association with greater weight gain in women having vaginal deliveries and increased risk with obesity only in those having cesarean deliveries.

Postpartum hemorrhage associated with obesity was described by Bowers & Cohen[4] and with greater weight gain by Magann et al.[10] The study data showed no such risk for obesity and as such are inconsistent with Naef et al[14] findings, which characterized obesity as a risk factor. Moreover, it was found no previous reports stratifying risk of hemorrhage by route of delivery and reporting that the association of hemorrhage with greater weight gain is restricted to those with vaginal delivery. The risk of infection on C-section for obese patients was previously described[11] but interestingly, the risk for infection upon vaginal delivery was related not to obesity but rather to greater weight gain (though not statistically significantly) in this study analysis, as previously reported by Bahn et al.[1] Of note, in this regard, however, is the markedly greater overall risk of infection with cesarean delivery.

Critics of the 1990 Institute of Medicine's report, which raised the upper limits of recommended weight gain in pregnancy, suggest that the recommendations were based on concern about premature births and low birth weight without regard to macrosomia or gestational diabetes. The evidence of adverse outcomes with excess weight gain in obese women led these critics to suggest that obese patients should be encouraged to gain less then 11.4 kg during pregnancy.[6] The study findings of increased maternal and various perinatal adverse outcomes support this criticism.

One potential limitation of the study findings is that self-reported prepregnancy weight was used. However, Palta et al[17] findings suggest the resulting bias would be inconsequential. Stewart[22] suggests that self-reported measures are valid and reliable even in groups of people for whom one might expect the data to be of poor quality, such as those who are severely overweight. The validity of self-reported weight was considered acceptable for surveys of the prevalence of ponderosity in similar settings.[20] Another potential limitation is that outcomes in the study are based on chart review and some of them concerning labor complications are based on relatively small rates, leading to wide confidence intervals, and thus should be interpreted with caution. Finally, as a relatively large proportion of the sample was not followed up to term, even though study characteristics were similar among those remaining and those lost to follow-up, a certain potential for selection bias due to these losses to follow-up is possible.

The present study was conducted in a setting with a relatively high rate of cesarean delivery and with

rates of maternal and fetal complications more compatible with those found in developing countries. These facts should be taken into account when generalizing the findings here described. In addition, it was conducted in six state capitals of Brazil, a large country with multiracial distribution, thus providing data from a developing world clinical setting. The large size of the study allow for adjustment for several potentially confounders. The population attributable proportion of cesarean deliveries associated with prepregnancy excess weight (pre-obesity and obesity) was 11.3% and with greater weight gain, 9.6%. The study findings emphasize, in a world afflicted by a pandemia of obesity and in which a large proportion of women gain more weight than recommended during pregnancy, that efforts to reduce cesarean delivery will be hampered by the increasing proportion of obesity and large weight gain among pregnant women.

In conclusion, obesity and greater weight gain in pregnancy are important risk factors of C-section. Prepregnancy obesity or greater weight gain increase risk of meconium and hemorrhage in vaginal delivery, and infection, prematurity and perinatal death in cesarean delivery. These risks should be taken into account while making future pregnancy weight gain recommendations.

REFERENCES

1. Bahn SA, Jacobson J, Petersen F. Maternal and neonatal outcome following prolonged labor induction. *Obstet Gynecol*. 1998;92(3):403-7.

2. Behague DP, Victora CG, Barros FC. Consumer demand for caesarean sections in Brazil: informed decision making, patient choice, or social inequality?: a population based birth cohort study linking ethnographic and epidemiological methods. *BMJ*. 2002;324(7343):942-5.

3. Bianco AT, Smilen SW, Davis Y, Lopez S, Lapinski R, Lockwood CJ. Pregnancy outcome and weight gain recommendations for the morbidly obese woman. *Obstet Gynecol*. 1998;91(1):97-102.

4. Bowers D, Cohen WR. Obesity and related pregnancy complications in an inner-city clinic. *J Perinatol*. 1999;19(3):216-9.

5. Capurro H, Konichezky S, Fonseca D, Caldeyro-Barcia R. A simplified method for diagnosis of gestational age in the newborn infant. *J Pediatr.* 1978;93(1):120-2.

6. Cogswell ME, Serdula MK, Hungerford DW, Yip R. Gestational weight gain among average-weight and overweight women: what is excessive? *Am J Obstet Gynecol.* 1995;172(2 Pt 1):705-12.

7. Crane SS, Wojtowycz MA, Dye TD, Aubry RH, Artal R. Association between pre-pregnancy obesity and the risk of cesarean delivery. *Obstet Gynecol.* 1997;89(2):213-6.

8. Dietz PM, Callaghan WM, Morrow B, Cogswell ME. Population-based assessment of the risk of primary cesarean delivery due to excess prepregnancy weight among nulliparous women delivering term infants. *Matern Child Health J.* 2005;9(3):237-44.

9. Johnson JW, Longmate JA, Frentzen B. Excessive maternal weight and pregnancy outcome. *Am J Obstet Gynecol.* 1992;167(2):353-70.

10. Magann EF, Winchester MI, Carter DP, Martin JN Jr, Bass JD, Morrison JC. Factors adversely affecting pregnancy outcome in the military. *Am J Perinatol*. 1995;12(6):462-6.

11. Martens MG, Kolrud BL, Faro S, Maccato M, Hammill H. Development of wound infection or separation after cesarean delivery: prospective evaluation of 2,431 cases. *J Reprod Med*. 1995;40(3):171-5.

12. Martin JA, Hamilton BE, Sutton PD, Ventura SJ, Menacker F, Munson ML. Births: final data for 2002. *Natl Vital Stat Rep*. 2003;52(10):1-113.

13. Monteiro CA. Epidemiologia da obesidade. In: Halpern A, Godoy AFM, Suplicy HL, Mancini. MC, Zanella MT, organizadores. Obesidade. São Paulo: Lemos Editorial; 1998. p. 15-30.

14. Naef RW III, Chauhan SP, Chevalier SP, Roberts WE, Meydrech EF, Morrison JC. Prediction of hemorrhage at cesarean delivery. *Obstet Gynecol*. 1994;83(6):923-6.

15. Naeye RL. Maternal body weight and pregnancy outcome. *Am J Clin Nutr*. 1990;52(2):273-9.

16. Nucci LB, Duncan BB, Mengue SS, Branchtein L, Schmidt MI, Fleck ET. Assessment of weight gain during pregnancy in general prenatal care services in Brazil. *Cad Saúde Pública*. 2001;17(6):1367-74.

17. Palta M, Prineas RJ, Berman R, Hannan P. Comparison of self-reported and measured height and weight. *Am J Epidemiol.* 1982;115(2):223-30.

18. Parker JD, Abrams B. Prenatal weight gain advice: an examination of the recent prenatal weight gain recommendations of the Institute of Medicine. *Obstet Gynecol.* 1992;79(5 Pt 1):664-9.

19. Schmidt MI, Duncan BB, Reichelt AJ, Branchtein L, Matos MC, Costa e Forti A, et al. Gestational diabetes mellitus diagnosed with a 2-h 75-g oral glucose tolerance test and adverse pregnancy outcomes. *Diabetes Care*. 2001;24(7):1151-5.

20. Schmidt MI, Duncan BB, Tavares M, Polanczyk CA, Pellanda L, Zimmer PM. Validity of self-reported weight: a study of urban brazilian adults. *Rev Saúde Pública*. 1993;27(4):271-6.

21. Shepard MJ, Saftlas AF, Leo-Summers L, Bracken MB. Maternal anthropometric factors and risk of primary cesarean delivery. *Am J Public Health.* 1998;88(10):1534-8.

22. Stewart AL. The reliability and validity of self-reported weight and height. *J Chronic Dis.* 1982;35(4):295-309.

23. Vahratian A, Siega-Riz AM, Savitz DA, Zhang J. Maternal pre-pregnancy overweight and obesity and the risk of cesarean delivery in nulliparous women. *Ann Epidemiol.* 2005;15(7):467-74.

24. Zhang J, Yu KF. What's the relative risk?: a method of correcting the odds ratio in cohort studies of common outcomes. *JAMA.* 1998;280(19):1690-1.

Baseado em dissertação de mestrado apresentada à Faculdade de Medicina da Universidade Federal do Rio Grande do Sul, em 2002.