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In which groups of pregnant women can the caesarean delivery rate likely be reduced safely in the USA? A multicentre cross-sectional study

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ABSTRACT

Objectives To identify obstetrical subgroups in which (1) the caesarean delivery (CD) rate may be reduced without compromising safety and (2) CD may be associated with better perinatal outcomes.

Design A multicentre cross-sectional study.

Setting 19 hospitals in the USA that participated in the Consortium on Safe Labor.

Participants 228 562 pregnant women in 2002–2008.

Main outcome measures Maternal and neonatal safety was measured using the individual Weighted Adverse Outcome Score.

Methods Women were divided into 10 subgroups according to a modified Robson classification system. Generalised estimated equation model was used to examine the relationships between mode of delivery and Weighted Adverse Outcome Score in each subgroup.

Results The overall caesarean rate was 31.2%. Repeat CD contributed 29.5% of all CD, followed by nulliparas with labour induction (15.3%) and non-cephalic presentation (14.3%). The caesarean rates in induced nulliparas with a term singleton cephalic pregnancy and women with previous CD were 31.6% and 82.0%, respectively. CD had no clinically meaningful association with perinatal outcomes in most subgroups. However, in singleton preterm breech presentation and preterm twin gestation with the first twin in non-cephalic presentation, CD was associated with substantially improved maternal and perinatal outcomes.

Conclusions Women with repeat CD, term non-cephalic presentation, term twins or other multiple gestation and preterm births may be the potential targets for safely reducing prelabour CD rate, while nulliparas or multiparas with spontaneous or induced labour, women with repeat CD, term non-cephalic presentation, term twins or other multiple gestation and preterm births are potential targets for reducing intrapartum CD rate without compromising maternal and neonatal safety in the USA. On the other hand, CD may still be associated with better perinatal outcomes in women with singleton preterm breech presentation or preterm twins with the first twin in non-cephalic presentation.

Strengths and limitations of this study

- The Consortium on Safe Labor is one of the largest and most comprehensive perinatal database so far with clinical data from a contemporary population, which enabled us to examine the relationships between mode of delivery and Weighted Adverse Outcome Score in 10 mutually exclusive subgroups and adjust for a number of confounding factors.
- Since this is an observational study, associations reported in our analysis may not necessarily be causal.
- Although confounding by other variables was carefully considered, residual confounding cannot be excluded.

INTRODUCTION

In the past decade, the rate of caesarean delivery (CD) in the USA has remained above 30%,[1] and this trajectory appears likely to continue in the near future. High CD rates may be associated with unnecessary utilisation of health resources[2] and result in potential maternal and neonatal harm.[3 4]

Recent data suggested that CD rates below 20% at the population level are possible, safe and compatible with optimal health outcomes for mothers and their newborns.[5 6] For instance, the Netherlands has had a stable, relatively low CD rate (14.0% in 2000–2001 and 16.7% in 2010[7]) while maintaining good maternal and perinatal outcomes.[8 9] However, at the level of an individual health facility, it is often difficult to determine an appropriate CD rate. Differences in casemix and obstetric profile prevent direct comparisons with a universal reference rate for CD. Based on data disaggregation in 10 obstetric groups, Robson proposed a classification system that facilitates the understanding of the internal structure of the CD rate at individual health facilities and identification of strategic population groups to prevent unnecessary CD.[10]

This study examined the associations of mode of delivery with adverse maternal and neonatal outcomes in the 10 subgroups of

women in a large multicentre study. We aimed to identify (1) which groups contributed to the high overall CD rate, (2) in which groups the CD rate may be reduced safely and (3) in which groups CD may be associated with better perinatal outcomes.

METHODS

Study population

We used data from the Consortium on Safe Labor, a multicentre cross-sectional study that abstracted detailed labour and delivery information from electronic medical records in 19 hospitals across 9 American Congress of Obstetricians and Gynecologists (ACOG) US districts from 2002 to 2008. Eighty-seven per cent of births occurred in 2005–2007. Detailed description of the study is available elsewhere.[11] There were a total of 228 562 deliveries in the database. To avoid intraperson correlation, we selected the first delivery from each mother in the study (90.5%). To make our study population reflect the overall US obstetric population and to minimise the impact of the various number of births from different hospitals, we first standardised the population using ACOG district, maternal race/ethnicity, parity and fetal plurality based on 2004 National Natality data.[12] Then, based on the number of subjects each hospital contributed to the database, we assigned a weight to each subject.[11] We applied the weight to the current descriptive analysis.

Outcomes measures

Perinatal outcomes were measured using the individual Weighted Adverse Outcome Score (WAOS), calculated as the sum of WAOSs of all events.[13] The WAOS assigns a score of 750 for maternal death, 400 for intrapartum or in-hospital newborn death, 100 for uterine rupture, 65 for maternal intensive care unit admission, 60 for birth injury, 40 for unanticipated operative procedure, 35 for admission to neonatal intensive care unit for >24 hours, 25 for a 5 min Apgar score <7, 20 for blood transfusion and 5 for 3rd or 4th degree perineal tear. The minimal score for any individual delivery is 0 while the maximum is 750.

Classification of labour management subgroups

To identify sources of high CD rates and make appropriate comparisons in CD rates among hospitals or areas, we classified pregnant women into 10 mutually exclusive categories as described by Robson based on parity, gestational age, fetal presentation, number of fetuses, onset of labour and previous CD.[10] Such a classification scheme has gained wide acceptance by the international obstetric and midwifery communities.[14] In order to account for contemporary obstetric practices, we slightly modified the classification scheme,[15] For instance, in groups 2 and 4,[10] induction of labour and prelabour CD was combined for nulliparous and parous women, respectively. This classification cannot differentiate between intrapartum CD after induction of labour and prelabour CD. As induction of labour and repeat CS before labour is now common, combining these two groups of women may miss important information regarding the success of induction and its contribution to a high CD rate. In addition, the Robson classification separated breech (by parity) and transverse or oblique lies into three groups (6, 7, 9). Given that the total number of non-cephalic presentation births is small (around 4%–5%) and vaginal delivery is no longer promoted in many countries nowadays, these three groups may be combined into 1, so that the total number of subgroups remains 10. The Robson classification labels subgroups by numbers (1–10). To make the group label more intuitive, we also proposed a new labelling scheme using only two letters (table 1).

Statistical analysis

In our study, 7.3% of pregnant women had missing information on fetal presentation. Given the importance of fetal presentation in the classification scheme, multiple imputation was performed where a logistic regression model imputed the likelihood of cephalic/non-cephalic presentation in a particular subject five times based on maternal race, parity, previous uterine scar, number of fetuses, external cephalic version, smoking, placenta previa, cephalopelvic disproportion, gestational age, reason for admission to labour/delivery, trial of labour, induction, fetal scalp electrode, operative vaginal delivery and mode of delivery.[16] For the descriptive analysis, to reach one single number after multiple imputations, the mean of the five imputed values was used.[16]

For descriptive analyses that used a total population, no statistical testing was performed; nor were CIs calculated. To examine the linear associations of mode of delivery with adverse maternal and neonatal outcomes, we applied a generalised estimating equation model to account for correlations within each hospital. All models adjusted for a number of potential confounders wherever appropriate (see online supplementary file table S1). All analyses were performed using the SAS for Windows, V.9.4 (SAS Institute), with two-tailed tests and a significance level of $p<0.05$.

Patient and public involvement

Patients or public were not involved in the development of the research questions, design, recruitment and conduct of the study. There are no plans to disseminate the results of the research to study participants.

RESULTS

CD pattern in the USA

Table 1 and online supplementary figure S1 illustrate that the total CD rate in the USA was 31.2%, and prelabour and intrapartum CD rates were 18.1% and 13.1%, respectively. The repeat CD due to a previous CD (group PC) accounted for 11.2% of all deliveries and 29.5% of all CD. The CD rate in this group was 82.0%, and the majority were prelabour CD. Nulliparas with labour induction (group NI) was the second

Table 1 Modified classification and composition of caesarean delivery in the Consortium on Safe Labor of the USA, 2002–2008*

Modified classification group labels (original group labels)†	Characteristics of the group	Proportion of all deliveries (%)	Caesarean rate (%)	Rate of intrapartum caesarean delivery (%)	Proportion of total caesarean (%)
NS (1)	Nulliparous women with a single cephalic pregnancy, at ≥37 weeks gestation in spontaneous labour	16.3	14.8	14.8	7.7
NI (2a)	Nulliparous women with a single cephalic pregnancy, at ≥37 weeks gestation who had labour induced	15.0	31.6	31.6	15.3
NC (2b)	Nulliparous women with a single cephalic pregnancy, at ≥37 weeks gestation, who had caesarean delivery before labour	1.6	100.0	0.0	5.0
MS (3)	Multiparous women, without previous caesarean delivery, with a single cephalic pregnancy at ≥37 weeks gestation in spontaneous labour	20.5	3.1	3.1	2.1
MI (4a)	Multiparous women, without previous caesarean delivery, with a single cephalic pregnancy at ≥37 weeks gestation, who had labour induced	15.3	6.7	6.7	3.3
MC (4b)	Multiparous women, without previous caesarean delivery, with a single cephalic pregnancy at ≥37 weeks gestation, who had caesarean delivery before labour	1.0	100.0	0.0	3.1
PC (5)	Multiparous women, with at least one previous caesarean delivery with a single cephalic pregnancy at ≥37 weeks gestation	11.2	82.0	11.8	29.5
BR (6+7+9)	All women with a single breech, transverse or other abnormal fetal presentation, including women with previous caesarean delivery	4.8	92.6	19.0	14.3
TW (8)	All women with multiple pregnancies (eg, twins), including women with previous caesarean delivery	3.4	66.6	15.2	7.3
PT (10)	All women with a single cephalic pregnancy at ≤36 weeks gestation (ie, preterm), including women with previous caesarean delivery	10.9	35.6	14.3	12.4
	Total	100.0	31.2	13.1	100.0

*See text for details on multiple imputation performed.
†The new labelling system corresponds well with the previous numbering system as follows: 1=NS (nulliparous, spontaneous); 2a=NI (nulliparous, induced); 2b=NC (nulliparous, caesarean); 3=MS (multiparous, spontaneous); 4a=MI (multiparous, induced); 4b=MC (multiparous, caesarean); 5=PC (previous caesarean); 6, 7, 9 combined=BR (breech and other non-cephalic presentation); 8=TW (twin and other multiple pregnancies); 10=PT (preterm).

largest contributor to all CD (15.3%), not only because this group had a high intrapartum CD rate (31.6%) but also because this group accounted for 15.0% of all deliveries. Women with non-cephalic presentation (group BR) only accounted for 4.8% of all deliveries, but took up 14.3% of all CD. Among singleton preterm

births (group PT), the CD rate was 35.6%, which accounted for 12.4% of all CD.

The association between mode of delivery and maternal and neonatal outcomes

Table 2 shows that mode of delivery was not associated with the outcome in nulliparas with spontaneous onset of labour or induction (groups NS and NI) or preterm singleton births (group PT). In multiparas with spontaneous onset of labour or induction (groups MS and MI) or previous CD (group PC), CD had a slight but statistically significant association with the composite adverse outcome. However, the magnitude of the point estimates was quite small even though they reached statistical significance, thus, the clinical significance is questionable.

When we looked at women with breech presentation (group BR) as a whole, prelabour CD and intrapartum CD were both negatively associated with the adverse outcomes (prelabour CD (β=−28.31, 95% CI −48.76 to −7.86), intrapartum CD (β=−24.71, 95% CI −43.56 to −4.87)). However, when we separated this group into preterm BR and term BR, strong negative associations were found only in preterm BR (prelabour CD (β=−90.49, 95% CI −133.58 to −47.40), intrapartum CD (β=−80.36, 95% CI −121.33 to −39.39)) but not in term BR. For women with multiple gestation (group TW) as a whole, prelabour and intrapartum CD were both negatively associated with the adverse outcomes. Again, when we separated this group into preterm TW and term TW, no association was found in term TW. CD was modestly associated with a better outcome in preterm TW (prelabour CD (β=−7.53, 95% CI −14.62 to −0.45), intrapartum CD (β=−6.23, 95% CI −11.51 to −0.94)). However, when we further stratified these twin gestations, we found that the protective effort was mainly due to the benefits of CD in preterm twins with the first twin in non-cephalic presentation (prelabour CD (β=−20.77, 95% CI −48.26 to 6.71), intrapartum CD (β=−20.00, 95% CI −43.06 to −0.95)).

DISCUSSION

Main findings

Our study found that the top four contributors to the CD rate in the USA were repeat CD (group PC), nulliparas with labour induction (group NI), non-cephalic presentation (group BR) and preterm births (group PT). Based on the association between the mode of delivery and perinatal outcomes, groups PC, term BR, term TW (twins or other multiple gestation) and PT may be the potential targets for safely reducing prelabour CD rate, while groups NS (nulliparas with spontaneous labour), NI, MS (multiparas with spontaneous labour), MI (multiparas with labour induction), PC, term BR, term TW and PT are potential targets for reducing intrapartum CD rate. Groups PC and NI offer the greatest opportunity given their large contribution to the caesarean rate. On the other hand, CD may still improve perinatal outcomes in women with singleton preterm breech presentation or preterm twins with the first twin in non-cephalic presentation.

Interpretation

Repeat CD accounted for 29.5% of all CD. Among them, prelabour CD rate was 70.2%. A recent review found that trial of labour after caesarean (TOLAC) in comparison to elective repeat CD, has significantly lower risk of maternal death, but the risk of transfusion, uterine rupture, and perinatal and neonatal mortality may be increased, and no difference was found in newborn respiratory conditions, hypoxic–ischaemic encephalopathy or asphyxia.[17] Our study, which combined and weighted the adverse maternal and neonatal outcomes, did not find any benefits of prelabour CD in women with 1 or ≥2 prior CD. Thus, group PC may be an appropriate candidate for reducing the prelabour CD rate.

Two-thirds of women with previous CD are eligible for TOLAC,[18] which is a safe choice in carefully selected patients.[19] However, only 29% of US women attempt TOLAC versus 71% in the Netherlands,[15] and the associated success rate for vaginal birth has declined.[17] The Dutch experience showed that the rate of TOLAC over 70% and a successful VBAC rate of 75% appear to be achievable without compromising safety.[15] Although the Dutch experience may not be totally reproducible in the USA, the large differences suggest that there is room for improvement.

A more fundamental approach is to safely prevent primary CD. Contemporary US data showed that a high percentage of intrapartum CD were performed before 6 cm of cervical dilation, particularly in nulliparas and induced labour.[20] Allowing sufficient time for cervical change in early labour (<6 cm) may well serve to reduce the CD rate, particularly in labouring nulliparas and multiparas (groups NS, NI, MS and MI). The high CD rate in induced nullipara (group NI), which is the second largest contributor to the overall CD rate, might be because the patients were not given a sufficient trial of labour. Variations in the management of labour induction may also affect CD rates.[21] Careful selection of patients and the method of induction may help to improve the success rate of induction.

Dynamic contrasts in the association between mode of delivery and perinatal outcomes were observed in term and preterm pregnancy in both singleton breech (group BR) and non-cephalic multiple gestation (group TW).

Our study found that in term BR both prelabour and intrapartum CD had no association with the outcome. A recent review including randomised and observational studies showed that perinatal mortality and morbidity in the planned vaginal term breech delivery were significantly higher than with planned CD, but the absolute risks were relatively low.[22] A recent review showed that planned CD reduced perinatal or neonatal death as well as the composite outcome death or serious neonatal morbidity, at the expense of somewhat increased maternal morbidity.[23] However, in a subset with 2-year follow-up,

Table 2 The association between mode of delivery in subgroups and combined adverse maternal and neonatal outcomes by generalised estimated equation model

Modified classification of caesarean groups* (N, %)	WAOS	Unadjusted model	Adjusted model†
	Mean	β (95% CI)	β (95% CI)
Group NS (37 841, 20%)			
Intrapartum CD (5582, 15%)	7.16	2.72 (1.81 to 3.64)	0.14 (–0.71 to 1.00)
Vaginal delivery (32 259, 85%)	4.44	Ref.	Ref.
Group NI (30 892, 16%)			
Intrapartum CD (9686, 31%)	5.04	0.18 (–1.04 to 1.39)	–0.55 (–1.16 to 0.06)
Vaginal delivery (21 206, 69%)	4.86	Ref.	Ref.
Group NC (2851, 1.5%)			
Pre-labour CD (2851, 100%)	7.10	–	–
Vaginal delivery (0, 0%)	–	–	–
Group MS (42 272, 22%)			
Intrapartum CD (1365, 3%)	7.83	4.81 (3.39 to 6.23)	1.73 (0.23 to 3.23)
Vaginal delivery (40907, 97%)	3.02	Ref.	Ref.
Group MI (28 973, 15%)			
Intrapartum CD (2019, 7%)	7.02	3.57 (2.14 to 4.99)	1.95 (0.50 to 3.40)
Vaginal delivery (26 954, 93%)	3.45	Ref.	Ref.
Group MC (1403, 0.7%)			
Pre-labour CD (1403, 100%)	9.34	–	–
Vaginal delivery (0, 0%)	–	–	–
Group PC (overall) (17 289, 8.9%)			
Pre-labour CD (10 958, 63%)	4.83	0.96 (-0.03 to 1.94)	1.03 (0.03 to 2.03)
Intrapartum CD (2353, 14%)	5.58	1.70 (0.37 to 3.03)	1.30 (0.28 to 2.32)
Vaginal delivery (3978, 23%)	3.88	Ref.	Ref.
Group PC (prior number of CS=1) (12 292, 6.3%)			
Pre-labour CD (6738, 55%)	4.67	0.84 (–0.20 to 1.88)	1.06 (–0.04 to 2.17)
Intrapartum CD (1732, 14%)	5.79	0.76 (0.47 to 3.43)	1.38 (0.30 to 2.46)
Vaginal delivery (3822, 31%)	3.84	Ref.	Ref.
Group PC (prior number of CS≥2) (4997, 2.6%)			
Pre-labour CD (4220, 85%)	4.90	0.19 (–1.86 to 2.24)	0.01 (–1.67 to 1.70)
Intrapartum CD (621, 12%)	5.09	0.10 (–1.94 to 2.15)	0.50 (–0.90 to 1.90)
Vaginal delivery (156, 3%)	5.01	Ref.	Ref.
Group BR (overall) (7879, 4.1%)			
Pre-labour CD (5665, 72%)	21.08	–38.07 (–79.31 to 3.18)	–27.90 (–49.41 to –6.40)
Intrapartum CD (1582, 20%)	25.83	–33.31 (–73.91 to 7.30)	–23.85 (–44.02 to –3.67)
Vaginal delivery (632, 8%)	59.14	Ref.	Ref.
Group BR (breech) (7628, 4.0%)‡			
Pre-labour CD (5467, 72%)	20.99	–36.75 (–77.17 to 3.67)	–28.31 (–48.76 to –7.86)
Intrapartum CD (1529, 20%)	25.64	–32.10 (–70.86 to 6.66)	–24.71 (–43.56 to –4.87)
Vaginal delivery (632, 8%)	57.74	Ref.	Ref.
Group preterm BR (breech) (2512, 1.3%)‡			
Pre-labor CD (1714, 68%)	55.04	–93.92 (–133.79 to 54.06)	–90.49 (–133.58 to –47.40)
Intrapartum CD (566, 23%)	59.30	–89.66 (–125.67 to 53.66)	–80.36 (–121.33 to –39.39)
Vaginal delivery (232, 9%)	148.97	Ref.	Ref.
Group term BR (breech) (5116, 2.7%)‡			
Pre-labour CD (3753, 73%)	5.43	0.61 (–2.80 to 4.02)	0.88 (–2.62 to 4.37)
Intrapartum CD (963, 19%)	5.85	1.03 (–1.98 to 4.03)	0.41 (–2.69 to 3.50)
Vaginal delivery (400, 8%)	4.83	Ref.	Ref.

Continued

Table 2 Continued

Modified classification of caesarean groups* (N, %)	WAOS Mean	Unadjusted model β (95% CI)	Adjusted model† β (95% CI)
Group BR (transverse or oblique) (251, 0.1%)			
Pre-labour CD (198, 79%)	23.54	–	–
Intrapartum CD (53, 21%)	31.51	–	–
Vaginal delivery (0, 0%)	–	–	–
Group TW (overall) (4723, 2.4%)			
Pre-labour CD (2391, 51%)	27.88	−2.05 (−6.58 to 2.48)	−4.89 (−9.55 to −0.23)
Intrapartum CD (835, 18%)	32.17	2.25 (−3.24 to 7.74)	−4.89 (−8.58 to −1.19)
Vaginal delivery (1497, 31%)	29.93	Ref.	Ref.
Group preterm TW (3256, 1.7%)			
Pre-labor CD (1625, 50%)	38.10	−2.82 (10.22 to 4.58)	−7.53 (−14.62 to −0.45)
Intrapartum CD (646, 20%)	39.23	−1.68 (−8.68 to 5.31)	−6.23 (−11.51 to −0.94)
Vaginal delivery (985, 30%)	40.92	Ref.	Ref.
Preterm with first twin in cephalic presentation (1821, 0.9%)			
Pre-labour CD (682, 37%)	40.56	5.91 (−0.64 to 12.46)	−2.55 (−8.03 to 2.93)
Intrapartum CD (346, 19%)	36.60	1.94 (−5.00 to 8.89)	−0.33 (−5.63 to 4.97)
Vaginal delivery (793, 44%)	34.66	Ref.	Ref.
Preterm with first twin in non-cephalic presentation (1435, 0.7%)			
Pre-labour CD (943, 66%)	36.30	−28.78 (−65.00 to 7.43)	−20.77 (−48.26 to 6.71)
Intrapartum CD (300, 21%)	42.42	−22.67 (−55.10 to 9.77)	−20.00 (−43.06 to −0.95)
Vaginal delivery (192, 13%)	65.09	Ref.	Ref.
Group term TW (1467, 0.8%)			
Pre-labour CD (766, 52%)	5.15	−3.15 (−6.44 to 0.13)	−1.55 (−4.94 to 1.84)
Intrapartum CD (189, 13%)	7.12	−1.18 (−5.88 to 3.52)	−1.68 (−5.10 to 1.74)
Vaginal delivery (512, 35%)	8.30	Ref.	Ref.
Group PT (19444, 10%)			
Pre-labour CD (3282, 17%)	42.61	15.67 (10.08 to 21.27)	2.98 (−1.04 to 7.00)
Intrapartum CD (2706, 14%)	31.33	4.40 (−2.53 to 11.33)	−0.85 (−5.90 to 4.19)
Vaginal delivery (13 456, 69%)	26.93	Ref.	Ref.

*The new labelling system corresponds well with the previous numbering system as follows: 1=NS (Nulliparous, Spontaneous); 2a=NI (Nulliparous, Induced); 2b=NC (Nulliparous, Caesarean); 3=MS (Multiparous, Spontaneous); 4a=MI (Multiparous, Induced); 4b=MC (Multiparous, Caesarean); 5=PC (Previous Caesarean); 6,7,9 combined=BR (BReech and other non-cephalic presentation); 8=TW (Twin and other multiple pregnancies); 10=PT (PreTerm).
†Adjusted model: adjusted for a number of potential confounders (online supplementary table S1) wherever appropriate.
‡Transverse and oblique lies were deleted in the regression analysis because these are the hard indication for CD. It should be 100% CD.
CD, caesarean delivery.

the authors found no difference in long-term neurodevelopmental delay or death.[23]

There is insufficient evidence to evaluate the effects of the planned CD versus planned vaginal birth on preterm breech presentation, and the optimal mode of delivery of these babies remains controversial.[24] We found that the adverse perinatal outcome score decreased substantially with prelabour and intrapartum CD, which mainly due to the reduction of neonatal death. Consistent with these findings, a systematic review of seven observational studies concluded that planned CD for preterm breech presentation reduced the risks of neonatal mortality.[25] In addition, a recent cohort study also found that intended CD and emergency CD were associated with reduced perinatal mortality and morbidity in these women.[26] The risk of head entrapment may be increased in vaginal delivery, especially before 30 weeks of gestation because the circumference of the head is larger than that of the body. The fetal body can be delivered without full dilation of the cervix, but the aftercoming head may be retained by the cervix. Asphyxia related to difficult delivery has been described after preterm vaginal breech deliveries, and its incidence appears highest before 28 weeks.[27]

Our study also indicates that prelabour CD does not improve maternal and perinatal outcomes in term multiple gestations (95% were twins), which is consistent with a recent system review.[28] In contrast, there is increasing evidence for perinatal benefits related to vaginal birth. In a cross-sectional study of 6929 new born infants, non-urgent CD increased the risk of bag

and mask ventilation[29] compared with vaginal birth. In a retrospective study of twin births at 37 or more weeks gestation, elective CD was associated with an increased risk of neonatal transfusion.[30] Future research should aim to provide evidence on long-term outcomes.[28 31]

Our study further suggests that CD may be a better mode of delivery only for preterm multiple gestations with the first twin in non-cephalic presentation. Literature on this issue is still inconsistent, although most studies failed to show any significant benefit of any particular mode of delivery.[32] For example, our previous study in 4428 twins found that CD resulted in a lower infant and neonatal mortality when birth weight was between 500 and 749 g. But the beneficial effect of CD disappeared in infants weighing more than 1000 g.[33] A Swedish study found no relationship between mode of delivery and perinatal mortality or long-term adverse outcome for twins weighing less than 1500 g.[34] A recent study also showed that a policy of planned vaginal delivery of very preterm twins with the first twin in cephalic presentation did not increase either severe neonatal morbidity or mortality.[35] However, none of these studies was prospective; nor did they exclude emergency CD for various indications. As pointed by Biswas *et al*,[32] the inclusion of these unplanned CD in data analysis potentially skewed the results towards poorer neonatal outcomes in the CD groups (ie, confounding by indication).[32] Any benefit conferred by planned CD, therefore, may be nullified.[32]

Strengths and limitation

The major strength of this study is the large cross-sectional study with clinical data from a contemporary population, which enabled us to examine the relationships between mode of delivery and WAOS in 10 mutually exclusive subgroups and adjust for a number of confounding factors.

It should be noted that even though we selected 19 hospitals across 9 ACOG districts, our study subjects were not a random sample of all births in the USA. Academic institutions were over-represented. Though our weighted preterm birth rate and induction rate were higher than the national average, our overall CD rate was similar to the corresponding national average (31.2% vs 31.1% in 2006).[36] Since higher risk women were more likely to undergo a CD, many factors that might affect the association between mode of delivery and WAOS were controlled, but residual confounding is still possible. Second, the data used in this study may be considered a bit outdated, representing deliveries done nearly 10 years ago. However, the Consortium on Safe Labor is still one of the largest and most comprehensive perinatal database so far. The overall CD rate in the USA has not changed substantially over the past decade.[37] Thus, findings of this study may still be relevant. In addition, Robson classification is a very useful tool with the primary purpose to identify differences in caesarean rates across patient subgroups. However, it does not provide an explanation for these differences or distinguish the specific reason or indication for performing CD. The WAOS has been used to assess the effectiveness of interventions at the hospital level, but we found that it was also a useful indicator when it is used at the individual level. For example, in high-risk women such as preterm birth, the WAOS was much higher than low-risk women (eg, women with spontaneous labour). Finally, this is an observational study. Associations reported in our analysis may not necessarily be causal.

CONCLUSIONS

In summary, our study suggests that women with repeat CD, term non-cephalic presentation, term twins or other multiple gestation and preterm births may be the potential targets for safely reducing prelabour CD rate, while nulliparas or multiparas with spontaneous or induced labour, women with repeat CD, term non-cephalic presentation, term twins or other multiple gestation and preterm births are potential targets for reducing intrapartum CD rate without compromising maternal and neonatal safety in the USA. On the other hand, CD may still be associated with better perinatal outcomes in women with singleton preterm breech presentation or preterm twins with the first twin in non-cephalic presentation. Allowing labour to continue for a longer period before 6 cm of cervical dilation and increasing TOLAC rate are suggested approaches. Further clinical trials are needed to make a definitive conclusion on our findings.

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