The association of maternal obesity and obstetric anal sphincter injuries at time of vaginal delivery

Amin Tavakoli, MD; Viraj R. Panchal, MD; Genevieve R. Mazza, MD; Rachel S. Mandelbaum, MD; Joseph G. Ouzounian, MD, MBA; Koji Matsuo, MD, PhD

BACKGROUND: The risk of third- and fourth-degree perineal laceration after vaginal delivery in patients with obesity is relatively understudied and has mixed findings in existing literature.

OBJECTIVE: This study aimed to examine the association of maternal obesity and obstetric anal sphincter injuries at vaginal delivery.

STUDY DESIGN: The Healthcare Cost and Utilization Project's National Inpatient Sample was retrospectively queried to examine 7,385,341 vaginal deliveries from January 2017 to December 2019. The exposure assignment was obesity status. The main outcomes were third- and fourth-degree perineal lacerations after vaginal delivery. Statistical analysis examining the exposure-outcome association included (1) inverse probability of treatment weighting with log-Poisson regression generalized linear model to account for prepregnant and pregnant confounders for the exposure and (2) multinomial regression model to account for delivery factors in the inverse probability of treatment weighting cohort. The secondary outcomes included (1) the temporal trends of fourth-degree laceration and its associated factors at cohort level and (2) risk factor patterns for fourth-degree laceration by constructing a classification tree model.

RESULTS: In the inverse probability of treatment weighting cohort, patients with obesity were less likely to have fourth-degree lacerations and third-degree lacerations than patients without obesity (fourth-degree laceration: 2.3 vs 3.9 per 1000 vaginal deliveries, respectively; adjusted odds ratio, 0.62; 95% confidence interval, 0.56−0.69; third-degree laceration: 15.6 vs 20.1 per 1000 vaginal deliveries, respectively; adjusted odds ratio, 0.79; 95% confidence interval, 0.76−0.82). In contrast, in patients with obesity vs those without obesity, forceps delivery (54.7 vs 3.3 per 1000 vaginal deliveries, respectively; adjusted odds ratio, 17.73; 95% confidence interval, 16.17−19.44), vacuum-assisted delivery (19.8 vs 2.9 per 1000 vaginal deliveries, respectively; adjusted odds ratio, 5.18; 95% confidence interval, 4.85−5.53), episiotomy (19.2 vs 2.8 per 1000 vaginal deliveries, respectively; adjusted odds ratio, 3.95; 95% confidence interval, 3.71−4.20), and shoulder dystocia (17.8 vs 3.4 per 1000 vaginal deliveries, respectively; adjusted odds ratio, 2.60; 95% confidence interval, 2.29−2.94) were associated with more than a 2-fold increased risk of fourth-degree perineal laceration. Among the group with obesity, patients who had forceps delivery and shoulder dystocia had the highest incidence of fourth-degree laceration (105.3 per 1000 vaginal deliveries). Among the group without obesity, patients who had forceps delivery, shoulder dystocia, and macrosomia had the highest incidence of fourth-degree laceration (294.1 per 1000 vaginal deliveries). The incidence of fourth-degree perineal laceration decreased by 11.9% over time (P trend=.004); moreover, forceps delivery, vacuum-assisted delivery, and episiotomy decreased by 3.8%, 7.6%, and 29.5%, respectively (all, P trend<.05).

From the Division of Gynecologic Oncology, Department of Obstetrics and Gynecology, University of Southern California, Los Angeles, CA (Drs Tavakoli, Panchal, Mazza, Mandelbaum, and Matsuo); Division of Reproductive Endocrinology and Infertility, Department of Obstetrics and Gynecology, University of Southern California, Los Angeles, CA (Dr Mandelbaum); Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, University of Southern California, Los Angeles, CA (Dr Ouzounian); Norris Comprehensive Cancer Center, University of Southern California, Los Angeles, CA (Dr Matsuo)

This study was presented at the 43rd Annual Pregnancy Meeting of the Society for Maternal-Fetal Medicine, San Francisco, CA, February 6−11, 2023.

This study was funded by Ensign Endowment for Gynecologic Cancer Research (to K.M.). The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

The authors report no conflict of interest.

This study was exempted for ethical committee approval from the University of Southern California Institutional Review Board (approval number: HS-16-00481). Patient consent was not required because no personal information or detail is included.

The data on which this study is based are publicly available upon request at Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (https://www.hcup-us.ahrq.gov/nisoverview.jsp).

The manuscript's corresponding author (K.M.) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained. The National Inpatient Sample is developed for the HCUP that is sponsored by the AHRQ, and the program is the source of the deidentified data used. Race and ethnicity was grouped by the program. Moreover, the program has not verified and is not responsible for the statistical validity of the data analysis or the conclusions derived by the study team.

Cite this article as: Tavakoli A, Panchal VR, Mazza GR, et al. The association of maternal obesity and obstetric anal sphincter injuries at time of vaginal delivery. Am J Obstet Gynecol Glob Rep 2023;XX:x.ex−x.ex.

Corresponding author: Koji Matsuo, MD, PhD. koji.matsuo@med.usc.edu

2666-5778/$36.00

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http://dx.doi.org/10.1016/j.xagr.2023.100272

CONCLUSION: This national-level analysis suggests that patients with obesity are less likely to have obstetric anal sphincter injuries at the time of vaginal delivery. Furthermore, this analysis confirms other known risk factors for fourth-degree laceration, such as forceps delivery, vacuum-assisted delivery, episiotomy, and shoulder dystocia. However, we noted a decreasing trend in fourth-degree lacerations, which may be due to evolving obstetrical practices.

Key words: anal sphincter tear, fourth-degree laceration, obesity, obstetric anal sphincter injuries, third-degree laceration, vaginal delivery

Introduction

Historically, the reported incidence of perineal lacerations has been inconsistent because of the lack of standardized definitions.[1,2] Obstetrical perineal lacerations in general have been reported to occur in up to 78% of vaginal deliveries. These lacerations result from various risk factors and, in most cases, do not involve the anal sphincter complex.[3,4] More severe lacerations that do involve the anal sphincter complex are labeled obstetric anal sphincter injuries (OASIS).

In 2012, the American College of Obstetricians and Gynecologists (ACOG) developed a standardized definition for perineal lacerations, including definitions for third- and fourth-degree lacerations, which involve the anal sphincter complex.[2,5] If not properly diagnosed and repaired appropriately, these lacerations can lead to long-term sequelae, such as pain, fecal and gas incontinence, dyspareunia, and reduced quality of life.[6]

Many studies have reported on general risk factors for OASIS, which include fetal macrosomia, episiotomy, operative vaginal delivery, prolonged labor, primiparity, and persistent occiput posterior position.[7–9]

Of note, 1 risk factor for OASIS that continues to be poorly understood is maternal obesity. Although many have shown no statistical difference in OASIS between patients with and without obesity,[10–13] others have shown a decreased risk of OASIS in patients with obesity.[14,15] In addition, some data are suggesting that recurrent OASIS may be more likely in patients with obesity.[16]

Given the high prevalence of obesity in the United States[17] and the potential severe sequelae of OASIS, it is important to better understand the association between obesity and OASIS. This study aimed to examine the association of maternal obesity and OASIS at vaginal delivery.

Materials and Methods

Data

The Healthcare Cost and Utilization Project's National Inpatient Sample (NIS) was retrospectively queried.[18] The data are supported and distributed by the Agency for Healthcare Research and Quality. It approximates a stratified sample of 20% of discharges in each center from all the participating hospitals across 48 states and the District of Columbia. The NIS represents >95% of hospital discharge data in the US population.

Ethical consideration

The University of Southern California Institutional Review Board exempted the current study because of the use of publicly available deidentified data.

Study population

The study population included hospital-setting vaginal deliveries between January 2017 and December 2019. The starting point was chosen because of the availability of the World Health Organization's International Classification of Disease, Tenth Revision (ICD-10), Clinical Modification (ICD-10-CM) codes for the third-degree perineal laceration subclassifications.

Identification of vaginal deliveries followed previous studies.[19,20] These included diagnosis-related group codes 767, 768, 774, 775, 796, 797, 798, 805, 806, and 807; the ICD-10-CM codes O80; and the ICD-10 Procedure Coding System (ICD-10-PCS) codes 10D07Z3, 10D07Z4, 10D07Z5, 10D07Z6, 10D07Z7, and 10D07Z8.

Exposure

The exposure was obesity status, identified according to the ICD-10-CM codes. These included E66.0, E66.01, E66.1, E66.2, E66.8, E66.9, Z68.3, Z68.4, and O99.21. Pregnant patients with any of these codes were assigned as the group with obesity, and those without were assigned as the group without obesity. The ICD-10 codes were consistent throughout the study period.

Outcome measures

The primary outcomes were third- and fourth-degree perineal lacerations at the time of vaginal delivery. These outcome measures were identified with the ICD-10-CM codes. The fourth-degree perineal lacerations, defined as anal sphincter complex and anal epithelium injury, were based on the ICD-10-CM codes O70.3 and O70.4.[2] The third-degree perineal lacerations, defined as the injury to anal sphincter complex, were based on the ICD-10-CM code O70.2.[2]

The third-degree perineal lacerations were further classified into the following 3 tiers according to the ACOG definition[2]: grade 3a, defined as <50% of external anal sphincter thickness torn, identified as the ICD-10-CM code O70.21; grade 3b, defined as >50% of external anal sphincter thickness torn identified as the ICD-10-CM code O70.22; and grade 3c, defined as the injury to both external and internal anal sphincter torn, identified as the ICD-10-CM code O70.23.

Study covariates

The study covariates examined were preselected in view of relevance to the exposure and outcomes. These included 15 prepregnancy factors, 12 current pregnancy factors, and 10 delivery factors (a total of 37 factors). The identification of these study covariates was based on the ICD-10-CM or ICD-10-PCS codes that followed previous studies.[21,22] The study covariates were grouped as similar to previous studies.[19–23]

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Why was this study conducted?

The risk of third- and fourth-degree perineal laceration at vaginal delivery in patients with obesity is relatively understudied and has mixed findings in existing literature.

Key findings

In an analysis of 7,385,341 vaginal deliveries identified in the National Inpatient Sample from 2017 to 2019, patients with obesity were less likely to have fourth-degree and third-degree lacerations than patients without obesity (fourth-degree laceration: 2.3 vs 3.9 per 1000 vaginal deliveries, respectively; adjusted odds ratio [aOR], 0.62; 95% confidence interval [CI], 0.56−0.69; third-degree laceration: 15.6 vs 20.1 per 1000 vaginal deliveries, respectively; aOR, 0.79; 95% CI, 0.76−0.82). The incidence of fourth-degree perineal laceration decreased by 11.9% over time; moreover, forceps delivery, vacuum-assisted delivery, and episiotomy decreased by 3.8%, 7.6%, and 29.5%, respectively.

What does this add to what is known?

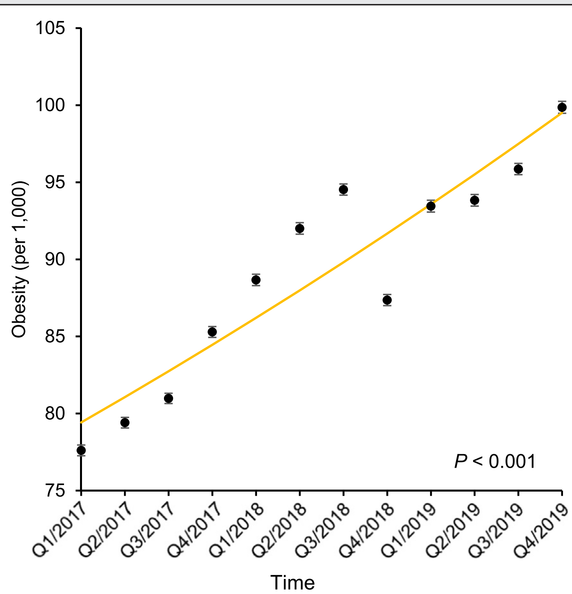
Patients with obesity are less likely to have obstetric anal sphincter injuries at the time of vaginal delivery. The decreasing trend in fourth-degree lacerations may be due to evolving obstetrical practices of decreasing operative delivery and episiotomy.

Prepregnancy factors included (1) patient demographics (age, year, race and ethnicity, primary payer, census-level household income, patient location, and region), (2) medical comorbidity (pregestational hypertension and pregestational diabetes mellitus), (3) substance use factor (tobacco), (4) gynecologic factors (uterine myoma), and (5) previous pregnancy factors (grand multiparity and previous uterine scar). This study examined race and ethnicity as this factor is associated with pregnancy and delivery characteristics and outcomes.

Current pregnancy factors included (1) fetal factors (multifetal pregnancy, malpresentation, large for gestational age [LGA], intrauterine growth restriction, polyhydramnios, and oligohydramnios), (2) maternal factors (gestational diabetes mellitus, gestational hypertension, and preeclampsia), and (3) membranous factors (premature rupture of membrane [preterm and term] and chorioamnionitis).

Delivery factors included hospital bed capacity, hospital location and teaching status, gestational age at delivery, labor obstruction, epidural anesthesia, episiotomy, shoulder dystocia, vacuum-assisted delivery, and forceps delivery.

FIGURE 1
Temporal trends of obesity



The cohort-level prevalence rates of individuals with obesity (*P* trend<.001) are shown. The vertical axes are truncated for visibility. The *dots* represent the observed values, and the *bars* represent the standard error. The *lines* represent the modeled value.

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Analytical consideration

Independent prepregnancy and pregnancy characteristics related to obesity were assessed with a log-Poisson regression generalized linear model in multivariable analysis. Multicollinearity was assessed among the covariates. The effect size for obesity compared with nonobesity was expressed with adjusted odds ratio (aOR) and a corresponding 95% confidence interval (CI).

To assess the association between maternal obesity and the third- and fourth-degree perineal lacerations at vaginal delivery, we mitigated the prepregnancy and pregnancy confounders followed by accounting for delivery factors. This analytical approach was adopted on the basis of the rationale that (1) maternal obesity is a preexisting event before pregnancy but may influence the subsequent pregnancy event and (2) the third- and fourth-degree perineal lacerations are the delivery events that chronologically occur after the pregnancy event.

Prepregnancy and pregnancy confounders between the 2 exposure groups were balanced by creating the inverse probability of treatment weighting (IPTW) cohort.[24] The propensity score was computed with a log-Poisson regression generalized linear model by accounting for prepregnancy and

TABLE 1
Characteristics related to obesity (multivariable analysis)

Characteristic	Obesity (−)	Obesity (+)	aOR (95% CI)	*P* value
Number	n=6,727,751	n=657,590		
Age (y)	28 (24−32)	28 (24−33)	1.01 (1.01−1.01)	<.001
Year				
2017	34.2	30.8	1.00 (reference)	
2018	33.2	33.9	1.10 (1.09−1.11)	<.001
2019	32.3	35.3	1.14 (1.13−1.15)	<.001
Race and ethnicity				
White	51.7	44.5	1.00 (reference)	
Black	13.1	20.4	1.47 (1.46−1.48)	<.001
Hispanic	19.7	24.2	1.25 (1.24−1.26)	<.001
Asian	6.3	3.1	0.58 (0.57−0.59)	<.001
Native American	0.7	1.0	1.35 (1.32−1.38)	<.001
Other	4.5	3.5	0.90 (0.89−0.92)	<.001
Unknown	3.9	3.2	0.97 (0.96−0.99)	<.001
Primary payer				
Medicaid	42.2	50.0	1.00 (reference)	
Private	51.4	45.2	0.90 (0.89−0.90)	<.001
Self-pay	2.8	1.6	0.62 (0.61−0.63)	<.001
Medicare	0.6	0.9	1.11 (1.08−1.14)	<.001
No charge	0.1	<0.1	0.42 (0.37−0.48)	<.001
Other	2.8	2.1	0.77 (0.75−0.78)	<.001
Unknown	0.1	0.1	0.96 (0.90−1.03)	.236
Household income				
QT1 (the lowest)	26.9	32.4	1.00 (reference)	
QT2	25.2	26.4	0.96 (0.95−0.96)	<.001
QT3	24.8	24.6	0.92 (0.91−0.92)	<.001
QT4 (the highest)	22.2	15.8	0.73 (0.72−0.73)	<.001
Unknown	0.9	0.8	0.94 (0.92−0.97)	<.001
Patient location				
Large central metropolitan	32.8	35.6	1.00 (reference)	
Large fringe metropolitan	23.9	22.4	1.01 (1.01−1.01)	.156
Medium metropolitan	20.7	21.6	0.99 (0.98−0.99)	<.001
Small metropolitan	8.8	8.4	0.92 (0.91−0.93)	<.001
Micropolitan	8.1	7.1	0.87 (0.86−0.88)	<.001
Not metropolitan or micropolitan	5.4	4.7	0.84 (0.83−0.85)	<.001
Unknown	0.3	0.1	0.53 (0.49−0.58)	<.001
Region				
Northeast	15.9	14.6	1.00 (reference)	
Midwest	21.8	21.7	1.08 (1.07−1.09)	<.001
South	37.7	37.6	1.00 (0.99−1.01)	.928

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TABLE 1
Characteristics related to obesity (multivariable analysis) *(continued)*

Characteristic	Obesity (−)	Obesity (+)	aOR (95% CI)	*P* value
West	24.5	26.1	1.17 (1.16−1.17)	<.001
Hypertensive disorder				
No	89.5	72.8	1.00 (reference)	
Pregestational	1.7	6.6	3.01 (2.98−3.04)	<.001
Gestational	4.7	10.6	2.33 (2.31−2.35)	<.001
Preeclampsia	4.1	10.0	2.29 (2.27−2.31)	<.001
Diabetes mellitus				
No	93.5	85.0	1.00 (reference)	
Pregestational	0.5	2.1	2.32 (2.28−2.36)	<.001
Gestational	6.1	12.9	1.89 (1.87−1.90)	<.001
Tobacco use				
No	95.0	93.5	1.00 (reference)	
Yes	5.0	6.5	1.24 (1.23−1.25)	<.001
Previous uterine scar				
No	96.6	95.6	1.00 (reference)	
Yes	3.4	4.4	1.20 (1.19−1.22)	<.001
Uterine myoma				
No	99.4	98.6	1.00 (reference)	
Yes	0.6	1.4	1.55 (1.52−1.58)	<.001
Grand multiparity				
No	99.9	99.7	1.00 (reference)	
Yes	0.1	0.3	1.51 (1.45−1.58)	<.001
Multifetal pregnancy				
No	99.3	99.1	1.00 (reference)	
Yes	0.7	0.9	1.15 (1.12−1.18)	<.001
Large for gestational age				
No	98.6	96.3	1.00 (reference)	
Yes	1.4	3.7	2.17 (2.14−2.20)	<.001
Intrauterine growth restriction				
No	96.9	97.5	1.00 (reference)	
Yes	3.1	2.5	0.74 (0.73−0.75)	<.001
Polyhydramnios				
No	99.0	98.1	1.00 (reference)	
Yes	1.0	1.9	1.38 (1.36−1.41)	<.001
Oligohydramnios				
No	97.8	96.8	1.00 (reference)	
Yes	2.2	3.2	1.41 (1.39−1.43)	<.001
Breech presentation				
No	99.5	99.4	1.00 (reference)	
Yes	0.5	0.6	1.01 (0.97−1.04)	.763

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TABLE 1
Characteristics related to obesity (multivariable analysis) *(continued)*

Characteristic	Obesity (−)	Obesity (+)	aOR (95% CI)	*P* value
PROM				
No	90.8	89.6	1.00 (reference)	
Preterm	2.5	3.1	1.13 (1.11−1.14)	<.001
Term	6.7	7.2	1.22 (1.21−1.24)	<.001
Chorioamnionitis				
No	98.1	97.1	1.00 (reference)	
Yes	1.9	2.9	1.33 (1.31−1.34)	<.001

Data are presented as median (interquartile range) or percentage, unless otherwise indicated. A log-Poisson regression generalized linear model was used for multivariable analysis.

aOR, adjusted odds ratio; *CI*, confidence interval; PROM, premature rupture of membranes; *QT*, quartile.

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pregnancy factors. The IPTW propensity score method assigned patients in the group with obesity a weight of 1/(propensity score) and those in the group without obesity a weight of 1/(1-propensity score).

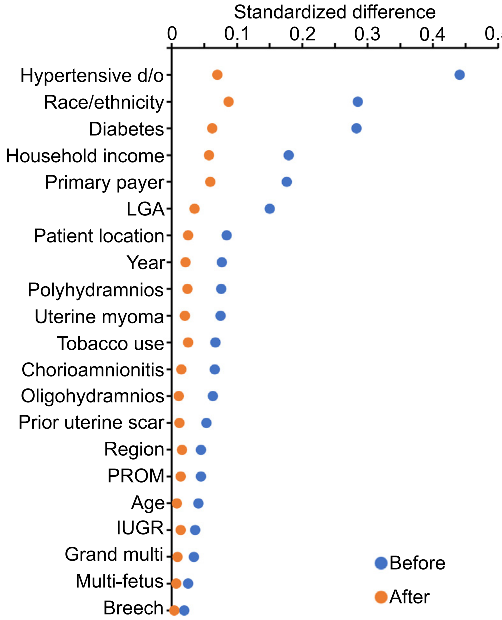
Stabilized weights and threshold techniques at the 1st percentile and 99th percentile were used.[24] Balance statistics between the 2 exposure groups were assessed with a standardized difference in the IPTW cohort, and a value of >0.20 was interpreted as a clinical imbalance between the exposure groups.[25]

The exposure-outcome association in the IPTW cohort was assessed by adjusting for the delivery factors. These were preselected as above (a total of 10 factors). The effect size for the group with obesity compared with that of the group without obesity on the outcome measures was assessed with a multinomial regression model, expressed with aOR and a corresponding 95% CI.

Various sensitivity analyses were performed to assess the robustness of the study findings. First, the exposure-outcome association was examined per the race and ethnicity group (White, Black, Hispanic, and Asian). Second, the outcome measures were assessed for the targeted delivery factors (episiotomy, vacuum-assisted vaginal delivery, forceps delivery, and shoulder dystocia). Third, temporal trends of obesity, third- and fourth-degree perineal lacerations at vaginal delivery, and targeted delivery factors were assessed at the cohort level. The linear segmented regression and log transformation were used to assess the temporal trend with year-quarter increments.

Finally, a classification tree for fourth-degree perineal laceration at vaginal delivery was constructed by recursive partitioning analysis per the exposure strata (obesity and nonobesity).[26] Targeted delivery factors (forces delivery, vacuum-assisted delivery, episiotomy, and shoulder dystocia) and a selected pregnancy factor (LGA) were entered into the modeling. These variables were preselected in the relevance of severe perineal laceration at vaginal

FIGURE 2
Balance statistics before and after the inverse probability of treatment weighting



Standardized differences before and after inverse probability of treatment weighting are shown. In the weighted model, all the modeled covariates were well balanced (standardized difference, ≤0.087).

d/o, disorder; *IUGR*, intrauterine growth restriction; *LGA*, large for gestational age; *PROM*, premature rupture of membranes.

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delivery. The chi-square automatic interaction detector method was used with a stopping rule of a maximum of 3 layers. In the determined patterns, the incidence rate of fourth-degree perineal laceration was computed.

The analysis was based on the national estimates provided by the NIS. Statistical interpretation followed a 2-tailed hypothesis, and a *P* value of <.05 was considered statistically significant. Cases with unknown data were grouped into 1 category in each variable. IBM SPSS Statistics (version 28.0; IBM, Armonk, NY), R (version 3.5.3; R Foundation for Statistical Computing, Vienna, Austria), and National Cancer Institute's Joinpoint Regression Program (version 4.8.0.1) were used for all analyses. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines to summarize the performance of the cohort study.[27]

Results

Obesity-related characteristics

A total of 7,385,341 vaginal deliveries were examined. A total of 657,590 patients with a diagnosis of obesity were compared with 6,727,751 patients without obesity. The number of individuals with obesity has increased from 78 per 1000 vaginal deliveries in the first quarter of 2017 to 100 per 1000 vaginal deliveries in the last quarter of 2019 (relative increase, 28.2%; *P* trend<.001) (Figure 1).

Patient and pregnancy characteristics per the exposure are shown in Table 1. In a multivariable analysis, an increasing number of individuals with obesity over time remained independent. Individuals with obesity were more likely to be older, Black, Hispanic, Native American, large central metropolitan and Western US residents, grand multiparous, and smokers; have medical comorbidities (pregestational hypertension and diabetes mellitus); and have uterine myoma and previous uterine scar; moreover, individuals with obesity were less likely to be Asian or privately insured and had a higher household income than individuals without obesity (all, *P*<.05).

TABLE 2
Covariate distributions in the IPTW cohort

Characteristic	Obesity (−)	Obesity (+)	SD
Age (y)	28 (24–32)	28 (24–32)	0.008
Year			0.021
2017	33.9	33.0	
2018	33.3	33.4	
2019	32.8	33.6	
Race and ethnicity			0.087
White	51.0	50.5	
Black	13.8	15.2	
Hispanic	20.1	21.2	
Asian	6.0	4.3	
Native American	0.7	0.8	
Other	4.4	4.3	
Unknown	3.9	3.8	
Primary payer			0.059
Medicaid	42.9	45.3	
Private	50.8	49.1	
Self-pay	2.7	2.1	
Medicare	0.6	0.7	
No charge	0.1	<0.1	
Other	2.7	2.6	
Unknown	0.1	0.1	
Household income			0.057
QT1 (the lowest)	27.4	28.8	
QT2	25.3	26.0	
QT3	24.7	25.0	
QT4 (the highest)	21.6	19.4	
Unknown	0.9	0.8	
Patient location			0.025
Large central metropolitan	33.1	32.7	
Large fringe metropolitan	23.8	23.5	
Medium metropolitan	20.8	21.4	
Small metropolitan	8.8	8.9	
Micropolitan	8.0	8.0	
Not metropolitan or micropolitan	5.3	5.3	
Unknown	0.3	0.2	
Region			0.016
Northeast	15.8	15.3	
Midwest	21.8	22.2	
South	37.7	37.8	
West	24.7	24.8	

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TABLE 2
Covariate distributions in the IPTW cohort *(continued)*

Characteristic	Obesity (−)	Obesity (+)	SD
Hypertensive disorder			0.070
No	88.0	85.8	
Pregestational	2.1	2.9	
Gestational	5.3	5.9	
Preeclampsia	4.7	5.4	
Diabetes mellitus			0.062
No	92.7	91.2	
Pregestational	0.6	1.0	
Gestational	6.7	7.8	
Tobacco use			0.025
No	94.9	94.3	
Yes	5.1	5.7	
Previous uterine scar			0.012
No	96.5	96.3	
Yes	3.5	3.7	
Uterine myoma			0.020
No	99.3	99.1	
Yes	0.7	0.9	
Grand multiparity			0.009
No	99.9	99.8	
Yes	0.1	0.2	
Multifetal pregnancy			0.007
No	99.3	99.2	
Yes	0.7	0.8	
Large for gestational age			0.035
No	98.4	98.0	
Yes	1.6	2.0	
Intrauterine growth restriction			0.014
No	96.9	97.2	
Yes	3.1	2.8	
Polyhydramnios			0.024
No	98.9	98.7	
Yes	1.1	1.3	
Oligohydramnios			0.011
No	97.7	97.5	
Yes	2.3	2.5	
Breech presentation			0.004
No	99.5	99.5	
Yes	0.5	0.5	
PROM			0.014

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Pregnancy characteristics associated with obesity included gestational hypertension, preeclampsia, gestational diabetes mellitus, multifetal pregnancy, LGA, polyhydramnios, oligohydramnios, premature rupture of membranes, and chorioamnionitis (all, $P<.05$) (Table 1).

Obesity and perineal laceration

Differences in the measured prepregnancy and pregnancy confounders between the group with obesity and the group without obesity were balanced by creating the IPTW cohort (Figure 2 and Table 2). All the measured study covariates were well balanced without clinical imbalance between the exposure groups in the IPTW cohort (standardized difference, ≤0.087). In the preweighted model, hypertensive disorder, race and ethnicity, and diabetes mellitus exhibited a clinical imbalance between the groups with and without obesity (standardized difference, >0.20).

Pregnant patients with obesity were 38% less likely to have fourth-degree perineal laceration at vaginal delivery than those without obesity (2.3 vs 3.9 per 1000 vaginal deliveries, respectively; aOR, 0.62; 95% CI, 0.56−0.69; $P<.001$) (Table 3). In contrast, in patients with obesity vs those without obesity, forceps delivery (54.7 vs 3.3 per 1000 vaginal deliveries, respectively; aOR, 17.73; 95% CI, 16.17−19.44; $P<.001$), vacuum-assisted delivery (19.8 vs 2.9 per 1000 vaginal deliveries, respectively; aOR, 5.18; 95% CI, 4.85−5.53; $P<.001$), episiotomy (19.2 vs 2.8 per 1000 vaginal deliveries, respectively; aOR, 3.95; 95% CI, 3.71−4.20; $P<.001$), and shoulder dystocia (17.8 vs 3.4 per 1000 vaginal deliveries, respectively; aOR, 2.60; 95% CI, 2.29−2.94; $P<.001$) were associated with more than a 2-fold increased risk of fourth-degree perineal laceration (Table 3).

Individuals with obesity were 21% less likely to have third-degree perineal laceration at vaginal deliveries than those without obesity (15.6 vs 20.1 per 1000 vaginal deliveries, respectively; aOR, 0.79; 95% CI, 0.76−0.82; $P<.001$) (Table 4). In contrast, in individuals with obesity vs those without obesity,

TABLE 2
Covariate distributions in the IPTW cohort *(continued)*

Characteristic	Obesity (−)	Obesity (+)	SD
No	90.7	90.3	
Preterm	2.6	2.7	
Term	6.7	7.0	
Chorioamnionitis			0.015
No	98.0	97.8	
Yes	2.0	2.2	

Data are presented as median (interquartile range) or percentage, unless otherwise indicated. Balance statistics with standardized differences are shown in Figure 1.

IPTW, inverse probability of treatment weighting; *PROM*, premature rupture of membranes; *QT*, quartile; *SD*, standardized difference.

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forceps delivery (177.9 vs 18.3 per 1000 vaginal deliveries, respectively; aOR, 11.22; 95% CI, 10.65−11.82; *P*<.001), vacuum-assisted delivery (78.4 vs 16.5 per 1000 vaginal deliveries, respectively; aOR, 4.19; 95% CI, 4.05−4.32; *P*<.001), and episiotomy (57.4 vs 17.2 per 1000 vaginal deliveries, respectively; aOR, 2.17; 95% CI, 2.10−2.25; *P*<.001) were associated with more than a 2-fold increased risk of third-degree perineal laceration (Table 4).

Sensitivity analyses

In an interaction term analysis for race and ethnicity (Table 5), the association of obesity and decreased likelihood of fourth-degree perineal laceration at vaginal delivery was more robust in Hispanic individuals (aOR, 0.50; 95% CI, 0.38−0.66) but not in Asian individuals (aOR, 0.78; 95% CI, 0.57−1.08). In addition, Asian patients were associated with higher odds of fourth-degree perineal laceration when they underwent forceps delivery (aOR: 25.70 vs 14.16−19.30) or vacuum-assisted delivery (aOR: 6.40 vs 3.77−5.12) or when diagnosed with shoulder dystocia (aOR: 3.81 vs 1.89−2.63) than other race and ethnicity patients (Table 5).

When the third-degree perineal lacerations were further stratified into the subclassification (Table 6), forceps delivery was associated with grade 3c perineal laceration (aOR, 25.69), followed by grade 3b perineal laceration (aOR, 19.10); the magnitudes of association were higher in third-degree laceration than in fourth-degree perineal laceration (aOR, 17.73) (Table 6). The odds of developing grade 3b or 3c perineal laceration with vacuum-assisted delivery were overall similar to the odds of developing fourth-degree perineal laceration with vacuum-assisted delivery (aOR, 4.74−4.96 vs 5.18) (Table 6).

At the cohort level, the incidence of fourth-degree laceration decreased by 11.9% from 4.2 to 3.7 per 1000 vaginal deliveries during the 3-year study period (*P* trend=.004) (Figure 3). The incidence of third-degree perineal laceration remained unchanged from 20.0 to 19.7 per 1000 vaginal deliveries (*P* trend=.522) (Figure 3). From 2017 to 2019, the number of patients receiving forceps delivery, vacuum-assisted delivery, and episiotomy decreased by 3.8% (from 8.0 to 7.7 per 1000 vaginal deliveries; *P* trend=.039), 7.6% (from 52.3 to 48.3 per 1000 vaginal deliveries; *P* trend=.019), and 29.5% (from 72.1 to 50.8 per 1000 vaginal deliveries; *P* trend<.001), respectively (Figure 4).

Finally, the incidence of fourth-degree perineal laceration at vaginal delivery was assessed based on the combination patterns of targeted risk factors in each exposure strata. Among the pregnant patients with obesity (Figure 5), forceps delivery was the first allocator of the classification tree (43.6 vs 2.0 per 1000 vaginal deliveries). The highest incidence rate of fourth-degree perineal laceration in patients with obesity was 105.3 per 1000 vaginal deliveries, which was seen in patients who had forceps delivery and shoulder dystocia (Figure 5).

In addition, forceps delivery was the first allocator of the classification tree in patients without obesity (fourth-degree perineal laceration: 56.3 vs 3.5) (Figure 6). The highest incidence rate of fourth-degree perineal laceration in patients without obesity was 294.1 per 1000 vaginal deliveries, which was seen in patients who had forceps delivery, shoulder dystocia, and macrosomia (Figure 6).

Comments

Principal findings

The first key finding of this current national-level analysis was that obesity was associated with a decreased likelihood of OASIS at vaginal delivery. Second, this study confirmed that surgical interventions (operative delivery and episiotomy) are associated with an increased risk of OASIS, especially forceps delivery. Finally, we noted a decreasing national-level trend in fourth-degree perineal lacerations during the study period, which paralleled the decreasing trend in operative vaginal delivery and episiotomy.

Insights for results

There are many important considerations when interpreting the results of this study, which showed an overall decreased likelihood of OASIS in patients with obesity. We hypothesize that this protective effect is likely multifactorial. Of note, 1 possibility for this finding, as hypothesized in previous studies, could be that patients with obesity have softer and more elastic perineal tissue, therefore making their perineum more resistant to tearing.[14,15,28]

Another contributing factor could be that uterine contractions in patients with obesity, which have been found to occur less frequently and with less force, could serve as a protective factor against more severe lacerations.[29] A final factor that could contribute to the aforementioned findings, which our study could not account for, is birthing position. Certain birthing positions have been

TABLE 3
Outcome analysis for fourth-degree perineal laceration

Characteristic	Rate[a]	aOR (95% CI)[b]	*P* value
Obesity			
No	3.9	1.00 (reference)	—
Yes	2.3	0.62 (0.56–0.69)	<.001
Forceps delivery			
No	3.3	1.00 (reference)	—
Yes	54.7	17.73 (16.17–19.44)	<.001
Vacuum-assisted delivery			
No	2.9	1.00 (reference)	—
Yes	19.8	5.18 (4.85–5.53)	<.001
Episiotomy			
No	2.8	1.00 (reference)	—
Yes	19.2	3.95 (3.71–4.20)	<.001
Shoulder dystocia			
No	3.4	1.00 (reference)	—
Yes	17.8	2.60 (2.29–2.94)	<.001
Gestational age (wk)			
<37	1.4	0.44 (0.38–0.52)	<.001
37–38	2.9	0.83 (0.77–0.89)	<.001
39	3.7	1.00 (reference)	—
40	5.0	1.26 (1.18–1.34)	<.001
≥41	6.0	1.48 (1.34–1.63)	<.001
Unknown	3.4	0.95 (0.56–1.61)	.838
Labor obstruction			
No	3.1	1.00 (reference)	—
Yes	17.8	1.66 (1.50–1.84)	<.001
Epidural anesthesia			
No	3.7	1.00 (reference)	—
Yes	3.8	0.97 (0.67–1.41)	.879
Hospital bed capacity			
Small	3.6	1.00 (reference)	—
Middle	3.7	1.02 (0.95–1.10)	.598
Large	3.8	1.07 (0.99–1.15)	.072
Hospital teaching			
Rural	4.2	1.00 (reference)	—
Urban nonteaching	3.9	0.98 (0.88–1.08)	.645
Urban teaching	3.6	0.97 (0.89–1.06)	.472

aOR, adjusted odds ratio; *CI*, confidence interval; *IPTW*, inverse probability of treatment weighting.

[a] Rate per 1000 vaginal deliveries in the IPTW cohort; [b] The IPTW cohort was created to account for the prepregnant and pregnancy confounders shown in Table 1. In the IPTW cohort, a multinomial regression model was fitted by modeling the delivery factors as shown in the table.

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TABLE 4
Outcome analysis for third-degree perineal laceration

Characteristic	Rate[a]	aOR (95% CI)[b]	P value
Obesity			
No	20.1	1.00 (reference)	—
Yes	15.6	0.79 (0.76–0.82)	<.001
Forceps delivery			
No	18.3	1.00 (reference)	—
Yes	177.9	11.22 (10.65–11.82)	<.001
Vacuum-assisted delivery			
No	16.5	1.00 (reference)	—
Yes	78.4	4.19 (4.05–4.32)	<.001
Episiotomy			
No	17.2	1.00 (reference)	—
Yes	57.4	2.17 (2.10–2.25)	<.001
Shoulder dystocia			
No	18.8	1.00 (reference)	—
Yes	49.5	1.42 (1.32–1.52)	<.001
Gestational age (wk)			
<37	6.2	0.35 (0.33–0.38)	<.001
37–38	14.7	0.79 (0.77–0.82)	<.001
39	18.9	1.00 (reference)	—
40	27.8	1.41 (1.37–1.45)	<.001
≥41	34.8	1.72 (1.65–1.80)	<.001
Unknown	14.7	0.82 (0.63–1.06)	.125
Labor obstruction			
No	17.8	1.00 (reference)	—
Yes	59.2	1.61 (1.53–1.70)	<.001
Epidural anesthesia			
No	19.6	1.00 (reference)	—
Yes	21.0	1.09 (0.92–1.28)	.317
Hospital bed capacity			
Small	19.8	1.00 (reference)	—
Middle	19.3	0.98 (0.95–1.02)	.343
Large	19.6	1.03 (0.99–1.06)	.110
Hospital teaching			
Rural	16.5	1.00 (reference)	—
Urban nonteaching	17.9	1.11 (1.05–1.16)	<.001
Urban teaching	20.4	1.32 (1.26–1.38)	<.001

aOR, adjusted odds ratio; *CI*, confidence interval; *IPTW*, inverse probability of treatment weighting.

[a] Rate per 1000 vaginal deliveries in the IPTW cohort; [b] The IPTW cohort was created to account for the prepregnant and pregnancy confounders shown in Table 1. In the IPTW cohort, a multinomial regression model was fitted by modeling the delivery factors as shown in the table.

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TABLE 5
Sensitivity analysis for fourth-degree perineal laceration (race and ethnicity)

	White	Black	Hispanic	Asian
Characteristic	aOR (95% CI)[a]	aOR (95% CI)[a]	aOR (95% CI)[a]	aOR (95% CI)[a]
Obesity				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	0.62 (0.54–0.71)[b]	0.72 (0.54–0.97)[b]	0.50 (0.38–0.66)[b]	0.78 (0.57–1.08)
Forceps delivery				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	17.01 (15.04–19.25)[b]	19.30 (14.32–26.02)[b]	14.16 (10.77–18.62)[b]	25.70 (19.75–33.44)[b]
Vacuum-assisted delivery				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	5.12 (4.68–5.60)[b]	3.77 (2.99–4.74)[b]	4.67 (3.91–5.57)[b]	6.40 (5.31–7.72)[b]
Episiotomy				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	3.87 (3.56–4.20)[b]	5.71 (4.64–7.03)[b]	4.89 (4.17–5.74)[b]	2.04 (1.69–2.46)[b]
Shoulder dystocia				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	2.63 (2.22–3.12)[b]	1.89 (1.25–2.86)[b]	2.36 (1.74–3.20)[b]	3.81 (2.59–5.60)[b]

aOR, adjusted odds ratio; *CI*, confidence interval; *IPTW*, inverse probability of treatment weighting.

[a] The IPTW cohort was created to account for the prepregnant and pregnancy confounders shown in Table 1. In the IPTW cohort, a multinomial regression model was fitted the association between maternal obesity and fourth-degree perineal laceration, adjusted for targeted factors (forces delivery, vacuum-assisted delivery, episiotomy, and shoulder dystocia), gestational age at delivery, labor obstruction, epidural anesthesia, and hospital factors (bed capacity and teaching). The effect sizes for obesity and targeted factors are shown in this table; [b] *P*<.05.

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TABLE 6
Sensitivity analysis for third-degree subgrades

	Grade 3a	Grade 3b	Grade 3c	Grade 4
Characteristic	aOR (95% CI)[a]	aOR (95% CI)[a]	aOR (95% CI)[a]	aOR (95% CI)[a]
Forceps delivery				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	9.68 (8.50–11.02)[b]	19.10 (16.20–22.49)[b]	25.69 (20.86–31.64)[b]	17.73 (16.17–19.44)[b]
Vacuum-assisted delivery				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	3.73 (3.42–4.06)[b]	4.96 (4.36–5.64)[b]	4.74 (3.94–5.70)[b]	5.18 (4.85–5.53)[b]
Episiotomy				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	1.32 (1.19–1.45)[b]	1.38 (1.19–1.61)[b]	1.41 (1.15–1.74)[b]	3.95 (3.71–4.20)[b]
Shoulder dystocia				
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	1.15 (0.96–1.37)	1.16 (0.90–1.50)	1.60 (1.13–2.25)[b]	2.60 (2.29–2.94)[b]

aOR, adjusted odds ratio; *CI*, confidence interval; *IPTW*, inverse probability of treatment weighting.

[a] The IPTW cohort was created to account for the prepregnant and pregnancy confounders shown in Table 1. In the IPTW cohort, a multinomial regression model was fitted the association between maternal obesity and fourth-degree perineal laceration, adjusted for targeted factors (forces delivery, vacuum-assisted delivery, episiotomy, and shoulder dystocia), gestational age at delivery, labor obstruction, epidural anesthesia, and hospital factors (bed capacity and teaching). The effect sizes for targeted factors are shown in this table; [b] *P*<.05.

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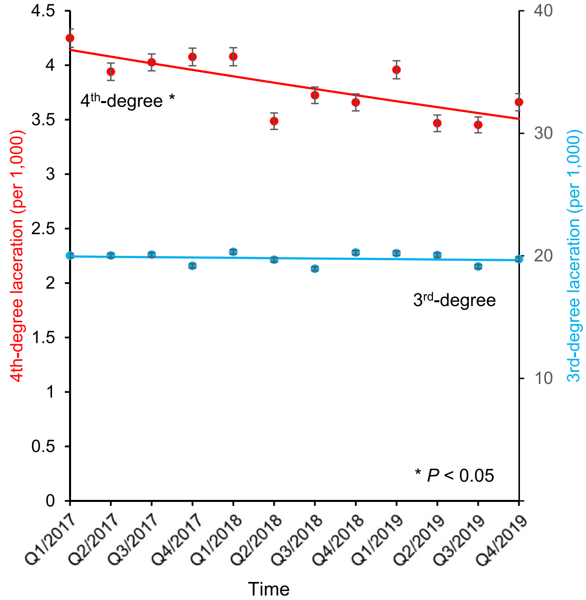
FIGURE 3
Temporal trends of third- and fourth-degree perineal lacerations



The cohort-level incidence rates of third-degree (*blue color*, *P* trend=.522) and fourth-degree (*red color*, *P* trend=.004) perineal lacerations are shown per 1000 vaginal deliveries. The vertical axes are truncated for visibility. The *dots* represent the observed values, and the *bars* represent the standard error. The *lines* represent the modeled value.

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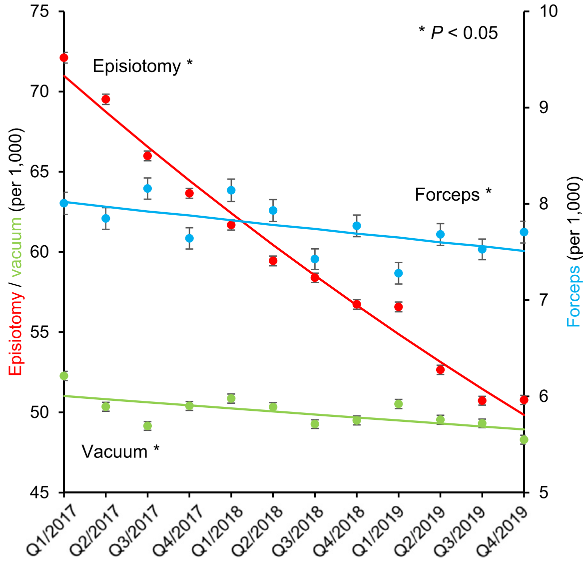
FIGURE 4
Temporal trends of surgical intervention at vaginal delivery



The cohort-level performance rates of episiotomy (*red color*, *P* trend<.001), vacuum-assisted delivery (*green color*, *P* trend=.018), and forceps delivery (*blue color*, *P* trend=.039) are shown per 1000 vaginal deliveries. The vertical axes are truncated for visibility. The *dots* represent the observed values, and the *bars* represent the standard error. The *lines* represent the modeled value.

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speculated to affect the risk of OASIS,[30] and it is possible that patients with obesity are more often opting for birthing positions that decrease the risk of OASIS or less likely opting for those that increase the risk of OASIS.

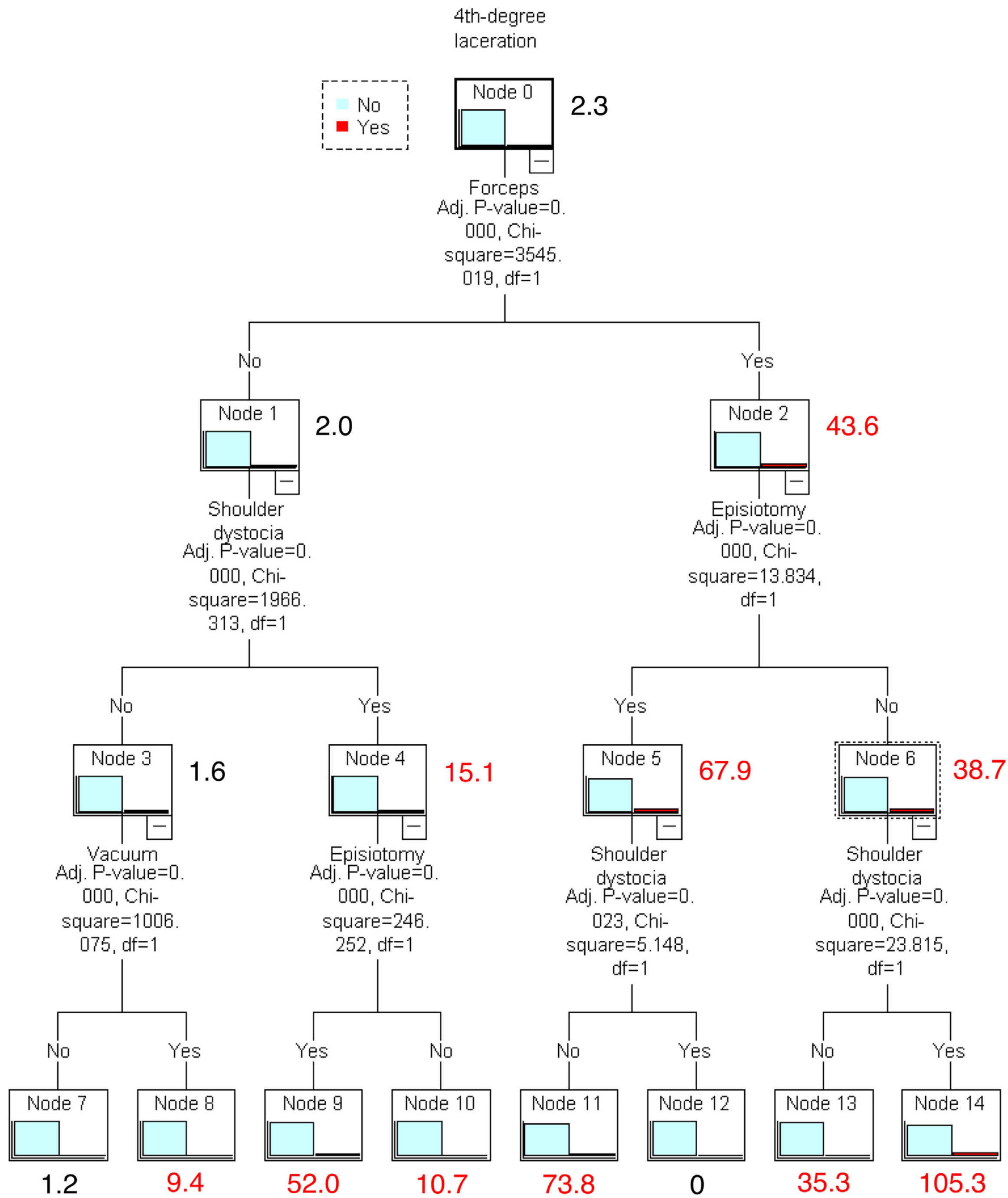
Next, our study showed that Asian patients had a disproportionally higher risk of fourth-degree laceration when undergoing operative delivery or when diagnosed with shoulder dystocia than other races and ethnicities. Asian race has been considered a risk factor for OASIS in several studies conducted in Western countries.[8,9,14,31] In contrast, studies conducted in Asian countries show that Asian race is not an independent risk factor for OASIS.[31] It remains uncertain why there are mixed data regarding this topic. However, our study provides important data showing that operative delivery and shoulder dystocia disproportionally increase the risk of fourth-degree laceration in Asian patients. In addition, obesity did not seem to have a protective effect against fourth-degree laceration in Asians as it does in other races and ethnicities, especially Hispanics (Table 5). Again, we hypothesize that it can be due to different tissue properties among different races or perhaps racial differences in pelvic outlet shape and size or perineal length.[31,32]

Finally, our study showed a decreasing trend in fourth-degree lacerations during the study period. This trend is reassuring and is most likely due to more recent obstetrical practices with fewer operative vaginal deliveries and fewer episiotomies (Figure 4). The decreasing trend in episiotomies is consistent with the recommended practice of restrictive episiotomy.[33] The decrease in operative delivery can be possibly related to an increased rate of cesarean deliveries and fewer providers currently being trained in forceps delivery.[34]

Strengths and limitations

Nationwide data capturing mechanism, contemporaneous study period, modern analytical approach, and several sensitivity tests enhanced the robustness of study findings. Key limitations included unmeasured bias with the lack of

FIGURE 5
Classification tree for fourth-degree perineal laceration (patients with obesity)



A classification tree for fourth-degree perineal laceration at vaginal delivery was constructed by recursive partitioning analysis (a maximum of 3 layers) in the group with obesity (n=657,590). Targeted delivery factors (forces delivery, vacuum-assisted delivery, episiotomy, and shoulder dystocia) and selected pregnancy factor (large for gestational age) were entered in the modeling. The rates of fourth-degree perineal laceration are shown per 1000 vaginal deliveries. The *red values* indicate the values higher than the cohort level of 2.3 per 1000 vaginal deliveries.

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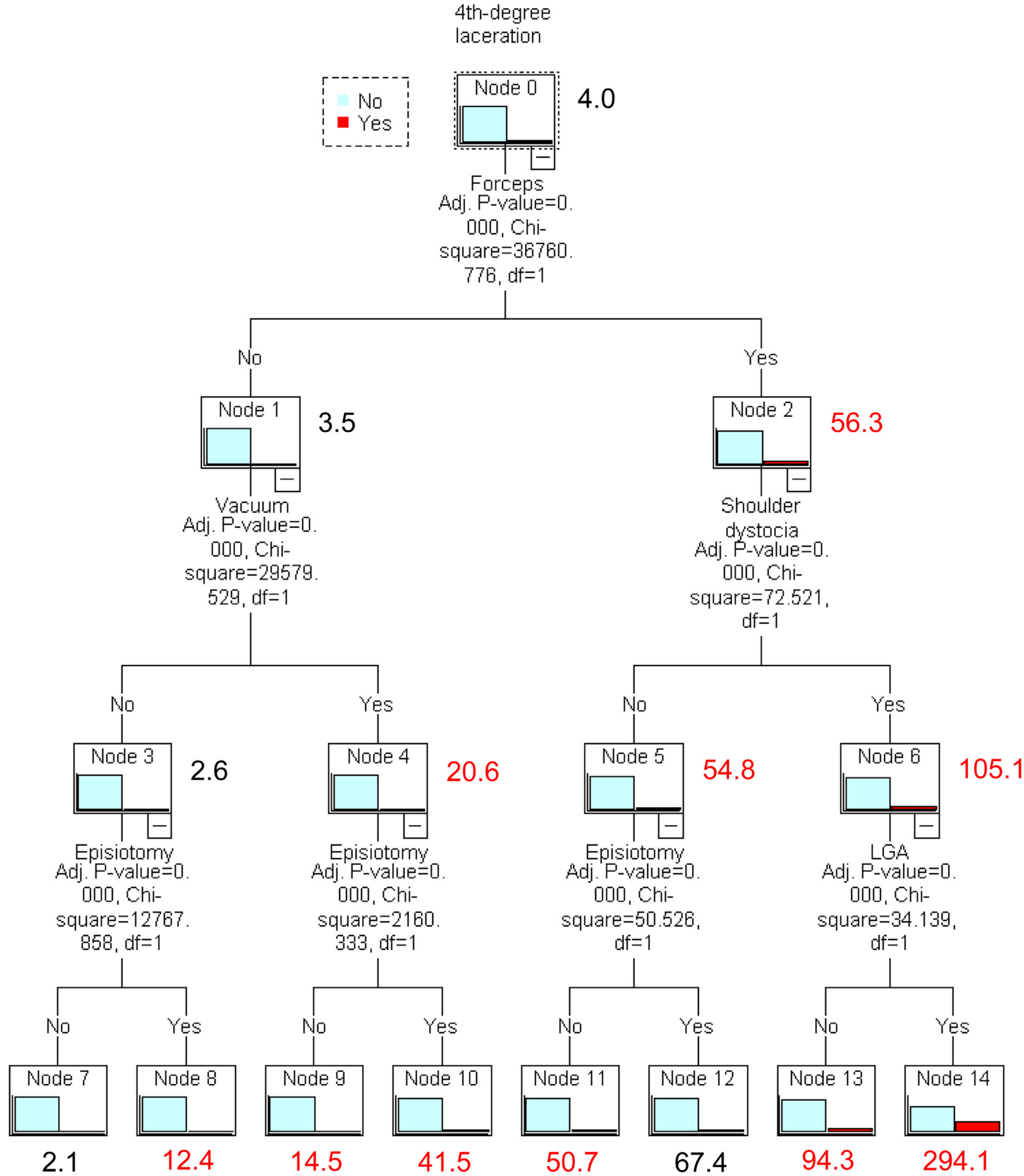
FIGURE 6

Classification tree for fourth-degree perineal laceration (patients without obesity)



A classification tree for fourth-degree perineal laceration at vaginal delivery was constructed by recursive partitioning analysis (a maximum of 3 layers) in the group with obesity (n=6,727,751). Targeted delivery factors (forces delivery, vacuum-assisted delivery, episiotomy, and shoulder dystocia) and selected pregnancy factor (large for gestational age) were entered in the modeling. The rates of fourth-degree perineal laceration are shown per 1000 vaginal deliveries. The *red values* indicate the values higher than the cohort level of 2.3 per 1000 vaginal deliveries.

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information on the details of obesity (eg, definition and cut point of body mass index for the codes), parity, and operative interventions (indication and surgeon's experience). These data may potentially affect the exposure-outcome association in the analysis.

In addition, neonatal information, postdischarge data, subsequent pregnancy information, and patient quality-of-life metrics were important outcomes in this type of study but were not available in the program. The exposure and outcome measures were solely based on administrative coding, and the accuracy of data, particularly for obesity, was not assessable without actual medical record review. The obesity rate in this study was lower than in other studies,[35] suggesting that the coding schema may undercapture the obesity cases. Furthermore, ascertainment bias and unknown generalizability in other populations were limitations.

Clinical and research implications

There are several important implications in this study, especially given the increasing prevalence of obesity and potentially serious sequelae of OASIS.[6,35,36] Our data, which show the most recent trend and risk factors for OASIS, reflect current obstetrical practices. This can be useful for physicians to refer to when counseling specific patients about OASIS. In previous literature, it has been suggested that obstetricians may be less willing to attempt operative delivery in patients with obesity.[14] Given the increased rate of cesarean delivery in patients with obesity,[37] these data might make physicians more likely to consider attempting operative delivery on patients with obesity before escalating to cesarean delivery. Specifically, data from Figures 5 and 6 can help physicians navigate the risk-to-benefit ratio of operative delivery and episiotomy in both patients with and without obesity.

Finally, our data regarding operative delivery and shoulder dystocia disproportionately increasing the risk of fourth-degree laceration in Asian patients can help guide counseling and shared decision-making in this demographic, specifically with forceps delivery.

Conclusion

The results of this nationwide assessment provided important information about obesity possibly being protective against OASIS and how this protective effect may be seen more in certain demographics. Further research is required to understand exactly why obesity may be protective and why it may be specific to certain demographics. ■

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