

# Maternal and Perinatal Outcomes of Extreme Obesity in Pregnancy

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## Abstract

**Objective:** To evaluate the effects of extreme obesity (pre-pregnancy BMI  $\geq 50.0$  kg/m<sup>2</sup>) in pregnancy on maternal and perinatal outcomes.

**Methods:** We conducted a population-based cohort study using the Newfoundland and Labrador Perinatal Database to compare obstetric outcomes in women with extreme obesity and those with a normal BMI (pre-pregnancy BMI 18.50 to 24.99 kg/m<sup>2</sup>). We included women with singleton gestations who gave birth between January 1, 2002, and December 31, 2011. Maternal outcomes of interest included gestational hypertension, gestational diabetes, Caesarean section, shoulder dystocia, length of hospital stay, maternal ICU admission, postpartum hemorrhage, and death. Perinatal outcomes included birth weight, preterm birth, Apgar score, neonatal metabolic abnormality, NICU admission, stillbirth, and neonatal death. A composite morbidity outcome was developed including at least one of Caesarean section, gestational hypertension, birth weight  $\geq 4000$  g, birth weight  $< 2500$  g, or NICU admission. Univariate analyses and multivariate logistic regression analyses (controlling for maternal age, parity, smoking, partner status, and gestational age) were performed, and adjusted odds ratios (aORs) and 95% confidence intervals were calculated.

**Results:** A total of 5788 women were included in the study: 71 with extreme obesity and 5717 with a normal BMI. Extremely obese women were more likely to have gestational hypertension (19.7% vs. 4.8%) (aOR 1.56; 95% CI 1.33 to 1.82), gestational diabetes (21.1% vs. 1.5%) (aOR 2.04; 95% CI 1.74 to 2.38), shoulder dystocia (7.1% vs. 1.4%) (aOR 1.51; 95% CI 1.05 to 2.19), Caesarean section (60.6% vs. 25.0%) (aOR 1.46; 95% CI 1.29 to 1.65), length of hospital stay more than five days (excluding Caesarean section) (14.3% vs. 4.7%) (aOR 1.42; 95% CI 1.07 to 1.89), birth weight  $\geq 4000$  g (38.0% vs. 11.9%) (aOR 1.58; 95% CI 1.38 to 1.80), birth weight  $\geq 4500$  g (16.9% vs. 2.1%) (aOR 1.87; 95% CI 1.57 to 2.23), neonatal metabolic abnormality (8.5% vs. 2.0%) (aOR 1.50; 95% CI 1.20

to 1.86), NICU admission (16.9% vs. 7.8%) (aOR 1.28; 95% CI 1.07 to 1.52), stillbirth (1.4% vs. 0.2%) (aOR 1.68; 95% CI 1.00 to 2.82) and composite adverse outcome (81.7% vs. 41.5%) (aOR 1.57; 95% CI 1.35 to 1.83).

**Conclusion:** Women with extreme obesity have increased risks of a variety of adverse maternal and perinatal outcomes. As approximately 6 per 1000 women giving birth in our population have extreme obesity, it is important to address these risks pre-conceptually and encourage a healthier BMI before pregnancy.

## Résumé

**Objectif :** Évaluer les effets de l'obésité extrême (IMC pré-grossesse  $\geq 50,0$  kg/m<sup>2</sup>) pendant la grossesse sur les issues maternelles et périnatales.

**Méthodes :** Nous avons mené une étude de cohorte en population générale au moyen de la *Newfoundland and Labrador Perinatal Database* en vue de comparer les issues obstétricales des femmes présentant une obésité extrême à celles des femmes dont l'IMC est normal (IMC pré-grossesse allant de 18,50 à 24,99 kg/m<sup>2</sup>). Nous avons inclus les femmes qui connaissaient une grossesse monofoetale et qui ont accouché entre le 1<sup>er</sup> janvier 2002 et le 31 décembre 2011. Parmi les issues maternelles d'intérêt, on trouvait l'hypertension gestationnelle, le diabète gestationnel, la césarienne, la dystocie de l'épaule, la durée de l'hospitalisation, l'admission à l'unité maternelle de soins intensifs, l'hémorragie postpartum et la mort. Parmi les issues périnatales, on trouvait le poids de naissance, l'accouchement préterme, l'indice d'Apgar, les anomalies métaboliques néonatales, l'admission à l'UNSI, la mortinaissance et le décès néonatal. Une issue composite en matière de morbidité a été élaborée; on y retrouve au moins un des facteurs suivants : césarienne, hypertension gestationnelle, poids de naissance  $\geq 4\ 000$  g, poids de naissance  $< 2\ 500$  g ou admission à l'UNSI. Des analyses univariées et des analyses de régression logistique multivariée (neutralisant l'effet de l'âge maternel, de la parité, du tabagisme, de l'état quant à la présence ou non d'un partenaire et de l'âge gestationnel) ont été menées, et des rapports de cotes corrigés (RCc) et des intervalles de confiance à 95 % ont été calculés.

**Résultats :** Au total, 5 788 femmes ont été incluses à l'étude : 71 présentant une obésité extrême et 5 717 présentant un IMC normal. Les femmes extrêmement obèses étaient plus susceptibles de connaître ce qui suit : hypertension gestationnelle (19,7 % vs 4,8 %) (RCc 1,56; IC à 95 %, 1,33 - 1,82), diabète gestationnel

**Key Words:** Obesity, extreme obesity, super-obesity, maternal, perinatal, Caesarean section

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(21,1 % vs 1,5 %) (RCc 2,04; IC à 95 %, 1,74 - 2,38), dystocie de l'épaule (7,1 % vs 1,4 %) (RCc 1,51; IC à 95 %, 1,05 - 2,19), césarienne (60,6 % vs 25,0 %) (RCc 1,46; IC à 95 %, 1,29 - 1,65), hospitalisation de plus de cinq jours (cas de césarienne exclus) (14,3 % vs 4,7 %) (RCc 1,42; IC à 95 %, 1,07 - 1,89), poids de naissance  $\geq 4\ 000$  g (38,0 % vs 11,9 %) (RCc 1,58; IC à 95 %, 1,38 - 1,80), poids de naissance  $\geq 4\ 500$  g (16,9 % vs 2,1 %) (RCc 1,87; IC à 95 %, 1,57 - 2,23), anomalie métabolique néonatale (8,5 % vs 2,0 %) (RCc 1,50; IC à 95 %, 1,20 - 1,86), admission à l'UNSI (16,9 % vs 7,8 %) (RCc 1,28; IC à 95 %, 1,07 - 1,52), mortinaissance (1,4 % vs 0,2 %) (RCc 1,68; IC à 95 %, 1,00 - 2,82) et issue indésirable composite (81,7 % vs 41,5 %) (RCc 1,57; IC à 95 %, 1,35 - 1,83).

**Conclusion :** Les femmes qui présentent une obésité extrême sont exposées à des risques accrus de connaître une variété d'issues indésirables maternelles et périnatales. Puisque, au sein de notre population, environ six parturientes sur 1 000 présentent une obésité extrême, il est important de traiter de ces risques avant la conception et d'inciter les patientes à obtenir un IMC plus santé avant de devenir enceintes.

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## INTRODUCTION

Obesity is increasing, both in the general population and in women of reproductive age.<sup>1-5</sup> Not only is the prevalence of obesity increasing over time but these increases have been proportionately greater for the heaviest weight classes.<sup>3</sup> Obesity in pregnant women increases the risks of maternal and perinatal complications.<sup>1,2,5-9</sup> The provincial rates of obesity vary across the country. In 2004, Newfoundland and Labrador had the highest provincial rate for women in Canada, at 34.5%, compared with the national rate of 23.2%.<sup>4</sup> A number of maternal and perinatal complications associated with obesity have been identified, but there is less information about the complications of extreme obesity (a pre-pregnancy body mass index  $\geq 50.0$  kg/m<sup>2</sup>).<sup>10-14</sup> Until 2011, there was no opportunity provincially for those with morbid obesity (BMI  $\geq 40.0$  kg/m<sup>2</sup>) or extreme obesity (BMI  $\geq 50.0$  kg/m<sup>2</sup>) to undergo bariatric surgery to help achieve a healthier BMI.

The objective of our study was to evaluate the effects of extreme obesity (BMI  $\geq 50.0$  kg/m<sup>2</sup>) on maternal and perinatal complications.

## METHODS

We performed a population-based cohort study of women with singleton pregnancies who delivered between January 1, 2002, and December 31, 2011, in the province of Newfoundland and Labrador. The cohort was identified using the Newfoundland and Labrador Provincial Perinatal Program Database, a computerized database that collects information on pregnancy outcomes for several regions of

the province. Although no validation study of the database has been published, quality assurance and data quality are ensured through the Newfoundland and Labrador Provincial Perinatal Program's routine edit checking process on extracted data. Women were excluded from the study if their pre-pregnancy BMI was not recorded. Pre-pregnancy BMI was based on self-reported height and weight recorded at the first prenatal visit. Pre-pregnancy BMIs were divided into categories based on Health Canada guidelines and World Health Organization recommendations. These categories were underweight (BMI  $< 18.50$  kg/m<sup>2</sup>); normal weight (BMI 18.50 to 24.99 kg/m<sup>2</sup>); overweight (BMI 25.00 to 29.99 kg/m<sup>2</sup>); obese (BMI 30.00 to 39.99 kg/m<sup>2</sup>); and morbidly obese (BMI  $\geq 40.00$  kg/m<sup>2</sup>).<sup>3,4</sup> The category of morbid obesity was based on the World Health Organization category of class III obesity.<sup>3,4</sup> Extreme obesity was defined as a BMI  $\geq 50.00$  kg/m<sup>2</sup>.<sup>15</sup> Women with a BMI  $\geq 50.00$  kg/m<sup>2</sup> were compared to women with a normal BMI (BMI 18.50 to 24.99 kg/m<sup>2</sup>).

Maternal characteristics including maternal age, parity, partner status, smoking status during pregnancy, pre-conception folic acid use, pre-gestational diabetes, and pre-gestational hypertension were described and compared between the two groups. Maternal outcomes that were evaluated included delivery by Caesarean section, gestational hypertension, gestational diabetes, induction of labour, augmentation of labour, epidural use (excluding elective Caesarean section), prostaglandin use for cervical ripening among those undergoing labour induction, operative vaginal delivery, shoulder dystocia, third and fourth degree tears, length of stay more than three and five days (excluding all deliveries by Caesarean section), maternal ICU admission, postpartum hemorrhage ( $> 500$  mL after vaginal delivery or  $> 1000$  mL after Caesarean section), venous thromboembolism, and maternal mortality. Neonatal outcomes included gestational age at delivery, preterm birth  $< 34$  and  $< 37$  weeks' of gestation, birth weight (including birth weight  $< 2500$  g, birth weight  $\geq 4000$  g, and birth weight  $\geq 4500$  g), Apgar score at one and five minutes, bag and mask ventilation at neonatal resuscitation, sepsis, intraventricular hemorrhage, respiratory distress syndrome, necrotizing enterocolitis, neonatal seizure, neonatal metabolic abnormality (including hypoglycemia, hypomagnesemia, and hypocalcemia), neonatal intensive care unit admission, malpresentation (noncephalic presentation), congenital malformations (both major and minor), stillbirth, and neonatal death. A composite adverse outcome was also developed; this included any one of delivery by Caesarean section, gestational hypertension, birth weight  $< 2500$  g, birth weight  $\geq 4000$  g, or NICU admission. Outcomes were based on ICD-10 coding.<sup>16</sup>

**Table 1. Demographic characteristics**

	BMI, n/N (%)		<i>P</i>
	18.5 to 24.99 kg/m <sup>2</sup>	At least 50.0 kg/m <sup>2</sup>	
N	5717	71	
Age, years†	29.5 (5.4)	30.3 (5.0)	0.16
Nulliparous	2615/5717 (45.7)	42/71 (59.2)	0.02
Partnered	4320/5681 (76.0)	57/71 (80.3)	0.41
Smoker	777/5711 (13.6)	10/71 (14.1)	0.91
Folic acid	1561/2690 (58.0)	15/33 (45.5)	0.15
Pre-existing diabetes	33/5717 (0.6)	4/71 (5.6)	0.001*
Essential hypertension	26/5717 (0.5)	5/71 (7.0)	< 0.001*
BMI, kg/m <sup>2</sup> †	22.1 (1.7)	54.0 (3.9)	

\*Fisher exact test  
†Mean (standard deviation)

Statistical analysis was performed using SPSS 19.0 (IBM Corp., Armonk, NY) and WINPEPI 10.5 (Computer Programs for Epidemiologists, Stone Mountain, GA). Descriptive statistics were used for the groups. Univariate analyses including chi-square and Fisher exact tests were used to compare dichotomous outcomes between the groups, and Student *t* test was used to compare continuous outcomes. Multiple logistic regression models were used to evaluate outcomes, adjusting for maternal age, parity, smoking status, partnered status, and gestational age (for outcomes other than gestational age at delivery). The factors included in the models were biologically plausible variables that have previously been associated with the outcomes of interest. The logistic regression models did not include essential hypertension or pre-gestational diabetes as these factors were considered steps in the possible association between extreme obesity and the outcomes of interest. Adjusted odds ratios (aOR) and 95% confidence intervals were calculated. A value of  $P < 0.05$  was considered significant. The number of women with extreme obesity resulting in one additional case of composite adverse outcome was calculated.

Ethics approval for the study was obtained from the university and the hospital.

## RESULTS

Of the 22 594 women with singleton pregnancies in the database, 12 891 (57.1%) had a pre-pregnancy BMI recorded; of these, 71 had a BMI  $\geq 50.00$  kg/m<sup>2</sup> (approximately 6 per 1000 pregnancies with BMI information available) and 5717 had a normal BMI (18.50

to 24.99 kg/m<sup>2</sup>). The range of BMI in women with extreme obesity was 50.05 to 70.85 kg/m<sup>2</sup>, with a mean BMI of 54.0 kg/m<sup>2</sup>.

The demographic characteristics of the women included in the study are shown in Table 1. Women with extreme obesity were more likely to be nulliparous and to have pre-existing diabetes and essential hypertension.

The maternal outcomes by univariate analyses are summarized in Table 2. Women with extreme obesity were more likely to develop gestational hypertension or gestational diabetes, to require Caesarean section, and to have a length of stay beyond five days. There was one maternal death, in a woman who was in the extreme obesity group ( $P = 0.012$ , Fisher exact test).

The perinatal outcomes are described in Table 3. Babies born to women with extreme obesity were more likely to weigh  $\geq 4000$  g and 4500 g, to have neonatal metabolic abnormalities, and to require NICU admission. The composite adverse outcome was more common in the extreme obesity group.

The multivariate logistic regression analyses showing the outcomes significantly associated with extreme obesity are summarized in Table 4. Women with extreme obesity had higher odds of gestational hypertension, gestational diabetes, shoulder dystocia, Caesarean section, a maternal length of stay of more than five days, neonatal birth weight  $> 4000$  g and 4500 g, neonatal metabolic abnormality, NICU admission, and stillbirth. The odds of composite adverse outcome (including any one of delivery by Caesarean section, gestational hypertension, birth weight  $< 2500$  g, birth weight  $\geq 4000$  g, or NICU admission) was higher in the extreme

**Table 2. Maternal outcomes**

	BMI, n/N (%)		P
	18.5 to 24.99 kg/m <sup>2</sup>	≥ 50.0 kg/m <sup>2</sup>	
Gestational HTN	275/5717 (4.8)	14/71 (19.7)	< 0.001*
Gestational diabetes	88/5717 (1.5)	15/71 (21.1)	< 0.001*
Induction of labour†	1506/4940 (30.5)	16/41 (39.0)	0.24
Use of prostaglandins‡	725/1506 (48.1)	9/16 (56.3)	0.52
Augmentation of labour†	1168/4940 (23.6)	13/41 (31.7)	0.23
Caesarean section†	654/4940 (13.2)	13/41 (31.7)	0.001
Caesarean section (all)	1427/5717 (25.0)	43/71 (60.6)	< 0.001
Epidural analgesia†	2859/4940 (57.9)	26/41 (63.4)	0.47
Shoulder dystocia§	59/4290 (1.4)	2/28 (7.1)	0.059*
3rd/4th degree tear§	99/4290 (2.3)	1/28 (3.6)	0.48*
Length of stay > 3 days§	907/4290 (21.1)	8/28 (28.6)	0.34
Length of stay > 5 days§	202/4290 (4.7)	4/28 (14.3)	0.042*
ICU admission	15/5717 (0.3)	1/71 (1.4)	0.18*
Postpartum hemorrhage	279/5717 (4.9)	7/71 (9.9)	0.087*
Blood transfusion	39/5717 (0.7)	1/71 (1.4)	0.39*
Venous thromboembolism	2/5717 (0.03)	0/71 (0)	> 0.99*
Maternal death	0/5717 (0)	1/71 (1.4)	0.012*

HTN: hypertension

\*Fisher exact test

†Excluding elective Caesarean sections

‡Among inductions of labour

§Excluding all Caesarean sections

**Table 3. Neonatal outcomes**

	BMI, n/N (%)		P
	18.5 to 24.99 kg/m <sup>2</sup>	≥ 50.0 kg/m <sup>2</sup>	
Composite adverse outcome*	2370/5717 (41.5)	58/71 (81.7)	< 0.001
Gestational age < 37 wks	406/5717 (7.1)	6/71 (8.5)	0.66
Gestational age < 34 wks	101/5717 (1.8)	1/71 (1.4)	> 0.99†
Birth weight < 2500 g	269/5717 (4.7)	3/71 (4.2)	> 0.99
Birth weight ≥ 4000 g	680/5717 (11.9)	27/71 (38.0)	< 0.001
Birth weight ≥ 4500 g	121/5717 (2.1)	12/71 (16.9)	< 0.001†
Apgar < 7 at 1 minute	275/5681 (4.8)	6/70 (8.6)	0.16
Apgar < 7 at 5 minutes	60/5707 (1.1)	2/71 (2.8)	0.18*
Bag-mask for resuscitation	334/5717 (5.8)	5/71 (7.0)	0.61
Metabolic disorder	113/5717 (2.0)	6/71 (8.5)	0.003†
NICU admission	444/5717 (7.8)	12/71 (16.9)	0.005
Congenital malformation	652/5717 (11.4)	11/71 (15.5)	0.28
Stillbirth	11/5717 (0.2)	1/71 (1.4)	0.14†
Neonatal death	13/5717 (0.2)	0/71 (0)	> 0.99†
Malpresentation	328/5717 (5.7)	6/71 (8.5)	0.30†

\*Includes at least one of Caesarean section, birth weight ≥ 4000 g, birth weight &lt; 2500 g, or NICU admission

†Fisher exact test

**Table 4. Logistic regression analyses showing maternal and neonatal outcomes significantly associated with extreme obesity**

Outcome	aOR	95% CI
Gestational hypertension	1.56	1.33 to 1.82
Gestational diabetes	2.04	1.74 to 2.38
Shoulder dystocia	1.51	1.05 to 2.19
Caesarean section	1.46	1.29 to 1.65
Length of stay > 5 days	1.42	1.07 to 1.89
Birth weight ≥ 4000 g	1.58	1.38 to 1.80
Birth weight ≥ 4500 g	1.87	1.57 to 2.23
Neonatal metabolic abnormality	1.50	1.20 to 1.86
NICU admission	1.28	1.07 to 1.52
Stillbirth	1.68	1.00 to 2.82
Composite adverse outcome*	1.57	1.35 to 1.83

Adjusted for maternal age, parity, smoking status, partnered status, and gestational age (for outcomes other than gestational age at delivery).

\*Includes at least one of Caesarean section, birth weight ≥ 4000 g, birth weight < 2500 g, or NICU admission.

obesity group. For every 10 women with extreme obesity, one additional composite adverse outcome occurred.<sup>17</sup>

## DISCUSSION

The rate of extreme obesity in our study population, of those with BMI reported, was approximately six per 1000 singleton pregnancies (0.6%). This rate is higher than that reported in the United Kingdom, at one of every 1200 women giving birth,<sup>15</sup> and in Missouri and Kentucky at 0.4%,<sup>12,13</sup> but is not as high as reported in Charleston, South Carolina at 2.2%.<sup>10</sup> In the current study BMI was calculated based on the woman's pre-pregnancy height and weight, whereas others have used either the last recorded weight prior to delivery or any weight in pregnancy giving a BMI of 50.00 kg/m<sup>2</sup> or more.<sup>10,11,15</sup> Had the last recorded weight during pregnancy been used in this study, the prevalence of extreme obesity would have been higher. We elected not to use the last recorded weight because weight gain during pregnancy is known to be a predictor of adverse maternal and neonatal outcomes, independent of pre-pregnancy BMI.<sup>18,19</sup>

The current study found a number of maternal complications independently associated with extreme obesity, including gestational hypertension, gestational diabetes, shoulder dystocia, Caesarean section, and prolonged length of stay. These findings cannot be explained by maternal age, parity, partner status, smoking, or gestational age, as these factors were adjusted in the

logistic regression models. The current study found the rates of gestational diabetes and shoulder dystocia higher than reported in other studies (gestational diabetes 21.1% compared with 11% to 12.9%<sup>10,15</sup>; shoulder dystocia 7.1% compared with 4%<sup>15</sup>).

The rate of Caesarean section in women with extreme obesity in the current study was 60.6%, somewhat higher than reported in other studies (49.1% to 56%).<sup>10,13-15</sup> This high rate has significant implications for these women and their health care providers. Previous research has found a 30% rate of wound complications after Caesarean section in women with extreme obesity, some of whom required readmission and reoperation.<sup>11</sup> Additional health care resources may be required for these women during labour, delivery, and the postpartum period.

Neonatal complications, including macrosomia, neonatal metabolic abnormalities, NICU admission, and stillbirth, were also more frequent even after adjusting for maternal age, parity, smoking, partner status, and gestational age. The rate of fetal macrosomia (birth weight ≥ 4500 g) of 16.9% is higher than noted in previous studies (3.4%).<sup>14</sup> Some of these outcomes have a long-term impact on the health of the child and result in additional use of health care resources in the neonatal period.

It is important to address the limitations of the study. Almost 43% of women with singleton gestations in the database did not have BMI recorded, most of which were missing data on height. This high rate of missing data for BMI has been noted by other researchers.<sup>20,21</sup> Women self-reported height and weight, usually at the first prenatal visit, and this provided the basis for the calculation of BMI. Some researchers note self-reporting may under-report true weight and BMI,<sup>4,22,23</sup> while others suggest that self-reporting is highly correlated with actual weight and BMI.<sup>24-26</sup> In the current study it is anticipated that the self-reported pre-pregnancy weight was close to the actual weight, especially as it was reported at the first prenatal visit when these women would have also been weighed. If the self-reported weight was lower than the actual weight our study would have underestimated the prevalence of extreme obesity. The sample size of the current study was relatively small for extreme obesity (N = 71). Despite this, it was found that a variety of maternal and neonatal adverse outcomes were independently associated with extreme obesity. There was insufficient statistical power to evaluate uncommon but significant complications, including blood transfusion, venous thromboembolism, and maternal ICU admission. Although there was only one maternal death (in the extreme obesity group) this finding was statistically significant by univariate analysis. Because there was only

one case, logistic regression could not be performed to determine if extreme obesity was independently associated with this outcome, while adjusting for other potential confounders. Finally, a *P* value of < 0.05 was considered statistically significant. Because multiple statistical tests were performed this may have increased the type I error. The current study did not have a single primary outcome with multiple secondary outcomes allowing for a significant *P* value < 0.05 for the primary outcome and an adjusted *P* value for the secondary outcomes. The use of the Bonferroni correction is felt by some experts to be overly conservative<sup>27</sup> and so it was not used in the current study.

The strengths of our study include the fact that this population based study adjusted for possible confounders including maternal age, parity, smoking, partner status, and gestational age. Pre-pregnancy BMI was used because using the last recorded weight in pregnancy to calculate the BMI would likely over-report the prevalence and would not account for the effect of weight gain in pregnancy. The self-reporting of weight and height was recorded at the first prenatal visit to minimize recall bias.

## CONCLUSION

Women with a pre-pregnancy BMI of  $\geq 50.00$  kg/m<sup>2</sup> have increased risks of a variety of significant adverse maternal and perinatal outcomes. This may have implications for the care of these women and their infants during pregnancy, delivery, and the postpartum period. Such women may require additional health care resources. It is important pre-conceptually to address these risks and to encourage a healthier BMI prior to pregnancy.

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