Attributable factors for the rising caesarean delivery rate over three decades: an observational cohort study

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January 7, 2021

Abstract

Objective: Caesarean delivery rates continue to rise globally the reasons for which are poorly understood. We aimed to characterize attributable factors for increasing caesarean delivery rates over a 30-year period within our health network. Design: Observational cohort study. Setting: Two hospitals (large tertiary referral hospital and metropolitan hospital) in Sydney, Australia, across two time periods: 1989-1999 and 2009-2016, between which the caesarean delivery rate increased from 19% to 30%. Participants: All women who had a caesarean delivery after 24 weeks gestation Methods: Data were analysed using multiple imputation and robust Poisson regression to estimate the changes in the caesarean delivery rate attributable to maternal and clinical factors. Main outcome measures: Caesarean delivery. Results: Fifty-six percent of the increase in the rate of caesarean delivery was attributed to changes in the distribution of maternal factors including maternal age, body mass index, parity and history of previous caesarean delivery. When changes in the obstetric management of multiple gestation, malpresentation and preterm singleton birth were considered, 66% of the increase in caesarean rate was explained. When pre-labour caesarean deliveries for maternal choice, suspected fetal compromise, previous pregnancy issues and suspected large fetus were excluded, 78% of the increase was explained. Conclusions: Most of the steep rise in the caesarean delivery rate from 19% to 30% is attributable to changes in maternal demographic and clinical factors.

Title:

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Running head / Short title:

The rising caesarean delivery rate

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Word Count

Abstract: 223 Main text: 2,757

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Main outcome measures: Caesarean delivery.

Results: Fifty-six percent of the increase in the rate of caesarean delivery was attributed to changes in the distribution of maternal factors including maternal age, body mass index, parity and history of previous caesarean delivery. When changes in the obstetric management of multiple gestation, malpresentation and preterm singleton birth were considered, 66% of the increase in caesarean rate was explained. When pre-labour caesarean deliveries for maternal choice, suspected fetal compromise, previous pregnancy issues and suspected large fetus were excluded, 78% of the increase was explained.

Conclusions: Most of the steep rise in the caesarean delivery rate from 19% to 30% is attributable to changes in maternal demographic and clinical factors.

Keywords: caesarean delivery, planned caesarean, emergency caesarean, indications, attributable risk, Robson groups

Tweetable Abstract: More than half of the increase in the rate of caesarean delivery is attributable to changes in maternal age, BMI, parity and history of caesarean delivery.

Introduction

Globally, the proportion of births which occur by caesarean delivery is increasing[1] but the underlying drivers are poorly understood. Several attempts have been made to assess how temporal changes in individual maternal characteristics, obstetric practice, and maternal request for caesarean delivery have influenced this trend.[2–5] Large observational studies in the United States have found that changes in maternal risk profile over time do not explain all the observed increases in caesarean rates, but these studies did not account for some factors such as age or body mass index (BMI).[5,6] Others have reported that maternal BMI alone explains 9% to 14% of caesarean deliveries.[2,7,8]

In an Australian setting, the most common indications associated with recent increases in caesarean deliveries were previous caesarean delivery, slow progress in labour, and breech presentation.[9] Additionally, the importance of primary caesarean delivery has been emphasized because it leads to planned repeat caesarean deliveries.[10] However, we do not know how much of the overall rising caesarean delivery rate is being driven by overall temporal changes in maternal characteristics.

By understanding the underlying drivers of increases in rates of caesarean section, clinicians and health systems can better explore safe preventative measures. This is important because primary caesarean deliveries can increase morbidity and mortality, increase risks in future pregnancies, and many women would choose to avoid caesarean delivery if safe to do so.[11,12]

The aims of this study were to assess the contribution of demographic and clinical factors to changes in the caesarean delivery rate during the time when it increased from less than 20% to more than 30% of all births.

Methods

Design:

This was a retrospective observational cohort study that compared changes in demographic, clinical and obstetric factors between two time periods: First, when the caesarean delivery rate was [?] 20% (Group A); second, when the caesarean delivery rate was [?] 30% (Group B).

Population:

The study population was all births occurring at or beyond 24 weeks' gestational age in a major inner-city hospital network in Sydney, Australia, and has been described in a previous publication.[9] Group A consisted of births from August 1989 to December 1999, when the annual caesarean delivery rate ranged from 18% to 20%. Group B consisted of births from January 2009 to December 2016, when the annual caesarean delivery rate ranged from 30% to 32%.

Study factors:

Changes in caesarean delivery rates were compared with respect to the following study factors: parity, previous caesarean delivery, maternal age, maternal BMI, plurality, fetal malpresentation, and preterm birth < 37 completed weeks' gestational age. We also accounted for changes in planned (elective/pre-labour) caesarean delivery for maternal choice alone, suspected fetal compromise, previous pregnancy issues (such as anal sphincter injury, pelvic floor trauma, or difficult birth) and suspected large fetus, because we previously found these indications for caesarean delivery increased over time.[9] Finally, changes in caesarean delivery rates were described by Robson group.[13]

Outcomes:

The primary outcome was caesarean delivery.

Data:

Clinical and demographic data were collected from the maternity database within our hospital network in Sydney, Australia. The data were identical to that described previously.[9] Data fields used were: maternal age, maternal BMI, parity, history of previous caesarean delivery, year of delivery, gestational age at delivery, plurality, fetal presentation, and indication for caesarean delivery.

Statistical analyses

Data were analysed using SAS version 9.4. Proportions were expressed as percentages. Non-normally distributed continuous data were expressed as medians and interquartile ranges. We described differences in raw caesarean delivery rates between Group A and Group B by Robson group. Robust Poisson regression was used to generate relative risks for the outcome of caesarean delivery, using the following explanatory variables: time-period (Group A or Group B), maternal age, maternal body mass index, parity group (nulliparous, parous, or parous with [?] 1 previous caesarean deliveries). Due to interactions between plurality, malpresentation, and preterm birth with time-period, the data were divided into four strata: (1) term cephalic singleton births; (2) preterm singleton births; (3) multiple gestations; (4) term non-cephalic singleton births. Robust Poisson regression was performed only in the first stratum (term, cephalic, singleton births) because maternal characteristics were not associated with the increase in caesarean deliveries within the other three strata.

Linearity of maternal age and BMI was assessed by categorizing these variables in to four groups and plotting the β-coefficients in the regression equation against the midpoints of these groups. If there was a non-linear relationship, the categorized variables were used. Missing data were handled using multiple imputation with 20 iterations.

To estimate the contribution of maternal factors to changes in the caesarean delivery rate within the first stratum ([1] term cephalic singleton births), we calculated the increase in number of caesarean deliveries attributable to maternal factors using the following formula:

Increase in number of caesarean deliveries attributable to maternal factors = \n*Increase in number of caesarean del*

Where,

$$Increase\ in\ number\ of\ caesarean\ deliveries\ among\ women = \ (P_B - P_A) \times N_B$$

where P_i *= proportion of all women with a term cephalic singleton birth in Group i who had a caesarean delivery, and*

N_B *= number of women with a term cephalic singleton birth in Group B*

and

Proportion of the increase in the caesarean delivery rate attributed to maternal factors\n= $\dfrac{RR_{\text{unadj}} - RR_{\text{adj}}}{RR_{\text{unadj}} - 1}$

RR_{unadj} = *unadjusted relative risk for group B compared to Group A*; \n$RR_{\text{adj}}$ = *relative risk for group B compared*

We additionally assessed the impact of changes in each of the other three strata ([2] preterm singleton births; [3] multiple gestations; [4] term non-cephalic singleton births) using the following formula:

Increase in number of caesarean deliveries attributable to changes in management = \nIncrease in number of caesarean

where P_i *= proportion of all women within the stratum in Group i who had a caesarean delivery, and*

N_B *= number of women within the stratum in Group B*

To estimate the effect of changes in clinical practice for maternal choice alone, suspected fetal compromise, previous pregnancy issues, and suspected large fetus, the entire analysis was repeated after excluding women who had planned (elective/pre-labour) caesarean deliveries for these indications.

Ethical approval

We obtained ethical approval for this study from the Sydney Local Health District (RPAH Zone).

Results

Demographics and caesarean delivery rates

Overall, there were 103,165 births in the cohort. After exclusions, 102,589 births with complete data remained for analysis: 48,215 in Group A, and 54,374 in Group B (Figure S1). On average, women in Group B were older and were more likely to be overweight or obese (Table 1). Group B also had a greater proportion of nulliparous women (50% vs 46%), and more women with a previous caesarean delivery (24% vs 14% of births to parous women, 12% vs 7.5% of all births).

The overall caesarean delivery rates were 19% in Group A and 30% in Group B (Table 2). Over the two time-periods, planned caesarean delivery increased from 9.7% to 19% and emergency caesarean delivery increased from 9.4% to 11.6% of all births (Table 2). The rate of caesarean delivery in women with no previous caesarean delivery increased from 15% to 23% and the rate in nulliparous women increased from 20% to 30%.

Comparison by Robson group

When compared by Robson group, there was a combined reduction in the size of groups 3 and 4 (term, singleton, cephalic, parous women) from 40% to 33% of all births and an increase in the size of groups 1 and 2 (term, singleton, cephalic, nulliparous women) from 39% to 44% of all births (Table 3). There was an increase in the size of group 5 (term, cephalic, previous caesarean delivery) from 5.6% to 11% of all births.

Increases were also found in the caesarean delivery rate within groups 1 and 2A (term, singleton, cephalic, nulliparous women who laboured) with a combined rise from 12% to 21%. Further, there were substantial increases in caesarean delivery rates for groups 1, 2A, 5, 6, 7, 8, and 10 as shown in Table 3.

Estimations of attributable risk

Fifty-six percent of the increase in caesarean deliveries (from 19% to 30%) could be attributed to changes in the distribution of maternal factors including maternal age, BMI, parity and history of previous caesarean delivery (Table 4). Over the time-period, the caesarean delivery rate would have increased from 19% to 25.3% based on differences in maternal parity, age, and BMI alone. Sixty-six percent of the increase in caesarean deliveries (from 19% to 30%) was accounted for when changes in caesarean deliveries for malpresentation, multiple gestation, and preterm birth were considered, and 78% was accounted for when planned (pre-labour) caesarean deliveries for maternal choice, suspected fetal compromise, a previous pregnancy issue or a suspected large fetus were excluded from the analysis. This left 22% of the increase in caesarean deliveries unexplained.

Expressed as a proportion of all births, the prevalence of planned caesarean deliveries for: maternal choice increased from 0.20% to 0.64% of all births; suspected fetal compromise increased from 0.33 to 1.36%; a previous pregnancy issue (such as anal sphincter injury, pelvic floor trauma, or difficult birth) increased from 0.0% to 0.66%; suspected large fetus increased from 0.24% to 0.55%.

Discussion

Main findings

Our main finding was that most of the steep rise in the caesarean delivery rate, which increased from about 19% to 30% between 1989 and 2016, could be attributed to changes in maternal characteristics of the obstetric population. Fifty-six percent of the rise was explained by changes in maternal age, body mass index, maternal history of previous caesarean delivery, and parity. In other words, the caesarean delivery rate was expected to increase from 19.1% to 25.3% over the time period studied had there been no changes in obstetric practice whatsoever. The management of malpresentation, multiple gestation, and preterm birth explained 10% of the rise in the caesarean delivery rate, and the exclusion of some 'newer' indications for planned (pre-labour) caesarean delivery resulted in 78% of the rise in caesarean deliveries being explained. The impact of planned caesarean delivery by maternal choice alone was minimal.

Interpretation

These findings are important because the changes in the rate of caesarean delivery over time mirrored Australian national rates,[9] and our more detailed institutional data provided insight into the probable causes of the national rate rise. More than 50% of the increase in rates of caesarean delivery was attributable to changes in baseline maternal factors rather than changes in obstetric practice or maternal choices, although these latter are often assumed to be the main drivers of increasing rates of caesarean delivery. We speculate that increases in planned pre-labour caesarean delivery for suspected large-for-gestational-age fetus and suspected fetal compromise are driven by increases in the prevalence and frequency of antenatal ultrasound.

Twenty-two percent of the increase in caesarean deliveries remained unexplained in our analyses. Possible attributable causes not accounted for in this analysis include the increase in caesarean deliveries in Robson group 5 (previous caesarean delivery, term, singleton cephalic) from 70% to 83% over the time-period. This could be due to a shift away from encouraging vaginal birth after previous caesarean delivery but could also be due to growing numbers of women with two or more previous caesarean deliveries, a factor we were unable to examine in our dataset. The marked increase in caesarean delivery in Robson groups 1 and 2A (nulliparous, term, singleton, labouring women) from 12% to 21% deserves scrutiny. Our previous finding in the same study population that caesarean delivery for slow progress in labour increased from 3.4% to 5.5% of all births[9] suggests that this group should be the target of future strategies to increase vaginal births.

Our finding that maternal background characteristics contribute significantly to the increase in the rate of caesarean delivery is consistent with the scientific literature. In some settings, it has been estimated that 14% of caesarean deliveries were due to maternal obesity[2,8] and 7% were due to gestational weight gain.[14] In Australia in 2018, 24.3% of pregnant women were older than 35 years.[15] Assuming a relative risk of 2.0 compared with younger women,[3] 20% of all caesarean deliveries could be attributed to advanced maternal age.[16] However, these estimates did not adjust for multiple factors. In the current study, the two largest factors explaining the increase in the caesarean delivery rate from 19% to 30% was the change in distribution of parity and previous caesarean births (Table 3).

We found an increase in primary caesarean delivery rates from 15% to 23%, and in nulliparous caesarean delivery rates from 20% to 30% (Table 2). Coupled with an approximate doubling in Robson category 5 from 5.6% to 10.6%, of all births, this confirms the findings of others that the increase in the caesarean delivery rate is being driven by an increase in primary caesarean deliveries.[11]

Table 4 can be used to illustrate what the caesarean delivery rate "would have been" in the 1990's (Group A) had the obstetric population consisted of exactly the same mix of maternal factors that were present in the 2010's (Group B). For example, had the population in Group A had the same mix of parity, maternal age and maternal BMI then the caesarean delivery rate would have been expected to be 25.4%, compared to 19.1%, with no changes in clinical care. With additional changes in caesarean delivery rates for malpresentation, multiple gestation, malpresentation and preterm birth, it would have increased to 26.5%, and with changes to rates of planned caesarean delivery for the indications listed in Table 4, it would have increased to 27.9%. Only the remaining two percent was unexplained.

Strengths and Limitations

The following are considered limitations of this study. Large clinical databases may be susceptible to data entry errors, however we have demonstrated the accuracy of a portion (2005 to 2009) of this database in the past.[17] Some of the fields used in the analysis were derived from multiple other fields, including some which allowed free text entry. This could lead to misclassification of items such as the indication for caesarean delivery or history of previous caesarean delivery which could bias the findings in any direction. Missing data (most commonly for maternal BMI) can lead to bias, but we used multiple imputation to reduce this risk. As the data were sourced from only two institutions in one city our findings may not be generalizable to other settings. Lack of information about the number of previous caesarean deliveries could have led to underestimation of the proportion of caesarean deliveries explained by maternal factors.

We believe this study had several strengths including the use of a large dataset with near complete data for factors such as maternal age and mode of birth which reduces information bias and the use of multiple imputation to control for missing data. Unlike national databases, our institutional database contained sufficient data fields to allow us to subdivide our outcome into indications for caesarean delivery and Robson categories.

Research is needed into the best way to manage labour as demographic profiles of populations change. For example, it is not known if older women or those with higher BMI require longer labours. There is evidence that strategies such as induction of labour in selected women[18–22] or ceasing oxytocin in active labour[23] can increase vaginal birth rates. The possibility that younger women are more susceptible to caesarean delivery for fetal concerns due to uterine hyperstimulation could lead to exploring intrapartum management options based on maternal age.[24] Studies are needed to establish the real value of planned caesarean delivery for previous obstetric anal sphincter injury or fetal concerns identified on antenatal ultrasound.

Conclusion

Much of the increase in the caesarean delivery rate between 1989 and 2016 is explained by changes in maternal demographics and history of caesarean delivery and a significant proportion is explained by changes in the route of delivery for multiple gestation, malpresentations, and preterm births. Planned caesarean delivery for maternal choice had minimal impact.

Disclosure of interests The primary author was supported by an Early Career Fellowship grant from the Australian Government National Health and Medical Research Council whilst conducting this research.

Contribution to authorship BdV conceived and designed the study and analysed the data. BdV, RM, AEB, PK collected data. BdV and RM wrote the first draft of the manuscript. All authors critically revised and contributed to the manuscript for publication. We certify that all authors are responsible for the content of the article and have read and approved the final version.

Details of ethics approval This study underwent institutional board review and received ethics approval from the Sydney Local Health District (RPAH Zone) ethics committee (Protocol No X16-0466) on April 17 2017.

Funding

The primary author was supported by an Early Career Fellowship grant from the Australian Government National Health and Medical Research Council whilst conducting this research.

Acknowledgements None

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Table/Figure Caption List

Table 1. Baseline demographic and clinical characteristics

Table 2. Caesarean delivery overall, by history of previous caesarean delivery, and in nulliparous women

Table 3. Caesarean delivery classified by Robson group and time period

Table 4. Attributable factors for the increase in caesarean delivery rate between 1989 and 2016

Figure S1: Study flow chart

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