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Maternal Body Mass Index and Regional Anaesthesia Use at Term: Prevalence and Complications

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Abstract

Background—There is an evidence gap regarding the use of regional anaesthesia (epidural, spinal, or combined epidural/spinal anaesthesia) and associated complications by maternal body mass index (BMI). We examine associations between regional anaesthesia, mode of delivery, and regional anaesthesia complications by pre-pregnancy BMI categories among term deliveries.

Methods—Retrospective cohort study of births in California, 2007–2010, utilizing linked birth certificate data and patient discharge data. Outcomes were mode of delivery (among laboured deliveries) and select regional anaesthesia complications. Multivariable Poisson regression was used to adjust for maternal characteristics.

Results—In women undergoing labour (i.e., laboured delivery), women with higher BMI categories were more likely to receive regional analgesia in a dose-response fashion (adjusted risk ratio [aRR] for primiparous women with category I obesity, 1.10, 95% confidence interval [CI] 1.10, 1.11), and in those receiving regional anaesthesia, were less likely to deliver vaginally (e.g., aRR 0.85, 95% CI 0.84, 0.85 for the same category of women). Regional anaesthesia complications displayed a complex relationship with maternal BMI, with women in intermediate obesity categories having decreased odds as compared to normal-weight women, and women in the highest BMI category having a twofold increased risk of complications (aRR for primiparous women 2.34, 95% CI 1.37, 4.02).

Conclusion—Labouring women in higher BMI categories were more likely to receive regional anaesthesia and more likely to deliver via caesarean compared to normal weight women and women without regional anaesthesia. Rates of anaesthesia complications were highest among women in the highest BMI category.

Keywords

Regional anaesthesia; BMI; caesarean delivery; labour

Introduction

Obesity results in major changes to a woman's physiology, body habitus, and mechanics (e.g., movement) during pregnancy and delivery in a variety of ways that research has not yet fully explained. Obesity-related physiological effects that have been documented in pregnancy and childbirth to date include lengthened gestation,¹ slower labour progression,² and decreased uterine contractility.³ As well, it is now well documented that a variety of perinatal outcomes differ by maternal body mass index (BMI). Women with obesity are at increased risk for a host of outcomes, including those that occur antepartum (e.g., gestational diabetes⁴ and hypertension⁵), intrapartum (e.g., caesarean delivery^{6, 7}), and postpartum (e.g., wound infection subsequent to caesarean delivery⁸). Regional anaesthesia, most commonly an epidural block alone but sometimes a spinal block or epidural/spinal combined, can be placed intrapartum either for analgesia during labour or for anaesthesia immediately prior to operative vaginal or caesarean delivery. Like obesity, epidural analgesia is associated with slower labour progression and altered labour management,^{9–11} although, unlike obesity, epidural use itself is not thought to increase the rate of caesarean delivery (according to evidence from randomized controlled trials¹²). However, relatively little literature documents the prevalence of epidural analgesia and mode of delivery subsequent to epidural among women of varying BMI, and the existing evidence comes from small studies at single centers.^{2, 3, 13}

What is known about maternal BMI and epidural use suggests that practice and outcomes around epidural may differ by women of varying BMI. For example, obesity results in structural challenges to adequate placement of an epidural catheter, including difficulty in palpating bony landmarks and increased depth of spinal structures,¹⁴ increasing the likelihood of multiple placement attempts. Upon successful placement, obese women have a lower analgesic requirement than non-obese women,¹⁵ but increased risk of needing repeat placement due to catheter dislodgement during labour.¹⁶ These physiological and pharmacokinetic differences suggest that other features of epidural use may differ by maternal BMI, with implications for obstetric care and women's health outcomes.¹⁷

In addition to these practice considerations, evidence is emerging that complications of epidural analgesia may be affected by maternal obesity. Epidural complications arise largely from puncture of the anesthetic/analgesic agent into a part of the spinal anatomy besides the epidural space, which can increase due to multiple and repeat placement attempts. The physical manifestation of these occurrences are varied, and range from mild (headache¹⁸) to serious (meningitis^{19, 20}). These complications can persist after delivery, and are a source of maternal morbidity, with the most common complication, postural puncture headache, affecting an estimated 1% of all women receiving epidural.¹⁸ This complication was also found to have an inverse relationship with BMI.²¹ Given the high prevalence of obesity (38.3% of women in the US have obesity²²) and the high frequency of epidural use (over 60% in vaginal deliveries²³), there is a need for more research on this topic to identify risks, clarify best practice, and enable women of all BMI to have a healthy birth outcome. We explore the use of regional anaesthesia, mode of delivery, and complications associated with regional anaesthesia receipt in women by pre-pregnancy BMI.

Methods

Study population

We conducted a retrospective cohort study using linked hospital discharge and vital records data (birth certificates and infant death files²⁴) for all births in California between 2007 and 2010 (N=2 094 220). The dataset contains linked birth and delivery records with de-identified information for a mother and neonate pair from neonatal and maternal discharge data and the neonate's birth certificate. Hospital discharge data are present for the mother in the nine months preceding birth and the year after delivery; infant discharge data is present for the first year after birth. This study was approved by the California Office of Statewide Health Planning and Development and by the Oregon Health and Science University institutional review board.

We excluded the following subjects from the analytic sample: fetal deaths, congenital anomalies of the newborn, multiple gestation, breech presentation, and records with either preterm birth (<37 weeks) or implausible gestational ages (total excluded 277 377).

Exposure: maternal body mass index

Maternal body mass index (BMI; kg/m²), was calculated from the woman's pre-pregnancy self-reported height and weight. BMI was classified as per the WHO as normal weight (BMI 18.5–24.9), overweight (BMI 25–29.9), and obesity classes I (BMI 30–34.9), II (BMI 35–39.9), and III (BMI ≥40). We further stratified within the obesity III category, to separately analyze morbid obesity (BMI 40–49.9) and super obesity (BMI ≥50). As we were focused on the association between BMI gradations among normal-weight to obese women, we excluded underweight women (i.e., BMI < 18.5 kg/m²; n=1756). The final analytic sample comprised of women with BMI ≥18.5 (normal BMI or greater, final n=1 815 087; Appendix 1).

Covariates

Demographic characteristics analyzed included maternal race/ethnicity (classified as Caucasian (non-Hispanic White), African-American (non-Hispanic Black), Hispanic, Asian (non-Hispanic Asian), and Other), maternal age (categorized as <20, 20–24, 25–29, 30–34, or ≥35 years), education (less than high school, high school diploma/GED, undergraduate college, or graduate school), insurance type (private, public, or none), and if the woman smoked tobacco during pregnancy. Additional covariates included the Kotelchuck Index (adequacy of prenatal care utilization,²⁵ adequate prenatal care as referent, defined as initiating prenatal care in either the 3rd or 4th month and having at least 8 prenatal care appointments), if the mother received Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) during the pregnancy, and low birthweight (<2500 grams) or macrosomia (>4000 g; Appendix 2). We controlled for low birthweight and macrosomia as confounders in some regression models but not others. Recent methodological work in epidemiology has highlighted the potential biases introduced when controlling for birthweight or gestational age when the variable is on the exposure-outcome causal pathway.^{26, 27} Therefore, in the first model (i.e., the association between BMI and regional anaesthesia use), we did not control for birthweight as it is likely to be a causal mediator.

However, in subsequent models where exposure (i.e., regional anaesthesia use) occurred intrapartum and outcomes (e.g., caesarean delivery, meningitis) occurred either intrapartum or postpartum, birthweight is indeed a confounder so we controlled for it.

There are different anesthetic considerations for managing labour versus performing a caesarean delivery, and we were interested in regional anaesthesia use and complications for women who laboured. We considered women with laboured delivery to be the denominator of interest for our exposure and outcomes, regardless of their eventual mode of delivery (i.e., spontaneous vaginal, operative vaginal, or laboured/intrapartum caesarean), so we excluded women who had a caesarean without indicators of labour, assuming these births to be prelabour scheduled caesarean deliveries. Laboured delivery was noted if any labour-related conditions captured in vital records data or ICD-9 codes were present (Appendix 3).²⁸ As regional anaesthesia receipt among women with a laboured delivery is our main research focus, this group (i.e., women with laboured deliveries) comprised our main analytic sample for analyses of regional anaesthesia prevalence and related complications.

To address the possibility that the assignment of laboured delivery status was overly broad, we conducted a sensitivity analysis to remove codes which could potentially be assigned before labour begins. These diagnoses in question – those for cephalopelvic disproportion, fetal distress, and uterine rupture – were removed from the definition of a laboured delivery. Parity of the mother at the index pregnancy was defined as primiparous if the mother had no previous births; multiparous if one or more children had preceded the index pregnancy.

Outcomes

For the primary study question, that of BMI category on regional anaesthesia use, regional anaesthesia was identified via ICD-9 procedure codes (03.90, 03.91) in the mother's discharge record, or if noted on the infant's birth certificate. Secondary outcomes which were analyzed include mode of delivery and regional anaesthesia complications. Mode of delivery was identified through the birth certificate, or through ICD-9 codes for vaginal delivery (650), operative vaginal delivery (either forceps (procedure code 72.1–72.4, diagnosis code 763.2) or vacuum (procedure code 72.7, diagnosis code 763.3), or caesarean delivery (procedure code 74, diagnosis code 669.7, 763.4). Regional anaesthesia complications were identified via ICD-9 codes for any one of the following: intraspinal abscess (324.1), reaction to spinal or lumbar puncture (349.0), nontraumatic extradural hematoma (432.0), or meningitis (bacterial (320), other organisms (321), unspecified cause (322)).

Statistical Analysis

Because parity is a critical predictor of many obstetric and perinatal outcome, and to consider parity as a potential effect modifier in the association between maternal BMI and outcomes, we stratified all analyses by parity (primiparous versus multiparous). We used cross-tabulation and multivariable Poisson regression with robust variance estimators²⁹ to assess the association of BMI category on epidural use (Model 1; normal weight as the referent group). The secondary research question was the association between maternal BMI and regional anaesthesia use on mode of delivery, an association we analysed 2 ways. In one

approach (Model 2), we analysed the association between maternal BMI category (referent: normal weight) and mode of delivery among labouring women with regional anaesthesia. In Model 3, we analysed the association between regional anaesthesia use and mode of delivery stratified by BMI category in labouring women, e.g., comparing normal weight women with regional anaesthesia to normal weight women without regional anaesthesia, then among overweight women, etc. We data on the timing on epidural administration during the labour course was unavailable, in Models 2 and 3 we acknowledge that causality between regional anaesthesia use and delivery mode may go in both directions. That is, administration of regional anaesthesia in labour may have an effect on mode of delivery, or intrapartum complications such as poor labour progression, fetal malposition, or concerning fetal status may drive administration of regional anaesthesia in preparation for possible operative vaginal or caesarean delivery. The final question concerned the association between BMI category and regional anaesthesia complications. In this model (Model 4), we modeled regional anaesthesia complications in labouring women with regional anaesthesia as a function of BMI category (referent group: women of normal BMI).

Results

Of the 1 815 087 non-anomalous, singleton, term pregnancies with maternal pre-pregnancy BMI 18.5 in California from 2007–2010 (Appendix 1), over 60% of the analytic sample (1 154 279 births) were to women with either overweight or obesity I (Appendix 2). There was a greater proportion of African-American and Hispanic women in the higher BMI categories; the same was true of multiparity status (women with obesity II: 9% African-American, 62% Hispanic, 66.2% multiparous versus women with normal BMI: 4.5% African-American, 41.7% Hispanic, 52.8% multiparous). As BMI category increased, the proportion of women with inadequate prenatal care utilization increased (women with normal BMI: 31.4% inadequate prenatal care vs 32.5% in women with obesity II), as did use of public insurance (43.9% vs 57.1%, women with normal BMI and with obesity II, respectively, WIC receipt (45.4% vs 64.7%, women with normal BMI vs women with obesity II), and smoking during pregnancy (3.1% vs 5.7%, women with normal BMI vs women with obesity II). Low birthweight decreased as BMI increased, although women with super obesity had slightly higher proportions of low birthweight babies than women with morbid obesity (1.4% in women with super obesity, 1.3% in women with morbid obesity). The proportion of macrosomic infants increased as BMI category increased, reaching 22% in women with super obesity.

To define the population of labouring women, we calculated the proportion of women with prelabour caesarean deliveries. As maternal BMI category increased, the proportion of mothers who delivered vaginally decreased (for instance, in primiparous women, 63.6% in those with overweight vs 44.3% in those with morbid obesity, in multiparous women, 69.4% in those with overweight vs 50.8% in those with morbid obesity), as did the proportion of women with operative vaginal deliveries (in primiparous women, 12.3% in women with overweight vs 5.8% in women with morbid obesity; in multiparous women, 5.1% in those with overweight vs 2.8% in those with morbid obesity) (Appendix 4). These women are, by definition, classified as having a laboured delivery, and compose 83.7% (1 520 044/1 815 087) of the larger cohort. As we are interested in examining the totality of regional

anaesthesia use in women with laboured deliveries, only women with evidence of labour, regardless of mode of delivery, were included in the main denominator in further analyses.

A sensitivity analysis was conducted to eliminate diagnoses that could have theoretically been assigned prior to labour and therefore served as an indication for prelabour caesarean delivery. In this, cephalopelvic disproportion, fetal distress, and uterine rupture were no longer considered laboured deliveries. The results did not change significantly (data not shown).

Demographic characteristics of the population of women with labour are presented in Table 1. Overall characteristics and trends – age, smoking during pregnancy, WIC food receipt – are similar to the larger analytic sample. For instance, WIC food receipt increases across the categories of maternal pre-pregnancy BMI in the group of women who laboured; 45.8% of women with normal BMI received WIC food, and in women with super obesity, 68.8% received WIC food. Maternal race/ethnicity characteristics are similar to the analytic sample; women with super obesity and who laboured are 14.2% African-American and 56.7% Hispanic (13.9% and 58.0%, respectively, in larger analytic sample).

When regional anaesthesia use is examined among women who laboured, women of higher BMI categories were more likely to have regional anaesthesia (Table 2). Primiparous women with morbid obesity received regional anaesthesia in 60.9% of laboured deliveries, compared to slightly more than half of deliveries in primiparous women of normal BMI (53.7%). Multiparous women with morbid obesity received regional anaesthesia in 45.9% of deliveries, compared to 42.9% of deliveries in women of normal BMI.

Among labouring women who received regional anaesthesia, we were interested in examining the ultimate mode of delivery as a function of maternal BMI (Model 2; Table 3). As BMI category increased, both primiparous and multiparous women with obesity were less likely to achieve a vaginal birth. Primiparous and multiparous labouring women with obesity were more likely to deliver by caesarean. Results around caesarean delivery with labouring could also be read as the converse – due to intrapartum factors, a caesarean delivery was indicated, necessitating regional analgesia.

In addition to mode of delivery in women receiving regional anaesthesia, we were also interested in the converse – mode of delivery in women of each BMI category, comparing women who received regional anaesthesia to those who did not (Model 3; Table 4). Regional anaesthesia use was associated with decreased risk of spontaneous, non-operative vaginal delivery in all parity and BMI categories. For example, in primiparous women with normal BMI, regional anaesthesia use was associated with a consistently decreased risk of spontaneous vaginal delivery of approximately 15% in women of all BMI categories. Among multiparous women, the decrease in risk of vaginal delivery associated with regional anaesthesia use was approximately 3% in women of normal BMI, and decreased risk of approximately 12% in women with morbid obesity. Conversely, regional anaesthesia use was associated with increased risks of both operative vaginal delivery and intrapartum caesarean delivery among almost all BMI and parity-categories of labouring women.

For the final question, that of regional anaesthesia complications by maternal BMI category, we found that complications displayed a complex relationship with maternal pre-pregnancy BMI (Table 5). In labouring primiparous women, receiving regional anaesthesia was not associated with the risk of complications among overweight and lower-obesity women, as compared with normal-weight women. Primiparous women with higher categories of obesity – that is, morbid and super obesity – had increased risk of regional anaesthesia complications. In contrast, multiparous women experienced decreased odds of regional anaesthesia complications in women of overweight and lower-obesity categories, when compared to women of normal BMI. However, the direction of association changed as BMI category increased in multiparous women, with a null association in women with morbid obesity, and significantly increased odds in women with higher categories of BMI (aRR 2.00, 95% CI 1.26, 3.16).

Comment

Main findings

We examine the relationship between regional anaesthesia utilisation, mode of delivery, and epidural complications across the BMI spectrum. Focusing on the population of labouring women, we find that regional anaesthesia use increases as maternal pre-pregnancy BMI category increases. Among women receiving regional anaesthesia, the risk of a vaginal delivery decreased as maternal BMI category increased; this coheres with the research demonstrating that increased maternal BMI is inversely associated with vaginal delivery,³⁰ although these prior studies have not focused specifically on labouring women who received regional anaesthesia.

Perhaps less intuitive is the finding that among strata of maternal BMI, the higher BMI categories of primiparous women had attenuated associations between regional anaesthesia use and spontaneous vaginal delivery (although still inverse associations). We posit that this trend may be explained by the overall very high probability of caesarean delivery among these women (in the range of 50 – 60% in the morbid and super-obesity categories, in contrast with 20% in the normal BMI category). This may suggest that there is less variability in the outcome of caesarean delivery among these highest maternal BMI categories to be explained by additional factors such as regional anaesthesia use, although future research should reproduce our findings and further our understanding of these associations. It is easy to postulate that normal weight women are more likely to attempt non-medicated deliveries, and therefore are more likely to elect for regional anaesthesia once the labour course becomes more complicated, and hence the higher caesarean rates.

The results observed for regional anaesthesia complications point to the complex relationship between maternal BMI and regional anaesthesia complications, in contrast with other adverse outcomes. Increasing BMI is often considered a risk factor for the majority of obstetric outcomes in a more dose-response fashion across the BMI spectrum (e.g. postpartum hemorrhage,³¹ large for gestational age infants³²), while we found increased odds of regional anaesthesia complications only in primiparous women with morbid obesity and super obesity, and in multiparous women with super obesity. It is worth noting that non-monotonic relationship observed between BMI and adverse regional anaesthesia outcomes is

also observed with some other outcomes (e.g., preterm birth³³), although more commonly after excluding underweight women, outcome get progressively worse as BMI category increases. Such instances may be rare but are nonetheless important to provide a complete picture of risk to inform clinical counseling and public health efforts.

As women enter into childbirth, procedure utilisation and associated outcomes are of particular interest for shared decision-making between patients and providers. When considering the additional complexities imposed on this situation by maternal BMI (from the perspective of maternal physiological/health profile, patient-provider interaction, and social factors), the considerations that should inform patient and provider decision-making are even more complex. In our study, we continue to refine the epidemiologic understanding of the complex inter-relationships between BMI, procedure use, and health outcomes within the context of pregnancy. We focused on regional anaesthesia use among labouring women, an intervention which is common but whose outcomes have not been fully elucidated as relates to maternal BMI.

The limitations of the study arise from restrictions imposed in the dataset. We are reliant on ICD-9 codes and the birth certificate to assign if a delivery was laboured; this algorithm has yet to be validated. Due to the reliance on either the birth certificate or ICD-9 codes present in hospital discharge records, we are unable to separate epidural-only from spinal-only analgesia from a combined epidural/spinal procedure, or to capture the use of general anaesthesia as an anesthetic method. Similarly, the structure of our dataset makes it impossible to capture the date of diagnosis for epidural complications, or the timing of anaesthesia administration in the course of parturition. Especially given that this lack of temporal granularity may introduce bidirectional causation between key outcomes (e.g., regional anaesthesia and mode of delivery), these associations cannot be interpreted causally. Lack of data on timing of events during labour also precludes us from knowing whether women with poor labour progression or more painful labour may have had regional anaesthesia placed for analgesia, or the decision for operative vaginal/caesarean delivery may have already been made and regional anaesthesia was placed specifically for the procedure. Further, hospital discharge records are only captured for a year after delivery, so limiting our analyses to labouring women who received epidural decreases the likelihood that non-pregnancy related complications would be captured in our outcome definition. Nonetheless, it is possible that some diagnoses of an epidural complication may not be associated with the epidural itself, and are associated with a separate hospitalization. Future research is needed on this topic to confirm our results, including studies in other populations and different data sources. Nonetheless, the rareness of severe epidural complications will generally require a large administrative dataset to analyze BMI-specific associations and verify their validity when using administrative data, with the attendant limitations of such data resources.

As well, we rely on maternal self-reported height and weight to categorize pre-pregnancy BMI. Although an imperfect ascertainment of pre-pregnancy height and weight, the literature³⁴ nonetheless supports utilization of self-report data in this context. The resources and time required to collect high-reliability, directly-observed BMI measurements (or other definitions of adiposity) also frequently makes these studies under-powered to analyze rare

outcomes such as severe epidural complications. Although we analyzed prepregnancy BMI as is common in perinatal epidemiology and which reflects a woman's baseline health status without the additional effect of gestational weight gain, future research should consider how gestational weight gain and/or delivery BMI might affect these outcomes, and whether this may differ from the associations observed with prepregnancy measures. We also rely on self-reported smoking status in this analysis, which has been shown to underestimate³⁵ true smoking prevalence.

In considering how future research can improve upon our approach to further fill this evidence gap, we recommend improvements in the definition of a laboured delivery, and also directly linking a presumed epidural complication to the epidural itself. Refinements in both of these areas will be possible now that the United States has shifted to ICD-10 coding, and as such data resources become increasingly available for secondary analysis research in coming years.

This study contributes to the limited understanding of the inter-relationships between epidural use, maternal BMI, mode of delivery, and epidural complications. In general, increased maternal BMI was observed to be a risk factor for intrapartum caesarean delivery among the population of labouring women who received an epidural, although the contribution of epidural use itself was not necessarily causative (and indeed this contribution of epidural diminished somewhat with increasing maternal BMI). Similarly, women in the highest BMI categories were at increased risk for epidural complications, but not all classes of obesity were thus affected. Obesity is clearly one of the factors implicated in epidural use and epidural effects, but more research will be needed to disentangle the precise nature of these associations, and to enable labouring women to have the healthiest outcomes possible of childbirth, regardless of their BMI or epidural use. As women with obesity already have increased chances of caesarean delivery and subsequent adverse outcomes, it will be especially important to maximize our understanding of modifiable drivers of outcomes in this vulnerable population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Demographic and health factors for women who laboured by maternal pre-pregnancy BMI status, California 2007–2010

Table 1

	Maternal pre-pregnancy body-mass index (kg/m ²)				
	Normal	Overweight	Obesity I	Obesity II	Super obesity
	18.5–24.9	25–29.9	30–34.9	35–35.9	40–49.9
Number (%)	179,173 (11.8)	560,644 (36.9)	419,675 (27.6)	180,528 (11.9)	84,706 (5.6)
Maternal race/ethnicity					
Caucasian	51,827 (29.2)	161,666 (29)	103,304 (24.7)	42,376 (23.6)	20,920 (24.8)
African-American	8,053 (4.5)	22,864 (4.1)	20,883 (5.0)	11,556 (6.4)	7,586 (9.0)
Hispanic	74,532 (41.9)	275,906 (49.6)	252,879 (60.5)	115,108 (64)	51,871 (61.4)
Asian	38,212 (21.5)	81,783 (14.7)	31,958 (7.7)	7,758 (4.3)	2,584 (3.1)
Other	5,091 (2.9)	14,518 (2.6)	8,617 (2.1)	3,011 (1.7)	1,455 (1.7)
Maternal Age					
<20	32,994 (18.5)	84,349 (15)	59,642 (14.2)	24,916 (13.8)	10,422 (12.3)
20–24	31,189 (17.5)	98,837 (17.6)	80,642 (19.2)	37,763 (20.9)	18,680 (22.1)
25–29	43,484 (24.4)	146,731 (26.2)	118,714 (28.3)	53,080 (29.4)	26,182 (30.9)
30–34	42,713 (23.9)	138,604 (24.7)	98,004 (23.4)	39,992 (22.2)	18,594 (22.0)
35	28,163 (15.8)	92,123 (16.4)	62,673 (14.9)	24,777 (13.7)	10,828 (12.8)
Education					
Less than high school	39,061 (22.6)	129,353 (23.8)	115,502 (28.4)	49,581 (28.2)	20,719 (25.1)
High school	40,627 (23.5)	131,641 (24.3)	113,879 (28.0)	55,701 (31.7)	28,468 (34.4)
College	71,826 (41.5)	223,147 (41.1)	152,209 (37.4)	63,557 (36.2)	31,115 (37.6)
Graduate degree	21,522 (12.4)	58,235 (10.7)	25,819 (6.3)	6,969 (4.0)	2,399 (2.9)
Parity					
Primiparous	90,369 (50.5)	261,154 (46.6)	174,106 (41.5)	71,497 (39.6)	34,679 (41.0)
Multiparous	88,755 (49.5)	299,374 (53.4)	245,457 (58.5)	108,986 (60.4)	50,004 (59.0)
Smoking during pregnancy	5,451 (3.0)	17,231 (3.1)	15,609 (3.7)	8,457 (4.7)	4,925 (5.8)
Insurance type					
Public	79,054 (44.1)	253,716 (45.3)	219,005 (52.2)	99,837 (55.3)	47,938 (56.6)
Private	94,934 (53.0)	295,565 (52.7)	193,868 (46.2)	78,102 (43.3)	35,668 (42.1)

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Maternal pre-pregnancy body-mass index (kg/m ²)						
	Normal	Overweight	Obesity I	Obesity II	Morbid obesity	Super obesity
	18.5–24.9	25–29.9	30–34.9	35–35.9	40–49.9	50
None	5,167 (2.9)	11,319 (2.0)	6,782 (1.6)	2,584 (1.4)	1,094 (1.3)	87 (1.0)
Kotelchuck Index						
Adequate Plus	52,535 (30.3)	155,274 (28.4)	113,271 (27.7)	49,222 (28)	24,550 (29.8)	2,788 (32.2)
Adequate	72,042 (41.5)	237,851 (43.6)	177,378 (43.4)	75,071 (42.7)	33,642 (40.8)	3,321 (38.3)
Intermediate	29,621 (17.1)	98,459 (18.0)	75,529 (18.5)	31,860 (18.1)	14,438 (17.5)	1,436 (16.6)
Inadequate	19,362 (11.2)	54,352 (10.0)	42,744 (10.5)	19,520 (11.1)	9,726 (11.8)	1,126 (13.0)
WIC food	81,177 (45.8)	268,108 (48.3)	238,169 (57.3)	111,767 (62.4)	54,098 (64.4)	6,073 (68.8)
Birthweight						
2500 g	6,350 (3.5)	9,990 (1.8)	5,542 (1.3)	2,283 (1.3)	993 (1.2)	119 (1.3)
>4000 g	5,207 (2.9)	35,662 (6.4)	44,009 (10.5)	25,160 (13.9)	14,395 (17.0)	1,848 (20.7)

Table 2

Proportion of primiparous or multiparous deliveries^a with regional anaesthesia, and adjusted risk^b for regional anaesthesia receipt, in laboured California deliveries (2007–2010; Model 1)

Maternal pre-pregnancy body-mass index (kg/m ²)						
	Normal	Overweight	Obesity I	Obesity II	Morbid obesity	Super obesity
Primiparous	n (%) Denominator aRR (95% CI)	148,536 (56.9) 261,154 1.06 (1.05, 1.06)	100,959 (58.0) 174,106 1.10 (1.10, 1.11)	42,302 (59.2) 71,497 1.14 (1.13, 1.15)	21,105 (60.9) 34,679 1.18 (1.17, 1.19)	2,300 (62.1) 3,706 1.21 (1.18, 1.25)
Multiparous	n (%) Denominator aRR (95% CI)	129,215 (43.2) 299,374 1.05 (1.04, 1.06)	101,350 (41.3) 245,457 1.09 (1.08, 1.10)	46,252 (42.4) 88,986 1.16 (1.14, 1.17)	22,946 (45.9) 50,004 1.24 (1.23, 1.26)	2,509 (48.1) 5,222 1.33 (1.29, 1.37)

^aDenominator includes labouring women (i.e., laboured caesarean or vaginal delivery)

^bAdjusted for education (high school as referent), maternal age (25–29 as referent), maternal race/ethnicity (Caucasian as referent), Kotelchuck index (adequate as referent), insurance (private insurance as referent), WIC receipt, and smoking during pregnancy

Table 3

Association between parity, maternal BMI and mode of delivery in labouring women with regional anaesthesia, California, 2007–2010 (Model 2)

Maternal pre-pregnancy body-mass index (kg/m ²)					
	Normal	Overweight	Obesity I	Obesity II	Super obesity
Primiparous women					
Unassisted vaginal delivery					
n (%) ^a	32,844 (67.7)	93,882 (63.2)	59,087 (58.5)	22,750 (53.8)	9,906 (46.9)
aRR ^b (95% CI)	1.00 (Reference)	0.93 (0.92, 0.94)	0.85 (0.84, 0.85)	0.76 (0.76, 0.77)	0.67 (0.66, 0.68)
Operative vaginal delivery					
n (%) ^a	7,876 (16.2)	21,216 (14.3)	11,763 (11.6)	3,771 (8.9)	1,416 (6.7)
aRR ^b (95% CI)	1.00 (Reference)	0.92 (0.90, 0.94)	0.80 (0.78, 0.82)	0.68 (0.66, 0.70)	0.58 (0.55, 0.61)
Caesarean delivery					
n (%) ^a	10,924 (11.7)	46,992 (16.1)	44,713 (21.1)	24,697 (26.5)	15,623 (33.5)
aRR ^b (95% CI)	1.00 (Reference)	1.39 (1.36, 1.43)	1.88 (1.84, 1.93)	2.40 (2.35, 2.46)	2.97 (2.89, 3.05)
Denominator	48,532	148,536	100,959	42,302	21,105
Multiparous women					
Unassisted vaginal delivery					
n (%) ^a	32,211 (84.5)	105,994 (82.0)	80,355 (79.3)	35,119 (75.9)	16,393 (71.4)
aRR ^b (95% CI)	1.00 (Reference)	0.97 (0.97, 0.98)	0.94 (0.94, 0.95)	0.90 (0.90, 0.91)	0.85 (0.84, 0.86)
Operative vaginal delivery					
n (%) ^a	3,130 (8.2)	10,450 (8.1)	7,370 (7.3)	2,882 (6.2)	1,258 (5.5)
aRR ^b (95% CI)	1.00 (Reference)	1.03 (0.99, 1.07)	1.00 (0.96, 1.04)	0.94 (0.90, 0.99)	0.95 (0.89, 1.00)
Caesarean delivery					
n (%) ^a	2,759 (7.2)	12,771 (9.9)	13,625 (13.4)	8,251 (17.8)	5,295 (23.1)
aRR ^b (95% CI)	1.00 (Reference)	1.35 (1.30, 1.41)	1.79 (1.72, 1.86)	2.33 (2.23, 2.43)	3.02 (2.89, 3.16)
Denominator	38,100	129,215	101,350	46,252	22,946

^aDenominator includes women with regional anaesthesia and laboured delivery

^b Adjusted for education (high school as referent), maternal age (25–29 as referent), maternal race/ethnicity (Caucasian as referent), Kotelchuck index (adequate as referent), insurance (private insurance as referent), WIC receipt, smoking during pregnancy, and birthweight (both low birthweight and macrosomia).

Table 4

Adjusted risk^a of delivery mode in primiparous or multiparous women with regional anaesthesia, relative to women without regional anaesthesia by BMI category (Model 3).

		Maternal pre-pregnancy body-mass index (kg/m ²)				
		Normal	Overweight	Obesity I	Obesity II	Super obesity
Primiparous	Vaginal	0.87 (0.87, 0.88)	0.85 (0.85, 0.85)	0.85 (0.84, 0.86)	0.84 (0.83, 0.85)	0.87 (0.80, 0.95)
	Operative	1.26 (1.22, 1.30)	1.25 (1.22, 1.27)	1.19 (1.16, 1.22)	1.22 (1.16, 1.28)	1.11 (0.88, 1.40)
	Labour ed caesarean	1.40 (1.35, 1.45)	1.42 (1.39, 1.44)	1.29 (1.26, 1.31)	1.23 (1.20, 1.26)	1.06 (0.99, 1.12)
Multiparous	Vaginal	0.94 (0.93, 0.94)	0.92 (0.91, 0.92)	0.91 (0.90, 0.91)	0.89 (0.88, 0.89)	0.84 (0.81, 0.87)
	Operative	1.65 (1.56, 1.74)	1.68 (1.63, 1.73)	1.70 (1.64, 1.75)	1.65 (1.57, 1.73)	1.59 (1.30, 1.95)
	Labour ed caesarean	1.88 (1.77, 2.00)	1.99 (1.94, 2.05)	1.85 (1.80, 1.89)	1.75 (1.69, 1.80)	1.48 (1.34, 1.62)

Results are adjusted risk ratio (95% confidence interval)

^a Adjusted for education (high school as referent), maternal age (25–29 as referent), maternal race/ethnicity (Caucasian as referent), Kotelchuck index (adequate as referent), insurance (private insurance as referent), WIC receipt, smoking during pregnancy, and birthweight (both low birthweight and macrosomia).

Table 5

Proportion^a and adjusted risk ratio^b for regional anaesthesia complications by parity and BMI category, California, 2007–2010 (Model 4).

		Maternal pre-pregnancy body-mass index (kg/m ²)					
		Normal	Overweight	Obesity I	Obesity II	Morbid obesity	Super obesity
Primiparous	n (%)	134 (0.3)	372 (0.3)	243 (0.2)	126 (0.3)	87 (0.4)	15 (0.7)
	Denominator	48,532	148,536	100,959	42,302	21,105	2,300
	aRR (95% CI)	1.00 (Reference)	0.85 (0.70, 1.05)	0.83 (0.67, 1.04)	1.04 (0.81, 1.34)	1.36 (1.02, 1.81)	2.34 (1.37, 4.02)
Multiparous	n (%)	166 (0.4)	436 (0.3)	350 (0.4)	150 (0.3)	98 (0.4)	22 (0.9)
	Denominator	38,100	129,215	101,350	46,252	22,946	2,509
	aRR (95% CI)	1.00 (Reference)	0.75 (0.62, 0.90)	0.77 (0.64, 0.94)	0.74 (0.59, 0.93)	0.95 (0.73, 1.24)	2.00 (1.26, 3.16)

^aDenominator includes labouring women with regional anaesthesia use

^bAdjusted for education (HS as referent), maternal age (25–29 as referent), maternal race/ethnicity (Caucasian as referent), Kotlichuck index (adequate as referent), insurance (private insurance as referent), WIC receipt, tobacco use, and birthweight (both low birthweight and macrosomia).