

# Associations between the Safe Prevention of Primary Cesarean Delivery Care Consensus and Maternal/Neonatal Outcomes

Pamela Estrada, MD<sup>1</sup>  Laura Tipton, PhD<sup>2</sup> Rylan Chong, PhD<sup>2</sup> Dena Towner, MD<sup>1</sup>  
Kelly Yamasato, MD<sup>1</sup>

<sup>1</sup>Department of Obstetrics, Gynecology and Women's Health, University of Hawaii John A. Burns School of Medicine, Honolulu, Hawaii

<sup>2</sup>School of Natural Sciences and Mathematics, Data Science, Analytics, and Visualization, Chaminade University of Honolulu, Honolulu, Hawaii

**Address for correspondence** Pamela Estrada, MD, Department of Obstetrics, Gynecology and Women's Health, University of Hawaii John A. Burns School of Medicine, 1319 Punahoa Street, #824, Honolulu, HI 96826 (e-mail: pamelav.estrada@gmail.com).

Am J Perinatol

## Abstract

**Objective** This study aimed to compare cesarean delivery (CD) rates and maternal/neonatal outcomes before and after the 2014 ACOG/SMFM Obstetric Care Consensus for Safe Prevention of Primary CD.

**Study Design** This retrospective study compared unscheduled CD rates and outcomes of singleton, cephalic, term pregnancies at a tertiary-care teaching maternity hospital. Births 5 years before (March 2009–February 2014) and after (June 2014–May 2019) release of the consensus were included. Chi-square and *t*-test were used to compare outcomes and logistic regression to adjust for confounders.

**Results** In this study, 44,001 pregnancies were included, 20,887 before and 23,114 after the consensus. Unscheduled CD rates increased after the consensus (12.9 vs. 14.3%,  $p < 0.001$ ); however, there was no difference after adjustment (adjusted odds ratio [aOR], 0.97; 95% confidence interval [CI], 0.91–1.03). Vaginal birth after cesarean (VBAC) deliveries increased among multiparas (4.8 vs. 7.2%,  $p < 0.001$ ), which remained significant after adjustment (aOR, 1.51; 95% CI, 1.37–1.66). Postpartum hemorrhage, blood transfusion, and chorioamnionitis were modestly increased, while third-degree perineal lacerations decreased. Uterine rupture and neonatal outcomes were unchanged after adjustment.

**Conclusion** At our tertiary-care maternity hospital, the Safe Prevention of Primary CD Care Consensus was not associated with a change in unscheduled CD, though VBAC deliveries increased. We did not demonstrate improved neonatal outcomes and showed increased maternal morbidity that warrants further study.

## Keywords

- ▶ primary cesarean delivery rate
- ▶ prevent primary cesarean
- ▶ pregnancy
- ▶ vaginal birth after cesarean

## Key Points

- Consensus did not change unscheduled cesarean rates.
- Consensus associated with increased hemorrhage.
- Institutional outcomes can assist implementing changes.

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Cesarean delivery, one of the most common surgeries in the United States, comprises approximately 30% of all births.<sup>1</sup> While often necessary to reduce both maternal and neonatal morbidity, the procedure itself carries risks such as cardiac arrest, wound complications, infection, venous thromboembolism, and complications in subsequent pregnancies.<sup>2,3</sup>

Between 1996 and 2009, the U.S. cesarean rate rose from 20.7 to 32.9%.<sup>4</sup> Overall, since the peak in 2009, rates have experienced a modest decline, down to 31.9% in 2018.<sup>1</sup> In 2019, the rate of low-risk cesarean delivery and total cesarean deliveries was 25.6 and 31.7%, respectively.<sup>5</sup>

In response to the increasing cesarean delivery rate in the United States, the American College of Obstetricians and Gynecologists (ACOG) and Society of Maternal-Fetal Medicine (SMFM) released an obstetric care consensus in March 2014, Safe Prevention of the Primary Cesarean Delivery.<sup>6</sup> Studies examining cesarean delivery rates following the consensus demonstrate conflicting results, some showing decreasing rates,<sup>7,8</sup> while others finding no change.<sup>9</sup> Though nationally it is well established that cesarean rates have changed little since release of the consensus in 2014, more information is needed to evaluate these trends in the setting of changing patient demographics. In addition, while prior work has focused on primary cesarean delivery, it is plausible that labor guidelines aimed to decrease the primary cesarean rate have also affected outcomes of women undergoing trial of labor after cesarean (TOLAC). This study aims to compare the cesarean delivery rate before and after the Safe Prevention of the Primary Cesarean Delivery Obstetric Care Consensus, as well as number of vaginal birth after cesarean (VBAC) and maternal and neonatal outcomes.

## Materials and Methods

This retrospective cohort study included women with singleton pregnancies  $\geq 37^{0/7}$  weeks' gestation in cephalic presentation at Kapiolani Medical Center for Women and Children (Honolulu, HI), a tertiary-care community-based teaching hospital. We included deliveries from March 1, 2009, through May 31, 2019, 5 years before and after the release of the 2014 Safe Prevention of the Primary Cesarean Delivery Obstetric Care Consensus, excluding the 3 months following publication of the consensus (March–May 2014), to allow for adoption of the recommendations. Women with multiple gestations, intrauterine fetal demise, and those who underwent scheduled cesarean delivery were excluded. This study received institutional review board exemption from the Hawaii Pacific Health Research Institute.

Kapiolani Medical Center employed an educational approach to guideline adoption as there are no written labor management protocols or policies at this institution. Upon publication of the Care Consensus, obstetric residents, who provide care to the majority of laboring patients, were trained to follow its recommendations. In addition, a Grand Rounds was given on this publication to further encourage adoption by both trainees and attending providers. Though variability in labor management was present before and after education on the Care Consensus, the greatest overall change

to labor management was thought to be extension of the threshold for active-phase arrest from 2 hours without cervical change to 4 hours.

In addition to mode of delivery, other maternal outcomes evaluated included postpartum hemorrhage, blood transfusion, uterine rupture, chorioamnionitis, and third- and fourth-degree perineal lacerations, which were identified through International Classification of Disease-9 (ICD-9) and International Classification of Disease-10 (ICD-10) codes. Neonatal outcomes included umbilical artery pH  $< 7.0$ , 5-minute Apgar's score  $< 7$ , admission to the neonatal intensive care unit (NICU), and neonatal death prior to hospital discharge.

Other demographic/clinical variables assessed included maternal age and body mass index (BMI) at delivery, parity, maternal race/ethnicity (self-reported on the hospital birth certificate worksheet), and neonate birthweight. Hypertensive disease, diabetes (pregestational and gestational), intrauterine growth restriction, and macrosomia were identified via ICD-9 and ICD-10 codes.

Cesarean delivery, VBAC, and maternal/neonatal outcomes and demographics were compared before (March 2009–February 2014) and after (June 2014–May 2019) the consensus release using chi-square or analysis of variance (ANOVA) and *t*-tests for categorical and continuous variables, respectively, treating each birth as independent. This assumption was verified by nonsignificant autocorrelation coefficients for rates of most outcomes (see [Supplementary Table S1](#), available in the online version). Fixed multivariable logistic regression models were used to adjust for possible confounders, including variables with known associations with mode of delivery.<sup>10–12</sup> Analyses were conducted in R (version 4.1.0 for Windows; RStudio, Boston, MA) and Statistical Program for Social Sciences (SPSS 25.0 for Mac; SPSS Inc. Chicago, IL). Statistical significance was set to  $p < 0.05$ .

## Results

A total of 44,001 deliveries were included, 20,887 pregnancies before and 23,114 after the consensus. Patient demographics and other clinical characteristics are described in [Table 1](#). Of note, primiparity was significantly increased in the years after the consensus (20.1 before vs. 30.3% after,  $p < 0.001$ ), as well as induction of labor (22.0 vs. 27.4%,  $p < 0.001$ ).

Trends in cesarean, VBAC (expressed as percent of the multiparous women in this cohort), and induction of labor over the study interval are shown in [Fig. 1](#). Unscheduled cesarean delivery rates increased after the consensus (12.9 vs. 14.3%,  $p < 0.001$ ; [Table 2](#)), which was no longer significant after adjustment (adjusted odds ratio [aOR], 0.97; 95% confidence interval [CI], 0.91–1.03; [Table 3](#)). There were no differences in cesarean delivery rates after stratification by parity. Among multiparous women, VBAC deliveries increased (4.8 vs. 7.2%,  $p < 0.001$ ), and remained significant after adjustment (aOR, 1.51; 95% CI, 1.37–1.66).

Among other outcomes, postpartum hemorrhage (5.6 vs. 6.2%,  $p = 0.007$ ) and blood transfusion (0.8 vs. 1.2%,  $p < 0.001$ )

**Table 1** Demographics before and after the Safe Prevention of Primary Cesarean Delivery Consensus

Variable N (%) unless specified	Before consensus N = 20,887	After consensus N = 23,114	p
Maternal age, mean (SD), y	28.2 (6.2)	29.1 (6.0)	<0.001
Body mass index at delivery, mean (SD), kg/m <sup>2</sup>	31.2 (6.5)	31.4 (6.4)	0.003
Race/ethnicity			
Asian	7,221 (34.6)	8,718 (37.7)	<0.001
American Indian/Alaskan Native	13 (0.1)	25 (0.1)	
Black	83 (0.4)	185 (0.8)	
Native Hawaiian and other Pacific Islander	3,377 (16.2)	3,718 (16.1)	
White	1,552 (7.4)	2,006 (8.7)	
Multiracial	8,400 (40.2)	8,142 (35.2)	
Hispanic	162 (0.8)	250 (1.1)	
Unknown	79 (0.4)	69 (0.3)	
Primiparous	4,193 (20.1)	6,995 (30.3)	<0.001
Hypertension	2,296 (11.0)	3,742 (16.2)	<0.001
Diabetes (pregestational and gestational)	2,099 (10.0)	2,608 (11.3)	<0.001
Intrauterine growth restriction	470 (2.3)	494 (2.1)	0.44
Macrosomia	408 (2.0)	429 (1.9)	0.48
Induction of labor	4,586 (22.0)	6,327 (27.4)	<0.001
Birth weight (g) Mean (SD)	3,291 (449)	3,285 (443)	0.13

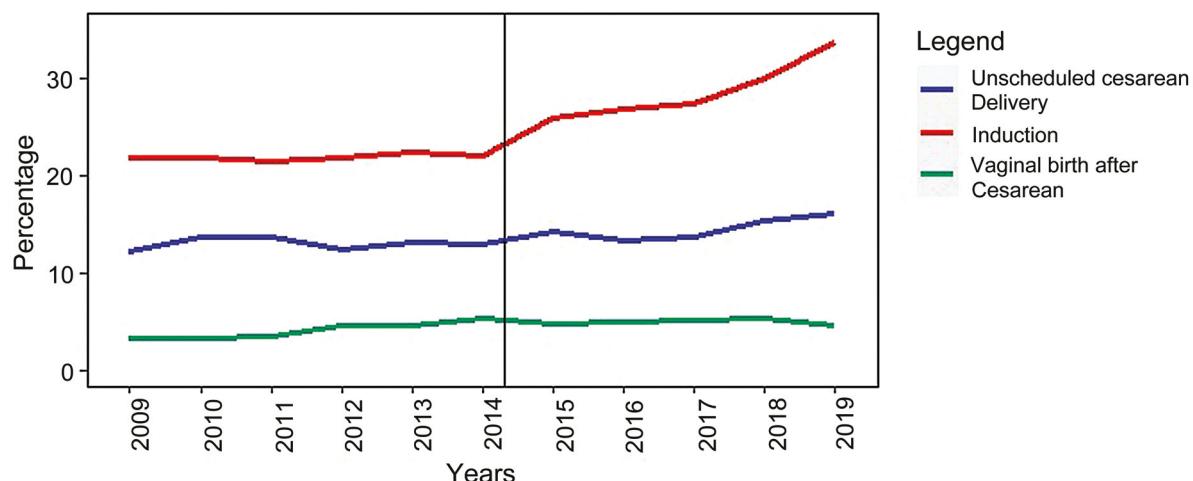
Abbreviation: SD, standard deviation.

increased which remained significant after adjustment (aOR, 1.09; 95% CI, 1.00–1.19; and aOR, 1.43; 95% CI, 1.17–1.74, respectively). Chorioamnionitis also increased after the consensus (11.3 vs. 14.0%, *p* < 0.001; aOR, 1.08; 95% CI, 1.01–1.15). Third-degree perineal laceration was decreased (4.6 vs. 3.6%, *p* < 0.001; aOR, 0.65; 95% CI, 0.59–0.73). Uterine rupture among multiparous women was increased (0.02 vs. 0.07%, *p* = 0.04), but no longer significant after adjustment (aOR, 2.66; 95% CI, 0.83–8.58). The uterine rupture to VBAC ratio was 0.005 before and 0.010 after the guidelines. Neonatal outcomes were

significant for increased NICU admission (OR, 1.17; 95% CI, 1.07–1.28) and 5-minute Apgar's score < 7 (OR, 1.31; 95% CI, 1.10–1.56; all *p* < 0.001), but there were no differences after adjustment. There was no difference in neonatal death prior to discharge after the consensus.

## Discussion

In this large single-institution cohort, women were 10% more likely to undergo an unscheduled cesarean delivery after the



**Fig. 1** Trends of unscheduled cesarean, vaginal birth after cesarean (multiparas only), and induction of labor rates across the study interval. Vertical line designates when the consensus was released.

**Table 2** Outcomes before and after the Safe Prevention of Primary Cesarean Delivery Consensus

Outcome N (%)	Before consensus N = 20,887	After consensus N = 23,114	P
Maternal			
Cesarean delivery	2,693 (12.9)	3,306 (14.3)	<0.001
Primiparous	796 (19.0)	1,430 (20.4)	0.07
Multiparous	1,897 (11.4)	1,876 (11.6)	0.45
Postpartum hemorrhage	1,163 (5.6)	1,428 (6.2)	0.007
Blood transfusion	176 (0.8)	288 (1.2)	<0.001
Chorioamnionitis	2,370 (11.3)	3,227 (14.0)	<0.001
Severe perineal laceration (vaginal delivery only)	N = 18,194	N = 19,808	
Third-degree laceration	831 (4.6)	714 (3.6)	<0.001
Fourth-degree laceration	102 (0.6)	95 (0.5)	0.30
Outcomes among multiparas only	N = 16,694	N = 16,119	
Vaginal birth after cesarean	800 (4.8)	1,157 (7.2)	<0.001
Uterine rupture	4 (0.02)	12 (0.05)	0.07
Neonatal			
Neonatal intensive care unit admission	877 (4.2)	1,126 (4.9)	0.001
Umbilical artery pH < 7.0	148 (1.1)	170 (1.1)	0.63
5-minute Apgar's score < 7	208 (1.0)	301 (1.3)	0.003
Death prior to discharge	15 (0.1)	12 (0.1)	0.52

2014 Safe Prevention of the Primary Cesarean Delivery Obstetric Care Consensus, though there was no change after adjusting for confounders. This finding contrasts with prior work,<sup>7,8,13</sup> though each study differed in the precise outcome and patient population studied. We cannot comment on the effect of the consensus specifically on cesarean for arrest and failed induction, which was the primary intent of that document. However, our findings, as well as overall stable national cesarean delivery rates,<sup>1</sup> do indicate that other patient and provider factors have had a stronger effect on the overall cesarean rate than the labor management recommendations.

Interestingly, we did find a 54% increase in VBAC deliveries among multiparous women after the consensus. This increase could be secondary to more women attempting a trial of labor, an increase in trials of labor being successful, and/or an underlying increase in prior primary cesarean deliveries. While we are not able to report VBAC rates specifically in those women undergoing TOLAC, it is plausible that providers are more inclined to prematurely diagnose arrest disorders in women with a history of cesarean delivery. In this way, the consensus may have contributed to the increase in VBAC in this cohort through the Hawthorn effect, though we cannot exclude the possibility of other contributing practice changes. Indeed, national VBAC rates continue to increase,<sup>1</sup> indicating likely other factors contributing to this trend. Uterine rupture, rare throughout the study interval, was statistically increased after the consensus though not after adjusting for induction rates and maternal/neonatal factors. Thus, maternal/neonatal factors likely contribute to these findings, but an impact of changing labor management

cannot be completely excluded. Unfortunately, we were unable to determine the uterine rupture rate only in women undergoing TOLAC, so trends in the number of TOLACs may also contribute. However, the ratio of uterine rupture to VBACs was higher after the consensus. Our findings therefore do not show that the consensus was associated with an increased rate of uterine ruptures, but warrants further study among women undergoing TOLAC.

We also noted modestly increased rates of chorioamnionitis, postpartum hemorrhage, and blood transfusion after the consensus, and these associations remained significant after controlling for possible confounders. Conversely, third-degree lacerations were decreased after the consensus and remained so after adjustment. The etiology underlying this association is unclear, but we also did not account for other risk factors such as operative vaginal delivery and episiotomy.

Although we noted increased NICU admission and low 5-minute Apgar's score after the consensus, they were no longer significant after adjustment. All of these outcomes may be affected by labor management, but even in the adjusted models, we could not account for all factors likely contributing to these findings. Previous studies have found conflicting associations between the consensus and maternal and neonatal complications,<sup>7,8</sup> though the larger cohort in this study may be better suited toward the examination of the uncommon adverse outcomes.

Strengths of this study include a large and diverse population that in many ways may be more representative of the general U.S. population and health care system than most other prior work. It also reflects the variation in practices as a

**Table 3** Odds and adjusted odds ratios after the Safe Prevention of Primary Cesarean Delivery

Outcome	After safe prevention of primary cesarean consensus <sup>a</sup>	
	OR [95% CI]	aOR [95% CI] Model fit <sup>b</sup>
<b>Maternal</b>		
Cesarean delivery	1.13 [1.07–1.19]	0.97 [0.91–1.03] 0.09
Primiparous only	1.08 [0.98–1.19]	0.94 [0.88–1.08] 0.17
Vaginal birth after cesarean (multiparas only)	1.54 [1.40–1.69]	1.51 [1.37–1.66] 0.02
Postpartum hemorrhage	1.12 [1.03–1.21]	1.09 [1.00–1.19] 0.03
Blood transfusion	1.49 [1.23–1.79]	1.43 [1.17–1.74] 0.02
Uterine rupture (multiparas only)	3.11 [1.00–9.64]	2.64 [0.83–8.58] 0.03
Chorioamnionitis	1.27 [1.20–1.34]	1.08 [1.01–1.15] 0.11
Third-degree laceration (vaginal delivery only)	0.78 [0.71–0.87]	0.65 [0.59–0.73] 0.07
Fourth-degree laceration (vaginal delivery only)	0.86 [0.65–1.13]	0.75 [0.56–1.02] 0.05
<b>Neonatal</b>		
Neonatal intensive care unit admission	1.17 [1.07–1.28]	1.05 [0.95–1.15] 0.03
Umbilical artery pH < 7.0	0.94 [0.75–1.17]	0.89 [0.71–1.13] 0.01
5-minute Apgar's score < 7	1.31 [1.10–1.56]	1.17 [0.97–1.42] 0.03
Death prior to discharge	0.72 [0.34–1.54]	0.80 [0.35–1.82] 0.13

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio.

<sup>a</sup>Using before consensus as reference.

<sup>b</sup>Adjusted for maternal age, maternal body mass index at delivery, birthweight, multiparity, maternal race, induction of labor, hypertension, and diabetes; except for vaginal birth after cesarean, in which multiparity was not included. Model fit expressed as Nagelkerke's R-Squared.

community-based teaching hospital, which is more generalizable as well. We also add to the limited data on VBAC trends. This study also included a large cohort to better describe trends over time and to more confidently comment on uncommon outcomes such as NICU admission.

Limitations include the retrospective cohort nature of this study, which is susceptible to selection, misclassification, and confounding biases. In addition, there is reliance on ICD-9 and ICD-10 codes for some of the clinical variables and outcomes. The transition from ICD-9 to ICD-10 during the study interval could conceivably affect these diagnoses. Changes in the electronic health records for data retrieval likewise have changed over this time through upgrades. However, our primary outcome of cesarean rates should not be affected by this change. Maternal BMI at delivery was used, as prepregnancy BMI was not reliably available for such a large cohort. While this skews the BMI distribution of this study, it also allows incorporation of clinical risks associated with gestational weight gain. Our institution also cares for a racially diverse unique population, many of whom belong to demographics with increased rates of obstetric complications.<sup>14–16</sup> Despite this, cesarean delivery rates in our institution and state are relatively low compared with national rates.<sup>5,17</sup> These institutional factors should be considered before extrapolating our findings to other institutions. For example, the portion of primiparous women (20–30%) is lower than that in most populations reported.<sup>7–9</sup> Also, as previously described, we were unable to stratify by indication for cesarean and unable to exclude all women who underwent cesarean without a trial of labor, though sched-

uled cesareans and fetal malpresentation were excluded. Adoption of the guidelines at our institution was primarily education targeting physicians (medical staff and trainees), an approach that may be similar to that of many other institutions. However, places choosing other approaches toward the guidelines, such as formal changes to policies or protocols, may have experienced different results. Finally, while the extended time interval included in this study allowed for better examination of trends and uncommon outcomes, clinical practice and patient demographics evolve over time, confounding our data in ways we may not have accounted for. For example, the ACOG definition of postpartum hemorrhage changed in 2017,<sup>18</sup> though we also found the more objective measure of blood transfusion to increase.

## Conclusion

This study contributes to our knowledge on trends on mode of delivery in the United States, more specifically, in relation to the 2014 Safe Prevention of the Primary Cesarean Delivery Obstetric Care Consensus. We did not find a decrease in cesarean delivery after the consensus yet an increase in some adverse outcomes was observed, highlighting the importance of examining institution-specific rates and practices to best implement changes that safely lower the cesarean delivery rate.

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#### Conflict of Interest

None declared.

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