Timing for elective cesarean and maternal fetal outcome: a retrospective cohort

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Abstract

Objective: To assess the relationship between the timing of elective cesarean section (C-section) and neonatal outcomes in a Brazilian population.

Methods: Retrospective cohort study including women with single gestation submitted to elective C-section from January 2013 to December 2016. Eligibility criteria included primiparous mothers and those who previously underwent a C-section, with gestational ages of 37–39 weeks (group I) or ≥ 39 weeks (group II), undergoing antepartum elective C-section without clinical indication.

Main Outcomes and Measures: adverse neonatal outcomes (NICU admission, respiratory distress, hypoglycemia, hiperbilirrubinemia, neonatal infection and meconium aspiration syndrome)

Results: There were 17,184 live births at Hospital Moinhos de Vento during the study period. Of these, remaining 3,722 C-sections without medical indication in nulliparous women or in those with one previous C-section. Of these, 1,460 were in group I and 2,262 were in group II. Neonatal intensive care unit (NICU) hospitalization, respiratory distress and hyperbilirubinemia were positively associated with group I in relation to group II ($p \leq 0.0001$, $p=0.001$ and $p=0.002$, respectively).

Conclusion: Elective C-section based on maternal request should not be recommended; however, for women who require elective C-section, neonatal outcomes suggest that delivery between 39 and 39+7 weeks is the optimal timing.

Key Points

Question: What is the relationship between the timing of antepartum elective cesarean section (C-section) and neonatal outcomes?

Findings: In this retrospective cohort that included 3722 C-sections without medical indication higher gestational age was associated with reduction of NICU admission, respiratory distress and hyperbilirubinemia, a significant difference.

Meaning: elective C-section, neonatal outcomes suggest that delivery between 39 and 39+7 weeks is the optimal timing.

Introduction

The increase in the number of cesarean sections (C-sections) has been reported in developed and under-developed countries (1). It is estimated that 6.2 million C-sections without clinical indication were performed worldwide in the year 2008. In Brazil, C-section rates have increased markedly: from 37.9% in 2000 to 53.9% in 2011 (2); and Brazil and China account for approximately 50% of all C-sections without clinical indication in the world (3). The World Health Organization (WHO) initially suggested, in 1985, that there was no justification for C-section rates above 10–15% of all deliveries to prevent or treat lifethreatening perinatal complications (4), but this proportion was reviewed and modified in 2015 to 19% (5).

A nationwide observational study in Brazil demonstrated that C-section proportions have unequal distributions. Ecological analysis revealed that the highest rates were associated with the richest geographic areas (C-section rates were increased according to the number of health facilities per 1000 population), with municipal level rates varying from 9–96%. Individual level analysis also showed that C-section rates were higher among primiparous white women with older age and more years of schooling (2).

Additionally, in 2008, C-sections represented 80% and 35% of the deliveries in the private and public sectors, respectively (3). In the last decade, these proportions continued to increase (6), probably because of the improvement in women's access to this procedure - not only when properly indicated, but also due to its indiscriminate use without clinical indication (7). In the public sector, patients are usually accompanied by many different medical professionals during the prenatal and childbirth care, which difficulties the creation of a bond. On the other hand, in the private sector, the same professional, chosen by the woman, often carries out these cares. This established link between the private obstetrician and the pregnant woman, coupled with a convenience in obstetric practice, has led to an increase in the scheduling of the delivery, without waiting for labor to begin (8).

Studies have been performed to evaluate possible associations among C-sections and maternal or neonatal morbidity and mortality. Considering morbimortality, C-section without clinical indication may be associated with increased risk of serious maternal (9) and neonatal outcomes (10), including respiratory complications in the newborn (11) and higher rates of fetal mortality (10). C-section also increases risks in future pregnancies, such as a higher frequency of abnormal placentation and rupture of the uterine scar. A greater risk of bladder injury and bleeding requiring transfusion is also assumed (12).

There is no consensus on the appropriate gestational age for an elective C-section. In England, for example, 97% of elective cesareans were performed at a gestational age greater than 37 weeks, and of these, 60% occurred between 39 weeks and 40 weeks (13). The American College of Obstetrics and Gynecology (ACOG) recommends that no elective C-section should be performed before the gestational age of 39 weeks. Below this gestational age, there is an increased risk of hospitalization in neonatal intensive care units (NICU), respiratory dysfunction and jaundice in the newborn (14). According to a recent study, infants delivered before the gestational age of 39 weeks are believed to be at increased risk for neonatal adverse outcomes: the risk gradually increases as gestational week at birth declines, especially when the infants are delivered by antepartum cesarean section without labour. The rate of neonatal problems, such as respiratory disorders, infection, hypoglycemia, hyperbilirubinemia, NICU admissions and prolonged neonatal hospitalization, was higher among women undergoing elective C-section with 37 gestational weeks when compared with those after 39 weeks. The study concluded that for women undergoing C-section, neonatal outcomes were best when birth was performed between the gestational ages of 39 weeks and 39 weeks and 6 days (15). Other Guidelines, such as "Birth after previous cesarean birth" by the Royal College for Obstetricians & Gynecologists and "cesarean Section" by NICE also recommend not performing an elective C-section before 39 weeks of gestational age (16, 17).

Due to the large number of C-sections performed in the supplementary health system in Brazil, the Federal Council of Medicine released in 2017 a note to the National Health Agency (ANS) with guidance to pregnant women on vaginal and surgical delivery, standardizing that elective cesarean sections should occur only after 39 weeks (18).

In order to assess the relationship between the timing of antepartum elective C-section (between 37–39 gestational weeks or after 39 weeks) and the possible adverse neonatal outcomes, a retrospective cohort study was performed at a large private obstetric center in Porto Alegre, Rio Grande do Sul, Brazil.

Methods

Study design and cohort

This is a retrospective cohort study carried out at the obstetric center of the Moinhos de Vento Hospital, located in Porto Alegre (Rio Grande do Sul, Brazil). This hospital has a large supplementary health system maternity, and accounts for over 4,000 annual deliveries, with a C-section rate of 80%.

Prior to the collection of any data, ethical approval was submitted and obtained from the Brazil Platform (www.saude.gov.br/plataformabrasil) and the Institutional Review Board of the Moinhos de Vento Hospital (CAAE reference nº 76917017.8.0000.5330).

The sample consisted of mothers and their newborns, submitted to C-section without clinical indication, performed from January 2013 to December 2016, before the ANS regulation (18). We included women who were primiparous or previously had a C-section (with no previous vaginal delivery), and were submitted to elective C-section without clinical indication performed between 37 and 41 weeks of gestational age. Participants under 18 years old, with a diagnosis of fetal malformation or dead fetus, with clinical indications for C-section, or with gestational age before 37 weeks were excluded.

All patients provided written informed consent prior to enrollment.
Participants were assessed according to their gestational age at the moment of the elective C-section: group I consisted of women submitted to elective C-section between 37 weeks to 38 weeks + 6 days, and group II consisted of those submitted to elective C-section at or after 39 weeks of gestational age.

Data Collection

Data on cesarean rates and occurrence of obstetric adverse events was obtained directly from the Moinhos de Vento Hospital registry system, from the time of the mother's hospitalization to her discharge, comprising all intercurrences of both the mother and the newborn.

Elective non-indicated C-section was considered as an antepartum C-section performed either on physician preference or on maternal request, both without clinical indications. In these cases, the Moinhos de Vento Hospital requires that participants sign a patient consent form, registered in the medical record, outlining the benefits and risks of C-section. Additionally, gestational age was determined in completed weeks of gestation (eg. 37 weeks included deliveries at 37 0/7–37 6/7 weeks and days), based on the combination of last menstrual period and first-trimester ultrasound.

Maternal sociodemographic (eg. age, ethnicity, marital status, schooling, body mass index [in kg/m^2]) and clinical (eg. number of gestations, previous abortions, ectopic gestations, previous C-sections, blood pressure, axillary temperature, heart rate, respiratory rate, length of hospitalization) data were collected. The following neonatal outcomes were evaluated and compared between both groups: NICU admission and prolonged neonatal hospitalization (5 days or longer), respiratory dysfunctions (eg. respiratory distress syndrome, pneumothorax, transient tachypnea), infection (eg. pneumonia, meningitis, sepsis or antibiotic treatment for 3 or more days), hypoglycaemia (eg. plasma glucose level < 1.9 mmol/L or the need of medical intervention), hyperbilirubinemia, fetal trauma, meconium aspiration syndrome (MAS), and APGAR index in the 5th minute (eg. ≥ 7 or < 7).

Hypoglycemia requiring drug treatment was considered when plasma glucose was less than or equal to 40 mg/dl in a symptomatic newborn. Respiratory dysfunction in the newborn was defined as tachypnea of 60 or more respiratory movements per minute and saturation of hemoglobin below 90%, regardless of cause. Meconium Aspiration Syndrome was defined as a report of labor with fetal distress, meconium-stained amniotic fluid, prolonged labor and physical examination with tachypnea, groaning, respiratory distress and cyanosis soon after delivery and with progressive worsening. In radiography, it encompassed bilateral infiltrates, increased lung volume, alternating areas of hypotransparency with hyperinflation, poverty of vessels, pneumomediastinum and pneumothorax.

Sample size

For all sample size calculations, the WinPEPI program (Programs for Epidemiologists for Windows) version 11.63 have been used, based on the study by HU *et al*. (2017) (13). Considering the proportions of neonatal complications for C-sections between 37–39 and after 39 weeks of gestational age, an acceptable difference of 5% and a loss estimate of 10%, the final sample size required was of 193 participants per gestational age group.

Statistical analysis

Regarding data processing, database double entry and review were performed using the R software (version 3.6.2, R Core Team, 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria) and Rstudio (version 1.1.4, RStudio: Integrated Development Environment for R, RStudio Team, 2016, Boston, MA).

Quantitative variables are described by mean and standard error of mean (± SEM) or by median and 95%CI, according to the Shapiro-Wilk test. Categorical variables are described as absolute (n) or relative (n%) frequencies.

To compare gestational age groups, Students' t or Mann-Whitney test for independent samples have been applied. Chi-Square test compared categorical variables within groups. To compare the outcome of NICU admission, we used Fisher exact test. Kendall's rank correlations were used to assess numeric variables, and logistic regression was used to associate categorical outcomes. The level of significance was set at 5% for all analyses.

Results

Sample characteristics

During the study period from January 2013 to December 2016, there were 17,184 live births at Hospital Moinhos de Vento. Of these, 13,457 were excluded because they were vaginal births, cesarean deliveries with medical indication, or multiparous women with cesarean indication. A total of 3,722 cesareans were included in the study, encompassing C-sections performed without medical indication in pregnant women with 1 previous cesarean section (and no vaginal delivery) and nulliparous women. Of these, 1,460 were classified in group I (from 37 to 38 weeks + 6 days) and 2,262 in group II (39 weeks and more) (Fig. 1 – Flowchart).

The mean age of women in both groups was 33 years. There was no significant variation regarding ethnicity, since most women were white in the overall sample (97,8%) and in both groups. About 74% of the women were married or living with partners and 25,6% were single or lived without a partner. The mean body mass index (BMI) in both groups was 28.7 kg/m^2 (Table 1).

Table 1
Baseline sample characteristics.

Variables	GROUP I C-Sect. 37 to 38 + 6 weeks (n = 1460)	GROUP II C-section ≥ 39 + 0 weeks (n = 2262)	OR (95%CI)	p-value*
Maternal age, years	33.0 [30.0–36.0]	33.0 [30.0–36.0]	-	0.146
Ethnicity Not white	46 (2.1)	31 (2.2)	1.05 (0.64–1.70)	0.928
Marital status Single	566 (25.3)	371 (25.6)	1.01 (0.87–1.18)	0.873
BMI, kg/m²	28.6 [26.2–31.6]	28.7 [26.3–31.8]	-	0.179

Results are presented as median [interquartile range] or n (%).

OR – Odds ratio; BMI - Body mass index; p - statistical significance index.

*Mann-Whitney or Chi-square test. Significance set at 5% for all analysis.

Main analysis

Clinical data are presented in Table 2. The number of non-nulliparous women was significantly higher in group II (41,1% *vs* 31,8% in group I, $p < 0.001$), while group I had a higher proportion of women with a previous C-section (25.6% *vs* 19.6% in group II, $p < 0.001$). The median length of hospital stay was similar between groups, around 2 days. There were minimal differences between groups regarding systolic and diastolic blood pressure, axillary temperature, heart rate and respiratory rate.

Table 2
Maternal clinical characteristics.

Variables	GROUP I C-Sect. 37 to 38 + 6 weeks (n = 1460)	GROUP II C-section ≥ 39 + 0 weeks (n = 2262)	OR (95%CI)	p-value*
Non-nulliparous	600 (31.8)	720 (41.1)	2.02 (1.58–2.60)	< 0.001
Previous C-section	374 (25.6)	443 (19.6)	1.41 (1.21–1.66)	< 0.001
SBP, mmHg	120.0 [113.0-129.0]	120.0 [112.0-128.0]	-	0.043
DBP, mmHg	71.0 [64.0–79.0]	71.o [64.0–79.0]	-	0.574
Axillary Temperature, Celsius	36.0 [35.8–36.4]	36.0 [35.8–36.3]	-	0.004
Heart rate, bpm	83.0 [76.0–92.0]	82.0 [76.0–90.0]	-	0.012
Respiratory rate, breaths per minute	20.0 [19.0–20.0]	20.0 [19.0–20.0]	-	0.088
Hospital stay length, days	2.0 [2.0–3.0]	2.0 [2.0–3.0]	-	0.773

Results are presented as median [interquartile range] or n (%).

OR – Odds ratio; CI – confidence interval; SBP – Systolic blood pressure; DBP – Diastolic blood pressure; bpm – beats per minute; p - statistical significance index.

*Mann-Whitney test. Significance set at 5% for all analysis.

Table 3. Neonatal adverse outcomes.

Variables	GROUP I C-Sect. 37 to 38 + 6 weeks (n = 1460)	GROUP II C-section ≥ 39 + 0 weeks (n = 2262)	OR (95%CI)	p-value*
5th minute APGAR ≥ 7	1458 (99.9)	2261 (100)	0.32 (0.01–4.1)	0.702
Fetal trauma	3 (0.2)	1 (0.0004)	4.65 (0.5-120.3)	0.340
NICU admission	74 (5.1)	42 (1.9)	2.82 (1.9–4.2)	< 0.001

Variables	GROUP I C-Sect. 37 to 38 + 6 weeks (n = 1460)	GROUP II C-section ≥ 39 + 0 weeks (n = 2262)	OR (95%CI)	p-value*
Respiratory distress	26 (1.8)	14 (0.6)	2.91 (1.5–5.8)	0.001
Hypoglycemia	5 (0.3)	1 (0.0004)	2.33 (0.9–5.9)	0.072
Hyperbilirubinemia	18 (1.2)	7 (0.3)	4.02 (1.7–10.2)	0.002
Neonatal infection	6 (0.4)	5 (0.2)	1.86 (0.5–6.2)	0.464
Thick meconium	0 (0)	1 (0.0004)	0.52 (0.02–12.7)	1
MAS	0 (0)	1 (0.0004)	0.52 (0.02–12.7)	1

Results are presented as n (%).

OR – Odds ratio; CI – confidence interval; APGAR – method of evaluation of fetal vitality; NICU – neonatal intensive care unit; MAS – meconium aspiration syndrome; p - statistical significance index.

*Mann-Whitney test. Significance set at 5% for all analysis.

Neonatal outcomes are presented in Table 3. NICU hospitalization and hyperbilirubinemia were more common in group I in relation to group II (Chi-Square test with adjusted residual analysis, $p < 0.0001$ and $p = 0.002$, respectively). Respiratory dysfunction was also more common in group I ($p = 0.001$). No statistical difference was found in 5th minute APGAR, fetal trauma, treated hypoglycaemia, neonatal infection, thick meconium and MAS ($p > 0.05$). Figure 2 represents the relationship between timing of C-section and adverse neonatal outcomes.

In logistic regression, overall higher gestational age was associated with reduction on odds of NICU admission (unadjusted OR 0.46, 95%CI 0.36–0.59), respiratory distress (unadjusted OR 0.52, 95%CI 0.33–0.78) and hyperbilirubinemia (unadjusted OR 0.35, 95%CI 0.20–0.61). Furthermore, in those with gestational age less than 39 weeks, higher gestational age was associated with reduction on odds of NICU admission (unadjusted OR 0.34, 95%CI 0.19–0.59) and length ($z = -3.87$, $p = 0.0001$ and $\tau = -0.185$, $p < 0.0001$) (Fig. 3). We also observed a reduction in neonatal complications as the gestational age increased.

Using the Mantel-Haenszel method, we corrected the odds of NICU admission among groups, by stratifying in presence/absence of neonatal adverse events. Group I maintained increased odds of the outcome (OR 1.82, 95%CI 1.02–3.23) (Fig. 4).

Discussion

This retrospective cohort study of antepartum elective or non-indicated C-section at a large obstetric center in Porto Alegre, Brazil, demonstrates that compared with deliveries at or after 39 weeks, earlier deliveries were significantly associated with NICU hospitalization, neonatal hyperbilirubinemia and respiratory distress.

The increasing rate of elective C-sections have motivated similar studies around the world, seeking to establish which gestational age is associated with less adverse outcomes for mothers and newborns. Overall, the conclusion is that surgical deliveries without clinical indication do not bring any maternal or fetal benefit, but increases risks for both (18).

A prospective multicenter study by Villar et al. (19) for the World Health Organization found a significantly higher risk of mortality and severe neonatal morbidity in C-section when compared to vaginal delivery, regardless of gestational age. The risk, however, decreased when the cesarean section is preceded by labor. The lack of labor affects the physiological process of onset of breathing, as there is no mechanical compression of the lungs necessary to facilitate postnatal pulmonary adaptation. This justifies the greater occurrence of transient tachypnea among newborns with elective surgical delivery.

Despite some limitations, our results are consistent with previous large population studies that showed that performing elective C-section before 39 weeks of gestation leads to a higher overall risk of adverse neonatal outcomes (20–23). In contrast, Wilmink *et al*. (2010) found a higher risk of neonatal complications with C-section at 41 weeks or later (22). Chiossi *et al*. identified that 39 weeks is an optimal timing of delivery, when comparing delivery at each gestational age (24), also supporting our findings. In Tita *et al*. (2009), the risk attributable to elective delivery before 39 weeks was 48% for 37 weeks of gestational age and 27% for 38 weeks - this means that postponing elective delivery until 39 weeks decreased cases of the primary outcome by 48% (which included, among others, death, sepsis, hypoglycemia, respiratory dysfunction and admission to a neonatal ICU) in relation to cesarean section at 37 weeks (21).

It is a consensus that even after reaching the term (gestational age of 37 weeks), the risk of adverse neonatal events decreases with each additional week up to 39 weeks (21, 22, 23, 25). This is one of the main reasons for guidelines to defend the postponement of elective C-section in low-risk pregnancies to at least 39 weeks of gestation, in addition to corroborating the division in early term (37 to 38 weeks and 6 days); full term (39 to 40 weeks and 6 days) and late term (41 to 41 weeks and 6 days) (26).

In a study by Doan et al (27), comparing fetal outcomes between early term and full term after elective cesarean section, the rate of neonatal adverse outcomes decreased significantly with increasing gestational age. Birth between 37 and 38 weeks and 6 days presented 2 times more risk (OR 2.40, 95%CI 1.58–3.66) for severe respiratory dysfunction; 3 times more risk of jaundice (OR 3.62, 95%CI 2.22–5.92) and 1.8 times more risk of hypoglycemia (OR 1.80, 95%CI 1.06–3.05). This demonstrated that, even after reaching term, neonatal outcomes continue to improve with increasing gestational age up to 41 weeks. In a classic study by Zanardo et al (28), there was a significant decrease in the risk of resuscitation or orotracheal intubation for elective C-sections performed after 38 weeks of gestation when compared to those performed between 37 weeks and 37 weeks and 6 days. In a large retrospective Chinese cohort (29), NICU admission rates were significantly higher (OR 3.73, 95%CI 2.84–4.89) in newborns with elective cesarean section at a gestational age of 37 weeks when compared to those at 39 weeks. A similar trend of increase risk with lower gestational age was found in relation to neonatal infection (OR 3.68, 95%CI 1.80–7.52), adverse respiratory outcome (OR 4.82, 95%CI 3.35–6.94), hypoglycaemia (OR 3.85, 95%CI 2.29–6.48), hyperbilirubinemia (OR 3.50, 95%CI 2.12–5.68) and prolonged hospital stay (OR 7.51, 95%CI 5.10-11.07). We found similar data in our study, showing reduction on odds of NICU admission, respiratory distress and hyperbilirubinemia with higher gestational ages.

The risk of stillbirth with increasing gestational weeks is an important concern for choosing the optimal time of elective C-section at term. Previous studies have not shown an increase in stillbirths after 39 weeks of gestational age (30, 31). In our study, the stillbirth rate was not evaluated because of study design limitations.

Neonatal and maternal mortality is a severe violation of the reproductive rights of women, since it could be prevented with efficient and early care (32). Studies of the timing of elective C-section sometimes involve medical and obstetric indications, which bias the conclusion about elective C-section before or after 39 gestational weeks.

Brazil is a country with high rates of C-sections and there is a significant difference in this index when comparing private and public hospitals. In supplementary health, the cesarean rate is 80–90%, while in the public sector it is 35–45% (33, 34, 35). In our country, C-sections are more frequent among white women, with more years of schooling and from higher socioeconomic groups (19). In the private sector, cesarean rates are extremely high in women at low obstetric risk, indicating the occurrence of the procedure without any clinical indication. Nakamura et al. found great difference in low-risk preterm rates when comparing the paying source: 25.4% in the public sector and 71.4% in the private, which raises the question of whether elective C-sections are causing iatrogenic prematurity (35). This corroborates the determination of a minimum gestational age for performing elective surgical delivery, aiming mainly to reduce morbidities associated with prematurity in newborns.

Our findings are consistent with those in the international medical literature. In our study, admission to the neonatal ICU, respiratory distress and hyperbilirubinemia were more frequent when the elective C-section was performed at a gestational age of less than 39 weeks, compared to the group in which it was performed at more than 39 weeks of gestation.

The key strength of the present study is that it used a large hospital-based retrospective cohort database. Furthermore, we performed a detailed examination of each woman's medical record so that the indication for C-section could be clearly ascertained. The hospital routine requiring a consent form for antepartum elective or non-indicated C-section enabled us to determine truly non-medically indicated prelabour C-section. We sought to eliminate adverse outcomes overestimation (confounder: indicated C-section) by analyzing cases of antepartum C-section without clinical indication. The gestational age was assessed in all cases by the first-trimester ultrasound, routinely used to confirm gestational week. However, there are some limitations in our study: some findings might fail to reach significance because the sample size was relatively small for some comparisons between groups (type II error). Additionally, a reflection of type I error may exist in one or more significant findings. Second, the current sample is rather homogeneous, and future research should examine these outcomes in more heterogeneous populations in terms of their sociodemographic characteristics. Third, intrapartum stillbirth and neonatal deaths were not included in these analyses.

The extent to which the increase in the number of C-sections could be attributed to medical preference or maternal demand should be a focus of future debates. In this sense, our results contribute to the existing research on this subject and confirm that waiting until 39 weeks for elective C-section is advisable, similar to other findings around the world (36). It is important to highlight, however, that despite being an increasing trend due to maternal request, performing primary C-sections antepartum can lead to substantial public health implications due to its effects on neonatal outcomes (37–39).

Conclusion

Elective C-section performed at 39 to 39/7 completed weeks of gestation was associated with better neonatal outcomes in a Brazilian population, in comparison to C-sections performed before 39 weeks. Elective C-section based solely on maternal request is not recommended, but for those women who require it, our results suggest that delivery at or after 39 weeks is the optimal timing due to reduced neonatal adverse outcomes.

A point to highlight in our work and that brings new data to the medical literature is the fact that all antepartum elective or non-indicated cesareans in the analyzed hospital required signature of a consent form. This ensures that all the cases included are cases without medical indication for C-section. Without this artifice, it may be difficult to differentiate between an elective cesarean section and one with medical indication, which would serve as a bias for neonatal outcomes.

In agreement with the world literature, the reduction of adverse neonatal outcomes of elective cesarean section at 39 weeks is evident when compared to those performed at 37 weeks of gestational age. However, there is also a notorious increase in maternal fetal risk when comparing C-section without clinical indication with vaginal delivery. These data should help doctors guide the pregnant woman about the appropriate way of delivery and the best gestational age for birth, avoiding unnecessary risks to the fetal maternal binomial.

Declarations

ETHICS APPROVAL AND CONSENT TO PARTICIPATE: The study was approved by the institutional Research Ethics Committee and conducted in accordance with the provisions of the Declaration of Helsinki. All patients provided written informed consent prior to enrollment. Ethical approval was recorded in and obtained from the Brazil Platform and the Institutional Review Board of the Moinhos de Vento Hospital (www.saude.gov.br/plataformabrasil, CAAE reference number 76917017.8.0000.5330).

AVAILABILITY OF DATA AND MATERIALS: All data generated or analysed during this study are included in this published article [and its supplementary information files].

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AUTHOR CONTRIBUTORSHIP: All authors listed above participated in the study to a significant extent. MR and JV worked on the conception, design, analysis and interpretation of data. MR, LH and FG worked on data collection. AVP, FSG and MS wrote and revised the article. GCM and CFF wrote the article and made the statistical analysis. All authors read and approved the submitted manuscript.

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Figures

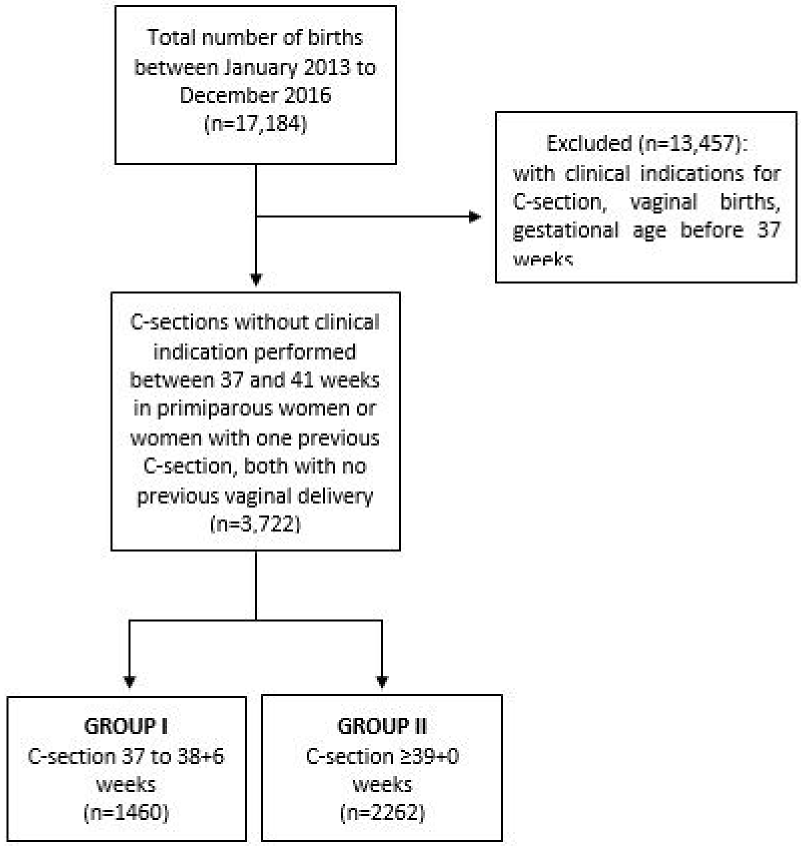

Figure 1

Flow chart of the study population (n = absolute frequency).

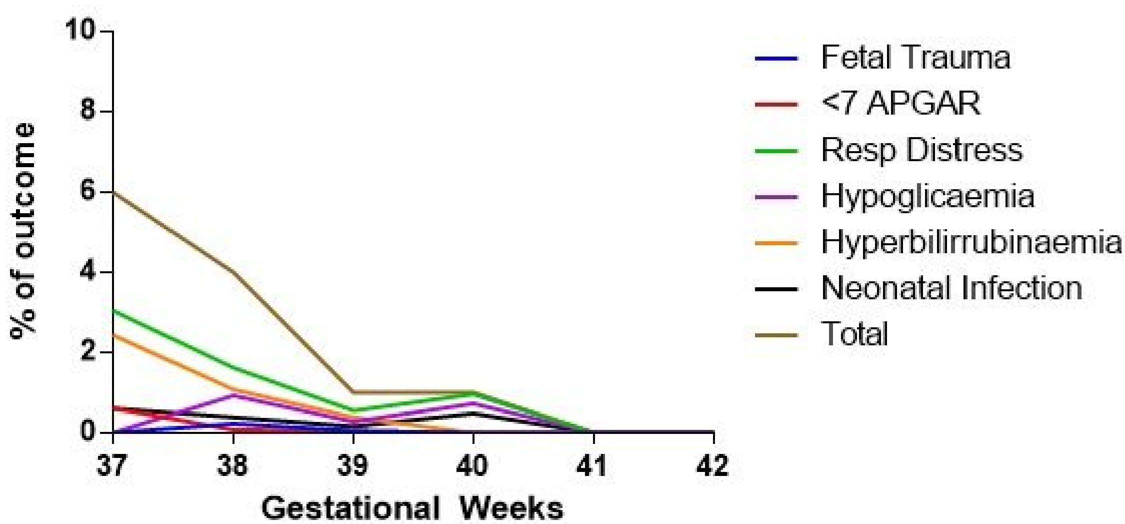

Figure 2

Rates of neonatal adverse events by week, expressed on percentages. Represents the relationship between timing of C-section and adverse neonatal outcomes.

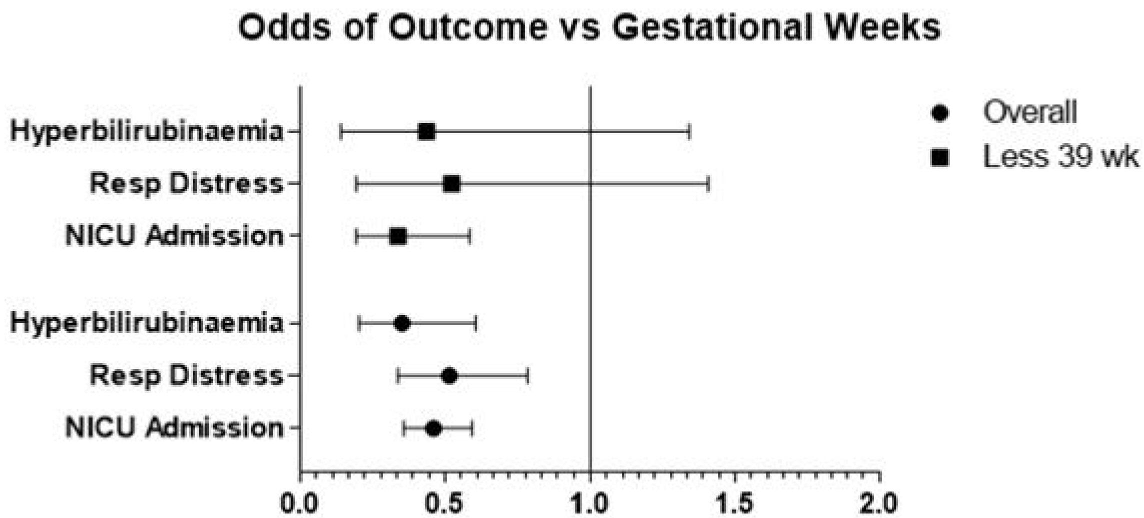

Figure 3

Unadjusted odds ratio of gestational week and neonatal adverse events (NAE), calculated using binomial logistic regression. The square represents C-sections performed before 39 weeks; the circle represents C-sections performed between 37 and 41 weeks.

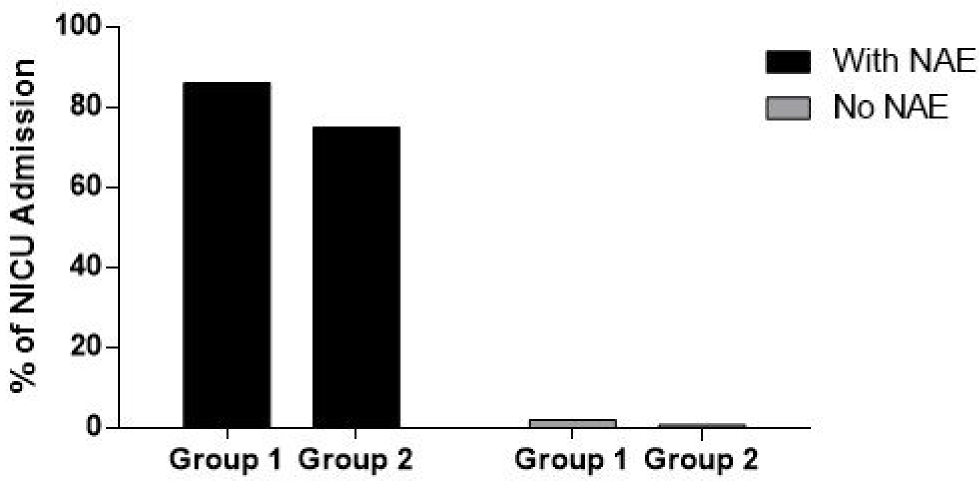

Figure 4

Percentage of Neonatal Intensive Care Unit (NICU) admission in each group, stratified by presence or absence of neonatal adverse events (NAE). Significances were not displayed for better visualization.