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The association of maternal body mass index and cesarean delivery after preterm induction of labor

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CREDIT AUTHORSHIP CONTRIBUTION STATEMENT: **Minhazur R. Sarker:** Conceptualization, Formal analysis, Investigation, Methodology, Writing - original draft, Writing - review & editing. **Rachel Wiley:** Conceptualization, Methodology, Writing - review & editing. **Daphne Yvette Lacoursiere:** Methodology, Supervision, Writing - review & editing. **Grace Noonan:** Conceptualization, Investigation, Writing - review & editing. **Daniella Rogerson:** Conceptualization, Methodology, Writing - review & editing. **Timothy Wen:** Methodology, Supervision, Writing - review & editing. **Cynthia Gyamfi-Bannerman:** Conceptualization, Supervision, Writing - review & editing. **Ukachi N. Emeruwa:** Conceptualization, Investigation, Methodology, Supervision, Writing - review & editing.

OBJECTIVE:

Preterm birth is the leading cause of neonatal morbidity, and one-third are medically indicated.[1] Blackwell et al. found that preterm induction of labor (IOL) were less often successful, with 30%-53% of indicated preterm births occurring via cesarean delivery (CD) without trial of labor, potentially due to perceived high failure.[2] Maternal obesity is associated with both higher rates of medically indicated preterm delivery as well as dysfunctional labor, and the question of utility of preterm IOL in patients with obesity is of clinical significance.[3] This study has 2 objectives: (1) to estimate the CD rate among patients undergoing preterm IOL, stratified by maternal obesity, and (2) to examine the associations between clinical and demographic factors and CD among patients undergoing preterm induction.

STUDY DESIGN:

This is a cross-sectional study using 2016 to 2023 United States National Vital Statistics System (NVSS) Birth Data, a publicly available de-identified dataset. Thus, the analysis was exempt from Institutional Review Board oversight.

We included nulliparous patients undergoing preterm IOL from 28+0 to 36+6 days which resulted in live birth. Our exclusion criteria are noted in Supplemental Figure 1. The primary exposure was maternal body mass index (BMI) class in kg/m^2 at time of delivery: underweight (<18.5), normal (18.5–24.9), overweight (25–29.9), class I (30–34.9), class II (35–39.9), class III (40–49.9), class IV (50–59.9), and class V (≥60). We limited baseline demographics to those available on the standardized birth certificate form, and our categorization is shown in Table 1.

For the first objective, we reported the proportion of CD stratified by maternal BMI category. We then dichotomized our cohort to either early preterm (28+0 to 33+6) or late preterm (34+0 to 36+6) IOL to assess gestational age associations. CD frequencies and proportions were calculated and compared using chi-square.

For the second objective, we fit logistic regression models to assess the relationship between BMI class and CD after preterm IOL. The covariates in our model are noted in Supplemental Table 1. Unadjusted and adjusted odds ratios (OR and aOR) with 95% CI were calculated as measures of association.

RESULTS:

Between 2016 and 2023, 236,551 live births were included: 7761 (3.3%) underweight, 83,835 (35.4%) normal weight, 60,500 (25.6%) overweight, 40,695 (17.2%) class I obesity, 23,300 (9.9%) class II obesity, 17,231 (7.3%) class III obesity, 2856 (1.2%) class IV obesity, and 373 (0.2%) class V obesity (Supplemental Figure 1). Increased BMI category was associated with increased maternal age, non-Hispanic Black patients, and pregnancy comorbidities (Table 1).

Among the entire cohort, 29.2% underwent CD, and increasing BMI category was associated with significantly increasing rate of CD, ranging from 15.6% in underweight patients to 67.0% in patients with class V obesity (Figure 1A). CD rates were also significantly higher for early preterm compared to late preterm IOL across all BMI categories, except class IV and V obesity (Figure 1B). In the adjusted regression model using normal weight as the reference, increasing maternal BMI category was associated with increasing odds of CD (Figure 1C). The full regression model is reported in Supplemental Table 1.

CONCLUSION:

Increasing maternal BMI category is associated with increased risk of CD after preterm IOL; however, the majority of patients delivered vaginally, except for class IV or V obesity. As obesity continues to increase nationally, along with associated diabetic and hypertensive comorbidities, so will the likelihood of preterm IOL. This analysis provides a contemporary understanding of CD rates to aid clinical decision-making. As IOL remains the standard of care, our findings allow obstetrical providers, especially those in settings without readily available obstetrical anesthesia, blood products, or capacity to mobilize for urgent cesarean, the ability to choose a delivery method optimizing maternal and fetal well-being.

A randomized trial secondary analysis of 1236 patients undergoing medically indicated preterm IOL noted similar findings, however, it was underpowered to assess additional clinical characteristics, especially in class IV and V.[3] Edwards, et al. assessed labor curves, revealing that higher BMI was associated with slower progression, possibly due to underlying physiological responses.[4] While limited to term gestation, a similar relationship is likely present in preterm labor, suggesting that BMI-tailored labor management may be warranted.[4]

Limitations of this study include potential data collection errors in birth center data, lack of available clinical variables of interest in the NVSS dataset (e.g., IOL indication, IOL methods, or starting cervical exam), possible selection bias due to provider threshold to offer IOL, and confounding by indication (i.e., differing threshold to call a failed IOL if surgical assistance or anesthesia or pediatric support is limited).

This study also has multiple strengths. First, the large national sample increases the generalizability and ability to conduct a robust BMI class-specific analysis. Second, our data reflects contemporary management. Finally, utilizing BMI at delivery, as opposed to pre-pregnancy, is more clinically relevant to CD risk.

While counseling for preterm IOL should involve shared decision making, our findings provide some insight into the risk of CD and that the majority of patients delivery vaginally.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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DATA AVAILABILITY STATEMENT

All data sets used for this manuscript are publicly available from the United States National Vital Statistics System (NVSS) Birth Data.

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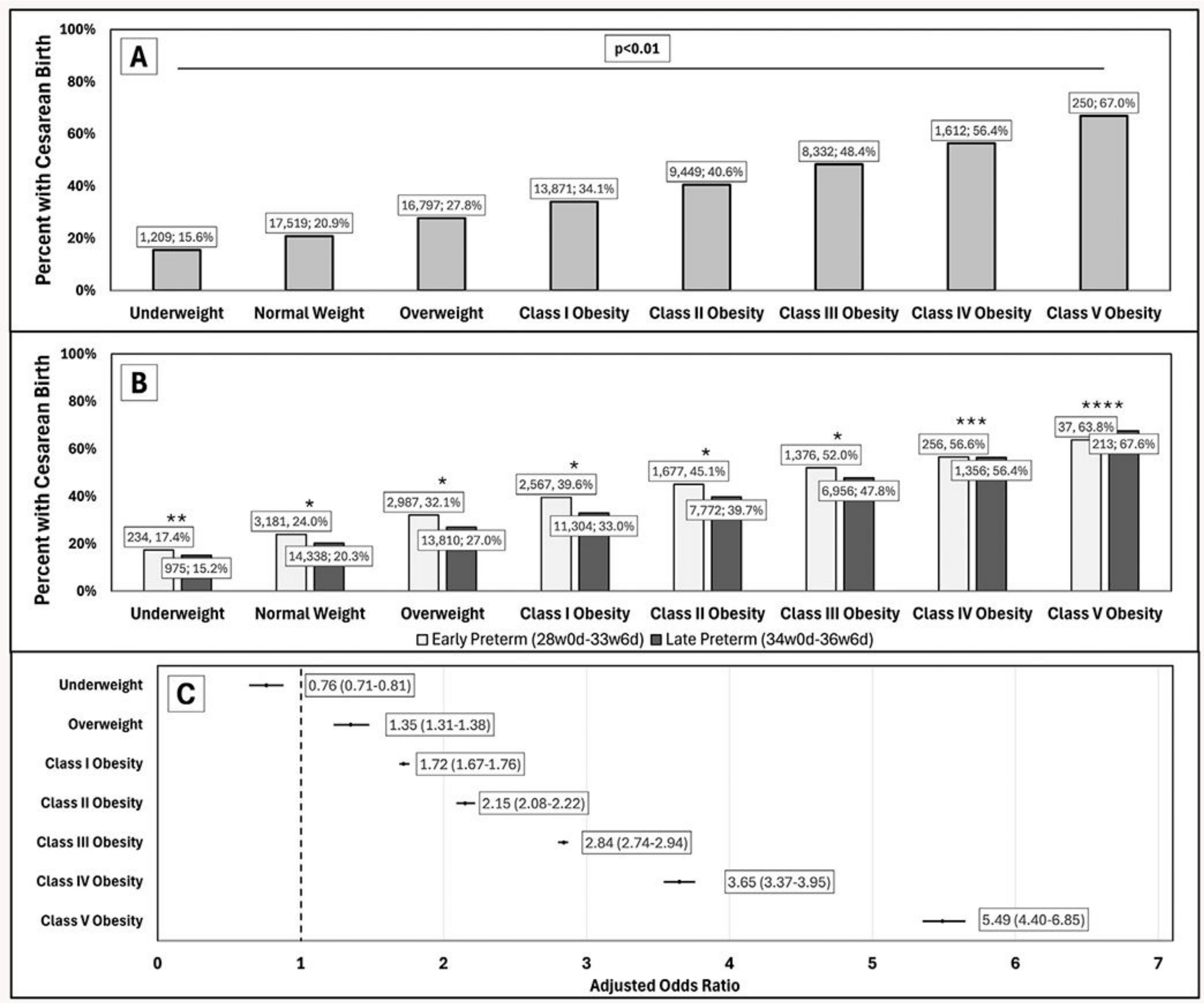

FIGURE 1. Association between maternal BMI at time of delivery and cesarean delivery among nulliparous patients undergoing preterm induction of labor

(A) Cesarean delivery rates by BMI category, (B) cesarean delivery rates stratified by early preterm (28w0d-33w6d) and late preterm (34w0d-36w6d) gestational age at time of delivery (* for p<.01, ** for p=0.04, *** for *p*=.93, and **** for *p*=.93), and (C) multivariable logistic regression for cesarean delivery using normal weight (BMI 18.5–24.9) as the reference (results adjusted for maternal age, self-reported maternal race and ethnicity, payer status, gestational age at delivery, pre-gestational diabetes, gestational diabetes, chronic hypertension, gestational hypertension spectrum, eclampsia, and macrosomia (fetal weight > 4000g) at delivery. All analyses were performed on Stata IC 15.1 (College Station, Texas, USA).

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TABLE 1

Baseline demographics and characteristics

	Underweight BMI <18.5 (n=7761)	Normal BMI 18.5-24.9 (n=83,835)	Overweight BMI 25-29.9 (n=60,500)	Class I Obesity BMI 30-34.9 (n=40,695)	Class II Obesity BMI 35-39.9 (n=23,300)	Class III Obesity BMI 40-49.9 (n=17,231)	Class IV Obesity BMI 50-59.9 (n=2856)	Class V Obesity BMI ≥ 60 (n=373)	*p*-value
Body mass index (BMI)	17.3±0.9	22.1±1.7	27.3±1.4	32.2±1.4	37.2±1.4	43.6±2.7	53.4±2.6	63.2±2.5	<.01
Maternal age	23.6±5.8	26.3±6.5	27.1±6.2	27.3±6.1	27.5±5.9	27.8±5.8	28.0±5.6	28.±5.2	<.01
Maternal age categories									<.01
Age < 35	7310 (94.2)	73,951 (88.2)	52,466 (86.7)	35,196 (86.5)	20,103 (86.3)	14,830 (86.1)	2468 (86.4)	321 (86.1)	
Age 35-39	366 (4.7)	7700 (9.2)	6280 (10.4)	4.346 (10.7)	2508 (10.8)	1916 (11.1)	317 (11.1)	47 (12.6)	
Age ≥ 40	85 (1.1)	2184 (2.6)	1754 (2.9)	1153 (2.8)	689 (3.0)	485 (2.8)	71 (2.5)	5 (1.3)	
Self-reported maternal race									<.01
Non-Hispanic White	3623 (46.7)	42,905 (51.2)	30,474 (50.4)	20,571 (50.6)	12,426 (53.3)	9347 (54.3)	1491 (52.2)	154 (41.3)	
Non-Hispanic Black	1617 (20.8)	13,347 (15.9)	10,097 (16.7)	7474 (18.4)	4661 (20.0)	3915 (22.7)	807 (28.3)	163 (43.4)	
Non-Hispanic American Indian or Alaskan Native	55 (0.7)	562 (0.7)	503 (0.8)	379 (0.9)	242 (1.0)	174 (1.0)	27 (1.0)	3 (0.8)	
Non-Hispanic Asian	636 (8.2)	6709 (8.0)	3325 (5.5)	1354 (3.3)	425 (1.8)	162 (0.9)	3 (0.1)	1 (0.3)	
Non-Hispanic Native Hawaiian or Pacific Islander	6 (0.1)	133 (0.2)	122 (0.2)	121 (0.3)	93 (0.4)	73 (0.4)	12 (0.4)	0 (0.0)	
Non-Hispanic more than one Race	217 (2.8)	2166 (2.6)	1534 (2.5)	1060 (2.6)	627 (2.7)	531 (3.1)	90 (3.2)	15 (4.0)	
Hispanic	1541 (19.9)	17,376 (20.7)	13,980 (23.1)	9448 (23.2)	4702 (20.2)	2940 (17.1)	409 (14.3)	37 (9.9)	
Unknown	66 (0.9)	637 (0.8)	465 (0.8)	288 (0.7)	123 (0.5)	89 (0.5)	17 (0.6)	1 (0.3)	
Payer status									<.01
Public insurance *	4830 (62.2)	38,337 (45.7)	26,369 (43.6)	17,831 (43.8)	10,142 (43.5)	7721 (44.8)	1407 (49.3)	219 (58.7)	
Private insurance	2706 (34.9)	43,309 (51.7)	32,710 (54.1)	22,094 (54.3)	12,849 (55.2)	9315 (54.1)	1422 (49.8)	149 (40.0)	
Self-pay	225 (2.9)	2189 (2.6)	1421 (2.4)	770 (1.9)	309 (1.3)	195 (1.1)	27 (1.0)	5 (1.3)	
Pre-gestational diabetes	73 (0.9)	1350 (1.6)	1718 (2.8)	1563 (3.8)	1198 (5.1)	1087 (6.3)	229 (8.0)	44 (11.8)	<.01
Gestational diabetes	357 (4.6)	4973 (5.9)	5928 (9.8)	563 (13.8)	3995 (17.2)	3448 (20.0)	649 (22.7)	85 (22.8)	<.01
Chronic hypertension	156 (2.0)	2585 (3.1)	3315 (5.5)	3388 (8.3)	2771 (11.9)	2963 (17.2)	783 (27.4)	123 (33.0)	<.01

	Underweight BMI <18.5 (n=7761)	Normal BMI 18.5-24.9 (n=83,835)	Overweight BMI 25-29.9 (n=60,500)	Class I Obesity BMI 30-34.9 (n=40,695)	Class II Obesity BMI 35-39.9 (n=23,300)	Class III Obesity BMI 40-49.9 (n=17,231)	Class IV Obesity BMI 50-59.9 (n=2856)	Class V Obesity BMI ≥ 60 (n=373)	*p*-value
Hypertensive disorders of pregnancy **	1711 (22.1)	23,718 (28.3)	21,829 (36.1)	16,522 (40.6)	10,227 (43.9)	7632 (44.3)	1224 (42.9)	150 (40.2)	<.01
Eclampsia	74 (1.0)	1097 (1.3)	955 (1.6)	694 (1.7)	414 (1.8)	314 (1.8)	58 (2.0)	7 (1.9)	<.01
Gestational Age	34.7±1.7	34.8±1.7	34.8±1.6	34.8±1.6	34.8±1.6	34.8±1.6	34.8±1.6	34.8±1.6	<.01
Gestational age categories									<.01
28w0d-33w6d	1343 (17.3)	13,278 (15.8)	9301 (15.4)	6484 (15.9)	3717 (16.0)	2647 (15.4)	452 (15.8)	58 (15.6)	
34w0d-36w6d	6418 (82.7)	70,557 (84.2)	51,199 (84.6)	34,211 (84.1)	19,583 (84.1)	14,584 (84.6)	2404 (84.2)	314 (84.5)	
Neonatal birthweight	2572±599	2689±623	2723±644	2717±648	2716±654	2730±644	2746±641	2675±604	<.01
Birthweight > 4000g	51 (0.7)	1043 (1.2)	1012 (1.7)	727 (1.8)	414 (1.8)	322 (1.9)	79 (2.8)	6 (1.6)	<.01

[*] Public insurance includes Medicaid, Indian health service, Tricare, other government, other pay, or unknown;

[**] Hypertensive disorders of pregnancy includes gestational hypertension and pre-eclampsia spectrum without eclampsia as is reported on the birth certificate dataset; Categorical and continuous variables are reported as n (%) and mean ± standard deviation, respectively. All analyses were performed on Stata IC 15.1 (College Station, Texas, USA).

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