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Cesarean sections and early-term births according to Robson classification: a population-based study with more than 17 million births in Brazil

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Abstract

Background Cesarean section (CS) rates are increasing worldwide and are associated with negative maternal and child health outcomes when performed without medical indication. However, there is still limited knowledge about the association between high CS rates and early-term births. This study explored the association between CSs and early-term births according to the Robson classification.

Methods A population-based, cross-sectional study was performed with routine registration data of live births in Brazil between 2012 and 2019. We used the Robson classification system to compare groups with expected high and low CS rates. We used propensity scores to compare CSs to vaginal deliveries (1:1) and estimated associations with early-term births using logistic regression.

Results A total of 17,081,685 live births were included. Births via CS had higher odds of early-term birth (OR 1.32; 95% CI 1.32–1.32) compared to vaginal deliveries. Births by CS to women in Group 2 (OR 1.50; 95% CI 1.49–1.51) and 4 (OR 1.57; 95% CI 1.56–1.58) showed the highest odds of early-term birth, compared to vaginal deliveries. Increased odds of an early-term birth were also observed among births by CS to women in Group 3 (OR 1.30, 95% CI 1.29–1.31), compared to vaginal deliveries. In addition, live births by CS to women with a previous CS (Group 5 - OR 1.36, 95% CI 1.35–1.37), a single breech pregnancy (Group 6 - OR 1.16; 95% CI 1.11–1.21, and Group 7 - OR 1.19; 95% CI 1.16–1.23), and multiple pregnancies (Group 8 - OR 1.46; 95% CI 1.40–1.52) had high odds of an early-term birth, compared to live births by vaginal delivery.

Conclusions CSs were associated with increased odds of early-term births. The highest odds of early-term birth were observed among those births by CS in Robson Groups 2 and 4.

Keywords Early-term births, Cesarean section, Robson classification

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Background

Cesarean section (CS) rates have been steadily increasing in recent decades, particularly in low- and middle-income countries (LMICs) [1]. Brazil is one of the countries with the highest CSs rates in the world (56%) [1], and almost 90% of these are among women who receive private healthcare during childbirth [2].

Brazil has a delivery care model characterized by excessive use of obstetric and neonatal interventions. However, from the 1980s onwards, a series of government policies and programs were instituted to change this situation [3]. In this context, programs were created to improve the quality of care during labor and birth, such as the Rede Cegonha strategy, in the public sector. This program promotes the implementation of a new care model for labor and birth [4]. The Parto Adequado project, in the private sector, has the main objective of reducing cesarean sections in private services in Brazil [5]. Despite past and current initiatives, the growing trend of caesarean sections remains.

CSs may be associated with lower maternal and perinatal mortality and morbidity when performed for medical reasons [6]. On the other hand, a cesarean delivery without a medical indication (for example elective and repeat CS) may lead to negative health outcomes [7], such as early-term births (37–38 weeks of gestation) [8–10]. Early-term live births have higher neonatal morbidity, admission to Neonatal Intensive Care Units (NICU), respiratory complications at birth, neonatal mortality, and delays in long-term developmental outcomes compared to 39–41 weeks of gestation [11–15]. In addition, early-term births may produce several economic consequences related to the cost of health, social, and educational services [16].

Early-term birth rates are high worldwide, ranging from 15.6 to 30.8% in high-income countries [17]. However, there is a lack of data from LMICs [8]. In Brazil, early-term births represent 35% of all live births [11]. A study showed that the prevalence of early-term births was 1.64 higher in municipalities with ≥80% CS rates, compared to those with <30% [8]. However, this study was not able to evaluate CS indications.

The Robson classification system is a useful standard to monitor and compare CS rates globally [18]. A low level of CS clinical need and rates is expected in Groups 1 to 4 (women at term, cephalic presentation, and a single fetus). On the other hand, a higher level of CS need and rates is expected in Groups 5 (women with a previous CS) and 6 to 10 (women with twins, breech position, other abnormal presentation, or preterm births) [19].

Understanding the relationship between CSs and early-term births in a country with one of the highest CS rates in the world has the potential to inform new strategies to optimize CSs use and reduce early-term births. Thus, this study evaluated the association between CSs and early term births in different Robson groups using data from more than 17 million live births in Brazil.

Methods

Study design and population

This population-based cross-sectional study used routine registration data from the Brazilian live birth information system (Sistema de Informações sobre Nascidos Vivos, SINASC), between January 1, 2012 and December 31, 2019.

SINASC includes information on mothers and newborns throughout Brazil, including the mother's name, place of residence, age, marital status, education, obstetric history (previous CS or vaginal deliveries), prenatal care, pregnancy characteristics (length of gestation, type of delivery, and fetal presentation) and newborn characteristics (singleton, multiples, birth weight; presence of congenital anomalies, and gestational age). The SINASC form does not record the number of previous births and, therefore, so we used the number of previous pregnancies as a proxy for parity.

Birth certificates are the instrument which feeds SINASC. This must be completed throughout the national territory for all live births [20]. The birth certificates, processed by the notifying units, are sent and consolidated by the national birth database [21]. SINASC is considered of adequate quality, acceptable, representative, opportune, stable, and capable of meeting the intended objective: to subsidize maternal and child care planning [22].

At term live births (37 to 41 completed weeks of gestation) for women aged 14 to 49 were included in the study. Live births weighing <500 g and birth anomalies (potentially related to the CS indication) were excluded. We also excluded records without detailed information on variables used in the Robson classification: type of delivery, previous pregnancy, gestational weeks at delivery, number of fetuses, delivery onset (prepartum CS, induced, or spontaneous vaginal delivery), and history of previous CSs.

Outcomes

The primary outcome in this study was early-term (37 and 38 weeks gestation) compared to full and late-term births (39 to 41 weeks of gestation). The main exposure variable was a CS compared with vaginal delivery. In order to study the association between a CS and early-term birth, we used the Robson classification system to compare groups of live births from women with expected high and low CS rates. Six obstetric characteristics: previous pregnancy, gestational weeks at delivery, number of fetuses, delivery onset (pre-labor CS, induced or spontaneous vaginal delivery), previous CS and fetal

presentation were used to create 10 mutually exclusive Robson groups. Group 10 was not included in the study since it included preterm births (<37 weeks of gestation).

Statistical analysis

Socioeconomic, maternal, and birth characteristics were summarized using frequency distributions. Logistic regression was used to estimate the odds ratio (OR) and 95% confidence intervals (95% CI) for the association between cesarean section and early-term birth.

We used propensity score matching (PSM) to control for confounding. Matching was based on risk factors, including race/ethnicity (white, black, Asian, mixed-race, and indigenous), maternal education (none, 1–3, 4–7, 8–12, and >12 years of education), marital status (married/civil partnership, single, widowed, or divorced), number of prenatal appointments (none, 1–3, 4–6, and ≥7 consultations), maternal age at delivery (14–19; 20–34; and 35–49 years old), newborns' gender (male or female) and year of birth (2012–2019). The propensity score was obtained via multiple logistic regression and matched using the nearest neighbor algorithm (1:1) without replacement and at a 0.1 caliper [23]. The analyses were conducted separately for each Robson group and the study population as a whole. Since a vaginal birth was more common than a CS in Robson Groups 1, 3 and 4, we generated matched pairs by selecting a vaginal birth for each CS. Conversely, for Groups 2, and 5 to 9, where a CS was more common, we selected a CS for each vaginal birth. In the analysis for the entire study population, we selected a vaginal delivery for each CS. We estimated the population attributable fraction (PAF) using the punaf package in Stata, which uses a logistics regression method and provides PAF and 95% CI [24]. For the PAF calculation, we used the OR obtained after the matching.

In addition, to assess differences between the early-term birth categories, we performed additional analyses, separately considering live births at 37 and 38 weeks of gestation (supplementary material). Considering the different distributions of CS rates across the geographic areas of the country, we carried out complementary analyses for the North, Northeast, Southeast, South and Central-west geographic regions. These additional multivariate logistic regression models were conducted according to the same method as the main analyses.

In order to test the robustness of our results, we performed additional analyses using a finer caliper (0.05) for matching, and crude and adjusted logistic regression for the same confounders used in the propensity score.

All analyses were performed using STATA version 15.0 (Stata Corporation, 153 College Station, USA).
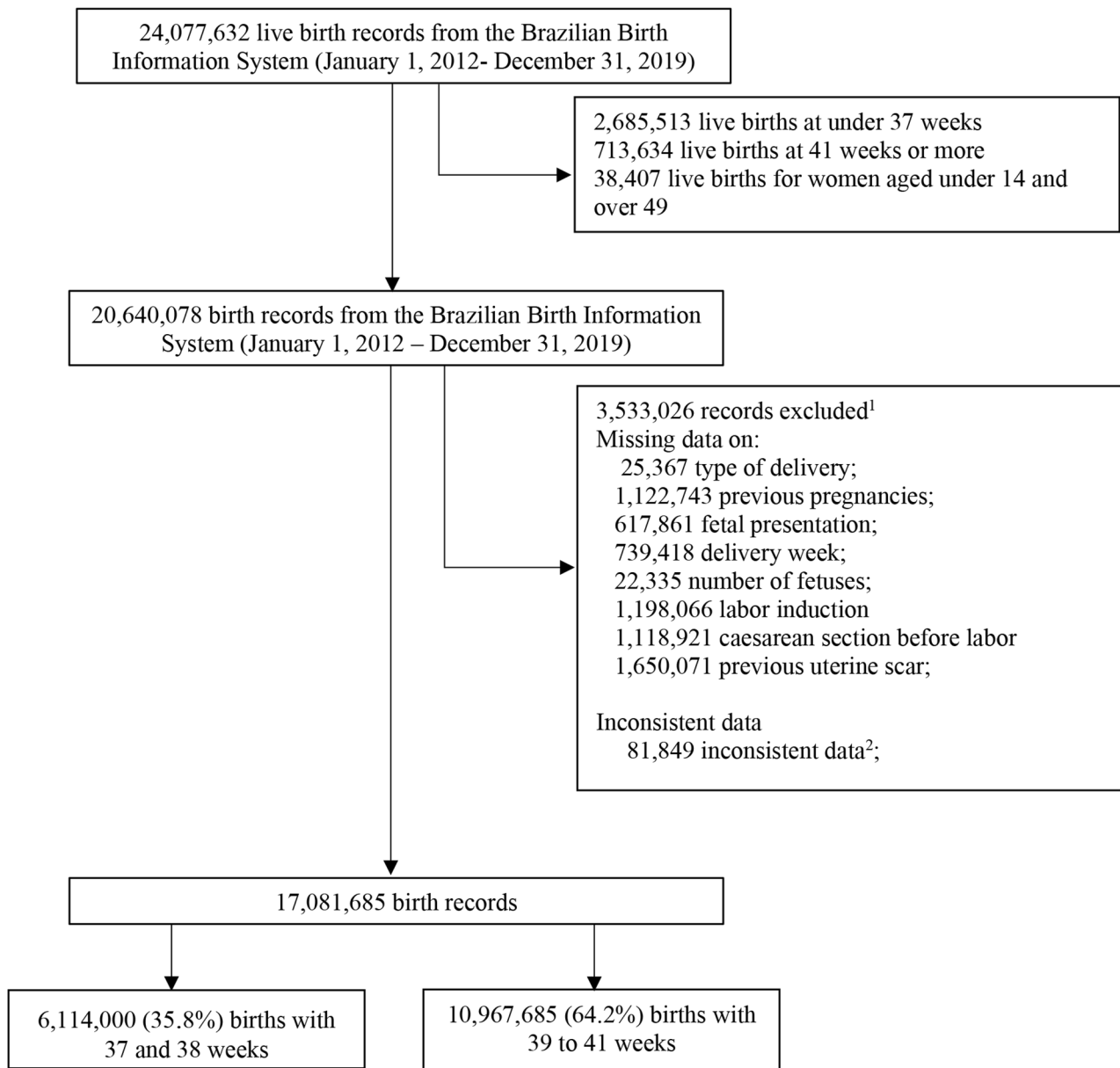
Results

During the study period, 24,077,632 live births were registered on SINASC. Of these, 17,081,685 (70.94%) were included in this study. Early-term births accounted for 6,114,000 (35.79%) of all the live births included in the study (Fig. 1). Compared to those with 39–41 weeks of gestation, early-term births were more frequent among mothers aged ≥35 years, married/in a civil partnership, with a higher level of education (12 years and over), were white, had a CS delivery, lived in wealthier geographic regions (Southeast, South and the Central-West), and were in Robson Group 5 (Table 1).

The proportion of CS deliveries in the general population (Table 2) was higher among older mothers, married/in a civil partnership, were white, with a higher level of education, attended more prenatal visits, and lived in wealthier geographic regions (Table 2). The proportion of live births via CS varied according to the Robson groups, from 17.49% in Group 3, to 97.21% in Group 9 (Table S2). Following PSM, women who delivered via a CS had very similar characteristics to women who had delivered vaginally in the general population (Table S2). The distribution of scores is displayed in Figure S1.

Early-term prevalence was 37.62% among those born by vaginal delivery, and 62.38% by CS (Table 3). Early-term births prevalence varied between Robson groups and type of delivery. Robson Groups 6 to 9 had a higher prevalence of early-term births, exceeding 88% among those born by CS. In Robson group 5, higher early term prevalence was also found in CS births (85.53%In the Robson Groups 1 to4, the prevalence of early-term birth by CS was higher in Robson Groups 2 (75.09%) and 4 (53.04%) than group 1 and 3 (Table 3).

Following adjustment via PSM, the odds of an early-term birth was 32% (95% CI 1.32–1.32) higher among live births delivered by CS than those born by vaginal delivery in all Robson groups. The odds for an early-term birth varied between Robson groups. When compared to those born by vaginal delivery, the odds of an early-term birth were more likely in those born by CS among nulliparous (Group 2 - OR 1.50; 95% CI 1.49–1.51) and multiparous women (Robson group 4 - OR 1.57; 95% CI 1.56–1.58) without a previous CS, with a single cephalic pregnancy, at term, and who had their labor induced or a pre-labor CS. Increased odds of an early-term birth were also observed among live births of multiparous women without a previous CS, with a single cephalic pregnancy, at term, and in spontaneous labor (Robson Group 3 - OR 1.30; 95% CI 1.29–1.31). The odds of an early-term birth were similar in those born by CS than those born by vaginal delivery in the group of nulliparous women with a single cephalic pregnancy, at term, and in spontaneous labor (Robson Group 1 - OR 1.04; 95% CI 1.04–1.05) (Table 3).

```
24,077,632 live birth records from the Brazilian Birth
Information System (January 1, 2012- December 31, 2019)
```

```
2,685,513 live births at under 37 weeks
713,634 live births at 41 weeks or more
38,407 live births for women aged under 14 and
over 49
```

```
20,640,078 birth records from the Brazilian Birth Information
System (January 1, 2012 – December 31, 2019)
```

```
3,533,026 records excluded¹
Missing data on:
  25,367 type of delivery;
  1,122,743 previous pregnancies;
  617,861 fetal presentation;
  739,418 delivery week;
  22,335 number of fetuses;
  1,198,066 labor induction
  1,118,921 caesarean section before labor
  1,650,071 previous uterine scar;

Inconsistent data
  81,849 inconsistent data²;
```

```
17,081,685 birth records
```

```
6,114,000 (35.8%) births with
37 and 38 weeks
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```
10,967,685 (64.2%) births with
39 to 41 weeks
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Fig. 1 Study population flow diagram. [1]The reasons for exclusion do not form a total of 3,558,215 since a record may lack multiple variables. [2]Contradictory data, such as records with no previous pregnancies and previous vaginal and caesarean deliveries

The live births from multiparous women with at least one previous CS and with a single cephalic pregnancy (Robson Group 5), delivered by CS, showed higher odds of being early-term than those delivered by vaginal delivery (OR 1.36; 95% CI 1.35–1.37). In addition, infants born by CS were more likely to be early-term births when born to nulliparous or multiparous women with a single breech pregnancy (Robson Group 6 - OR 1.16; 95% CI 1.11–1.21) and (Robson Group 7 - OR 1.19; 95% CI 1.16–1.23, respectively). Higher odds of early-term birth were also observed among live births of women with multiple

pregnancies (Robson Group 8 - OR 1.46; 95% CI 1.40–1.52) (Table 3).

Attributable fraction analysis indicated that 17% (95% CI 16.87–17.1) of early-term births were attributed to CSs, with a marked variation between Robson groups and a higher PAF in Groups 2 and 4, 23.69% (95% CI 23.30–24.00) and 25.75% (95% CI 25.40-26.09), respectively (Table 3). Additional analyses showed a higher prevalence of early-term births at 38 weeks of gestation, when compared to those at 37 weeks (27.95% versus 14.50%). For almost all Robson groups, the magnitude of the association between CSs and early-term birth was

Table 1 Characteristics of term births by gestational age in Brazil, 2012–2019 (17,081,685)

Variables	37 and 38 weeks		39–41 weeks	
	N	%	N	%
Maternal age (years)				
14–19	850,216	13.91	1,927,452	17.57
20–34	4,236,326	69.29	7,736,809	70.54
35–49	1,027,458	16.81	1,303,424	11.88
Marital status				
Married/ Civil partnership	3,640,617	60.01	5,915,818	54.39
Single	2,329,020	38.39	4,822,248	44.34
Widow	11,550	0.19	18,424	0.17
Divorced	85,511	1.41	119,908	1.10
Maternal education (years)				
None	24,028	0.40	53,892	0.50
1–3	128,171	2.12	281,047	2.59
4–7	911,495	15.06	1,995,877	18.39
8–12	3,489,541	57.65	6,720,211	61.93
12 +	1,500,087	24.78	1,800,365	16.59
Maternal ethnicity				
White	2,628,221	44.07	3,842,312	35.94
Black	314,990	5.28	643,998	6.02
Asian	27,215	0.46	43,448	0.41
Mixed-race	2,952,097	49.50	6,073,132	56.80
Indigenous	40,770	0.68	3,842,312	0.83
Number of prenatal visits				
None	76,268	1.25	149,537	1.37
1–3	318,912	5.24	586,734	5.37
4–6	1,357,776	22.32	2,377,916	21.78
7+	4,330,738	71.19	149,537	71.47
Newborns` sex				
Male	3,167,327	37.62	5,543,573	50.55
Female	2,945,934	62.38	5,423,211	49.45
Geographic region				
North	539,265	8.82	1,133,252	10.33
Northeast	1,328,210	21.72	2,816,163	25.68
Southeast	2,771,724	45.33	4,585,251	41.81
South	938,409	15.35	1,559,013	14.21
Central-West	536,192	8.77	874,006	7.97
Robson groups				
Robson 1	1,017,345	16.64	2,143,650	19.55
Robson 2	1,148,225	18.78	2,031,345	18.52
Robson 3	1,118,057	18.29	2,483,349	22.64
Robson 4	703,770	11.51	1,337,167	12.19
Robson 5	1,762,676	28.83	2,631,709	24.00
Robson 6	92,468	1.51	119,278	1.09
Robson 7	124,135	2.03	162,718	1.48
Robson 8	134,964	2.21	38,771	0.35
Robson 9	12,360	0.20	19,698	0.18

CS: Cesarean section; Robson groups: 1 (Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labor); 2 (Nulliparous women with single cephalic pregnancy, ≥37 weeks gestation who either had labor induced or were delivered by cesarean section before labor); 3 (Multiparous women without a previous uterine scar, with a single cephalic pregnancy, >37 weeks gestation, in spontaneous labor); 4 (Multiparous women without a previous uterine scar, with single cephalic pregnancy, ≥37 weeks gestation who either had labor induced or were delivered by cesarean section before labor); 5 (All multiparous women with at least one previous CS, with a single cephalic pregnancy, ≥37 weeks gestation); 6 (All nulliparous women with a single breech pregnancy); 7 (All multiparous women with a single breech pregnancy, including women with a previous CS); 8 (All women with multiple pregnancies, including women with a previous CS); 9 (All women with a single pregnancy with a transverse or oblique lie, including women with previous CS(s).

Table 2 Characteristics of term births by type of delivery in Brazil, 2012–2019 (17,081,685)

Variables	Vaginal delivery		CS	
	N (7,619,183)	% (44.60)	N (9,462,502)	% (55.40)
Maternal age (years old)				
14–19	1,711,363	22.46	1,066,305	11.27
20–34	5,191,928	68.14	6,781,207	71.66
35–49	715,892	9.40	1,614,990	17.07
Marital status				
Married/ Civil partnership	3,710,614	49.15	5,845,821	62.23
Single	3,758,569	49.79	3,392,699	36.11
Widow	12,380	0.16	17,594	0.19
Divorced	67,303	0.89	138,116	1.47
Maternal education (years)				
None	57,292	0.76	20,628	0.22
1–3	263,882	3.50	145,336	1.55
4–7	1,735,882	23.05	1,171,490	12.50
8–12	4,788,937	63.59	5,420,815	57.83
12 + year	685,209	9.10	2,615,243	27.90
Maternal ethnicity (years)				
White	2,190,329	29.52	4,280,204	46.35
Black	501,537	29.52	457,451	4.95
Asian	30,695	0.41	39,968	0.43
Mixed-race	4,593,923	61.91	4,431,306	47.99
Indigenous	104,029	1.40	25,469	0.28
Number of prenatal visits				
None	146,100	1.93	79,705	0.85
1–3	605,011	7.99	300,635	3.19
4–6	2,045,605	27.01	1,690,087	17.93
7+	4,776,213	63.07	7,356,498	78.04
Newborns` sex				
Male	3,827,049	50.23	4,883,851	51.62
Female	3,791,490	49.77	4,577,655	48.38
Geographic region				
North	893,178	11.72	779,539	8.24
Northeast	2,120,736	27.83	2,023,637	21.39
Southeast	3,010,994	40.31	4,285,981	45.29
South	994,422	13.05	1,503,000	15.88
Central-West	539,853	7.09	870,345	9.20

CS: Cesarean Section

greater among those born at 38 weeks of gestation, compared to those born at 37 weeks (Tables S3 and S4).

In the analysis by geographic regions, we observed a greater odd of early-term birth among those born by CS in the South (OR 1.49; 95% CI 1.48–1.50), Central-West (OR 1.34; 95% CI 1.33–1.35) and Southeast (OR 1.33; 95% CI 1.32–1.33). In the poorest regions of the country, these odds were 1.21 (95% CI 1.20–1.22) in the North and 1.19 (95% CI 1.18–1.19) in the Northeast. Analyzes for the different Robson Groups also show high chances of early-term birth among CS born in Groups 2 and 4

in all regions of the country, especially in the South and Central-West regions (Table S5).

The robustness analyses with a finer caliper in the PSM model, and bivariate and multivariate logistic regression produced similar results to the primary analyses (PSM) (Table S6).

Discussion

In this population-based study with more than 17 million live births, we observed that a cesarean delivery was associated with a more than 1.3-fold increase in the odds of an early-term birth, compared to a vaginal delivery. In the stratified analysis by Robson classification, we observed that among the live births from women in Robson Groups 2 and 4, those born by CS had a 50%, or greater, increase in the odds of an early-term birth, compared to those born by vaginal delivery. Increased odds of an early-term birth were also found among those born by CS in Robson Groups 3, 5, and 6–8, ranging from 16 to 46%. In addition, we observed greater odds of early-term birth among those born by CS in the South, Central-West and Southeast regions, especially in Robson Groups 2 and 4.

The prevalence of early-term births was higher in live births by CS than in those by vaginal delivery. We found a high proportion of early-term births from older, white, and higher educated mothers. The prevalence of early-term births (35.79%) was higher than those previously reported in developed countries, such as Japan (30.8%), Malta (30.7%), and Luxembourg (29.7%) [17]. However, the high prevalence of early-term births was similar to that observed in local studies [11, 25]. Early-term births accounted for 35% (95% CI 33.4%-36.7%) of all live births in the "Birth in Brazil study" [11]. Raspantini et al. (2016) observed that early-term births were responsible for more than 34.5% of births in the city of São Paulo [25].

Very few studies have evaluated the odds of an early-term birth associated with CSs [8–10]. A Brazilian study showed that early-term births were 1.64 (95% CI 1.62–1.61) times higher in municipalities with very high ones (≥80%), when compared to municipalities with lower CS rates (<30%) [8]. The association between CSs and early term delivery may differ between women with maternal or foetal indications (e.g., preeclampsia, placental abruption, and foetal distress), and no medical indication. There is insufficient information to identify high-risk pregnancies on SINASC data and, therefore, we used the Robson classification to evaluate a CS indication proxy, through which we were able to stratify groups of births of women with expected lower and higher CS rates and needs.

Our results show an increased risk of an early-term birth among those born by CS from nulliparous (Group 2) and multiparous women (Group 4). The high CS rates

Table 3 Early-term births by type of delivery according to the Robson Groups classification in Brazil, 2012–2019 (n = 17,081,68)

Robson Groups	Early-term births			PSM*		PAF	
	Total population	Vaginal	CS	OR	CI 95%	%	CI 95%
	N (%)	N (%)	N (%)				
1	1,017,345 (32.18)	554,043 (54.46)	463,302 (45.54)	1.04	1.04–1.05	2.83	2.45–3.20
2	1,148,225 (36,11)	286,022 (24.91)	862,203 (75.09)	1.50	1.49–1.51	23.69	23.30–24.00
3	1,118,057 (31.05)	891,385 (79.73)	226,672 (20.27)	1.30	1.29–1.31	16.10	15.70-16.56
4	703,770 (34.48)	330,500 (46.96)	373,270 (53.04)	1.57	1.56–1.58	25.75	25.40-26.09
5	1,762,676 (40.11)	202,212 (11.47)	1,560,464 (88,53)	1.36	1.35–1.37	18.29	17.89–18.69
6	92,468 (43.67)	6,248 (6.76)	86,220 (93.24)	1.16	1.11–1.21	8.47	5.99–10.89
7	124,135 (43.27)	13,674 (11.02)	110,461 (88.98)	1.19	1.16–1.23	10.02	8.35–11.65
8	132,964 (77.68)	15,857 (11.75)	119,107 (88.25)	1.46	1.40–1.52	10.65	9.58–11.71
9	12,360 (38.56)	311 (2.52)	12,049 (97.48)	1.09	0.89–1.32	5.45	-7.68-16.58
All groups	6,114,000 (37.79)	2,300,252 (37.62)	3,813,748 (62.38)	1.32	1.32–1.32	17.00	16.87–17.14

The early-term birth (37 and 38 weeks gestation) was compared with births at 39 to 41 weeks gestation. OR (odds ratio) from a logistic regression in which vaginal deliveries are the comparison group. *Variables used in PSM (propensity score matching): race/ethnicity, maternal education, marital status, number of prenatal appointments, maternal age at delivery, newborns` sex and year of birth. CS: Cesarean section. PAF: population attributable fraction. Robson groups: 1 (Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labor); 2 (Nulliparous women with single cephalic pregnancy, ≥37 weeks gestation who either had labor induced or were delivered by cesarean section before labor); 3 (Multiparous women without a previous uterine scar, with a single cephalic pregnancy, >37 weeks gestation, in spontaneous labor); 4 (Multiparous women without a previous uterine scar, with single cephalic pregnancy, ≥37 weeks gestation who either had labor induced or were delivered by cesarean section before labor); 5 (All multiparous women with at least one previous CS, with a single cephalic pregnancy, ≥37 weeks gestation); 6 (All nulliparous women with a single breech pregnancy); 7 (All multiparous women with a single breech pregnancy, including women with a previous CS); 8 (All women with multiple pregnancies, including women with a previous CS); 9 (All women with a single pregnancy with a transverse or oblique lie, including women with previous CS(s).

found in Robson Groups 2 and 4 may be related to the number of women undergoing a CS before the onset of labor (Groups 2b and 4b), which was higher than those undergoing induction (Groups 2a and 4a). Our hypothesis is that, in part, these groups had CSs due to medical reasons, or maternal preference, which may contribute to the increase in early-term births in these groups. A previous Brazilian study reinforces our hypothesis. Leal et al. (2017) [11] observed that among early-term live births, 47% were provider-initiated, mainly pre-labor CSs, and 30% were provider-initiated in women without clinical or obstetric needs.

Our hypothesis is corroborated by a high prevalence of CSs among highly educated women who live in richer geographic regions of the country. In addition, disparities in access to well-indicated CSs among women in the North and Northeast may also explain our findings, as well observed as in other Brazilian studies [26–29]. That also refers to a high number of CSs performed on women attended by private health services [26]. Raspantini et al. (2016) [25] observed a higher proportion of early-term births (52.20%) in private than in public network hospitals (30.30%), which may explain the gestational age mean of 38 weeks in private hospitals, compared to 39 weeks in public hospitals. Similarly, Diniz et al. (2016) [30] observed that the highest concentration of cesarean births in the private system occurred early-term (35%). It is known that performing an elective CS may lead to short- and long-term health effects for children [7]. Thus, public policies should be directed at reducing the number of elective CSs, especially in the private health sector.

Our results also showed an increased odds of an early-term birth among those born througha CS in the multiparous group without a previous CS (Robson Group 3). These results may be related to maternal preference for a CS for tubal ligation, as mentioned by Domingues et al. (2014) [2]. We also observed increased odds of an early-term birth among live births due to a CS in multiparous women with a previous CS (Robson Group 5). Group 5 represents the largest group of live births in this study (over 25%), and has one of the highest CS rates observed (over 85%). In a previous study, women with repeated elective CSs more frequently gave birth at the beginning of term [9, 10]. Concern about an increased risk of uterine rupture among women with multiple CS scars, following the onset of spontaneous labor may explain the high rates of early elective Cs in these groups [9].

In this study, we identified increased odds of early-term birth associated with CS among those born to nulliparous or multiparous women with a single breach pregnancy (Groups 6 and 7, respectively) and multiple pregnancies (Group 8). Studies have shown that there is an increased risk of perinatal mortality and morbidity when a twin pregnancy continues beyond 37 weeks, and that lower risks are seen when twins are born between 36 and 38 weeks [31, 32]. Our study findings of our study may indicate the higher indication (preference) of a CS as a type of delivery for multiple pregnancies, although the safest method for delivering twins at term, or close to term, remains a controversial issue [33–35].

A CS is an effective intervention to protect maternal and fetal health when performed for well-defined clinical reasons [6]. A CS may be the consequence of

a situation that may be identified during pregnancy (Groups 6 or above), or result from a cascade of unexpected and unpredictable events (eclampsia, HELLP syndrome, fetal asphyxia, and uterine rupture) [36] in women not classified in Groups 6–9. A high cesarean section rate is expected in Robson Groups 6 to 9, and consequent early delivery results from appropriate clinical decisions. CSs in the low-risk group may result from unexpected developments requiring a CS. In both groups, it may result from non-clinical factors, such as convenience for obstetricians or mothers [26, 27].

Our study showed that 17% of Brazilian early-term births were attributed to CSs. We also found higher population attributable risks to CSs in live births to mothers in Robsons Groups 2 and 4, in which low CS rates are expected. Our results suggest that Brazil faces two interrelated epidemics: a CS epidemic and one of early-term births, especially among those born at 38 gestational weeks, related to high CS rates in women with induced labor and before labor (Robson Groups 2 and 4). It is known that early-term infants are at a greater risk of adverse birth outcomes than those born at full-term [11–15], especially when born by CS [12]. Thus, different organizations, such as the American College of Obstetricians and Gynecologists, have recommended that CSs without clinical indications should not be performed before the 39th week of gestation [37].

Although CS rates are still high in Brazil, different programs, policies and strategies created and implemented in health services aim to improve the quality of obstetric care, especially during labor and birth [3–5]. In this scenario, the collaborative obstetric care model is identified, with integration of doctors and obstetric nurses into the team, in addition to other professionals, such as doulas, aiming to reduce the use of unnecessary interventions and CSs [38]. Thus, there is a need for changes in the predominant and traditional model of obstetric care in Brazil, with improvements to the quality of prenatal care and childbirth and reductions in adverse outcomes for mothers and children.

Strengths and Limitations

This study has several strengths. To the best of our knowledge, this is the first study to use the Robson classification to assess CSs and early-term births. The Robson classification helps to identify target groups that may benefit from health implementations or interventions that contribute towards the reduction of CS rates in Brazil. The use of PSM made it possible to reduce the effect of confounding due to socioeconomic differences between live births of the women who had a vaginal delivery or CS. We also studied and compared early-term births by Robson subgroups and geographic areas of the country, rather than focusing on a small subset. However,

there are also a number of limitations to this study. The main limitation is the lack of data on maternal and fetal health conditions (e.g., preeclampsia and fetal distress). However, the Robson classification proved to be a viable proxy to assess the clinical indication of a CS through groups with the lowest and highest expected rates and clinical needs for CSs. Further limitation is the high percentage of missing data for some of the main variables used to classify women into one of the Robson Groups, and possible errors in identifying the onset labor. In addition, we do not know if the women went into labor and there was a failure in conducting the birth by professionals, with the use of obstetric interventions, which culminated in the evolution of CSs. In addition, residual confounding is possible, due to the lack of data on maternal comorbidities (e.g., diabetes and, hypertension), pregnancy body mass index, and the quality of local health services.

Conclusions

Our results provide evidence that CSs are associated with high odds of early-term births, with the highest observed among those born by CS in Robson groups 2 and 4. The association between cesarean delivery and early-term birth were also observed among live births of women in Group 3, 5, and 6 to 8. The results of this study provide important evidence for the implementation of public policies targeting the reduction of unnecessary CSs, especially the Robson groups with a low indication, which will consequently allow a reduction in the number of early-term births. We emphasize the importance of conducting further studies that focus on providing additional knowledge of early-term births, especially in countries with high CS rates.

List of abbreviations

CS	Cesarean section
CI	Confidence interval
CIDACS	Centre for Data and Knowledge Integration for Health
CIDACS-RL	Centre for Data and Knowledge Integration for Health - Record Linkage
ISC-UFBA	Federal University of Bahia's Collective Health Institute
LMICs	low- and middle-income countries
NICU	Neonatal Intensive Care Units
OR	Odds Ratio
PAF	population attributable fraction
PSM	propensity score matching
SINASC	National live birth system
HELLP	hemolysis, elevated liver enzymes and low platelets

Supplementary Information

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Supplementary Material 1

Authors' contributions
ASR and RCRS conceptualized and designed the study, conducted the analyses, drafted and revised the manuscript. ESP, FJAO, and MFA conceptualized and designed the study, contributed to data interpretation, and critically reviewed the intellectual content of the manuscript. MLB, LCR, and MYI conceptualized and designed the study, acquired data, contributed to data interpretation, and critically reviewed the intellectual content of the manuscript. IRF, RLF, CSST, and NO contributed to data interpretation and a critical review of the manuscript. All of the authors approved the final, submitted version of this manuscript, and accepted accountability for all aspects of this work.

Data availability
The data described in the manuscript, code book and analytical code will be made available upon request to the corresponding author, E-mail: linny_Rochaa@hotmail.com. Importantly, restrictions apply to the availability of these data. However, upon reasonable request and provided all ethical and legal requirements are met, the institutional data curation team can make the data available. Further information can be obtained at https://cidacs.bahia.fiocruz.br/acesso-aos-dados/.

Declarations

Ethics approval and consent to participate
This research was approved by the research ethics committee at the Institute of Collective Health, Federal University of Bahia (ISC-UFBA) (reference numbers 41695415.0.0000.5030 and 18022319.4.4.2319.4.5030), and the London School of Hygiene and Tropical Medicine, London, reference number 22817. This study exclusively employed secondary data. Secondary data from official information systems, made available for use in this project, were used in accordance with National Research Ethics Commission of the National Health Council standards, resolution 466 of December 2012. These standards define that use without the term of free and informed consent in health research, can be conducted in the impossibility of obtaining people's consent, considering that the research offers minimal risks, and the rights or interests of those involved are not violated, and privacy and anonymity are preserved. All procedures to pre-process and link administrative data were performed in a secure room at CIDACS: an environment with strict security and data protection procedures that follow the regulatory framework and ethical standards established in Brazil. None of the researchers in this study had access to any personally identifiable information. All de-identified database was used for analyses, which can only be accessed by previously authorized researchers. All steps subsequent to obtaining data were performed following CIDACS information security protocols.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Boerma T, Ronsmans C, Melesse DY, Barros AJD, Barros FC, Juan L, Moller A-B, Say L, Hosseinpoor AR, Yi M, et al. Global epidemiology of use of and disparities in caesarean sections. The Lancet. 2018;392(10155):1341–8.
2. Domingues RMSM, Dias MAB, Nakamura-Pereira M, Torres JA, d'Orsi E, Pereir APE, Schilithz AOC. Leal MdC: process of decision-making regarding the mode of birth in Brazil: from the initial preference of women to the final mode of birth. Cad Saúde Pública. 2014;30(1):101–S116.
3. Leal MdC. : Childbirth and birth in Brazil: an evolving scenario. In., vol. 34: SciELO Brasil; 2018.
4. Brasil. Portaria nº 1.459, de 24 de junho de 2011. In. Edited by Saúde Md: Diário Oficial da União; 2011.
5. Brasil. Resolução Normativa–RN Nº 368, de 6 de janeiro de 2015. In. Edited by Saúde Md, Suplementar ANdS; 2015.
6. Betran AP, Torloni MR, Zhang JJ, Gülmezoglu AM. WHO Statement on caesarean section rates. BJOG: an international journal of obstetrics and gynaecology. 2016;123(5):667–70.
7. Sandall J, Tribe RM, Avery L, Mola G, Visser GH, Homer CS, Gibbons D, Kelly NM, Kennedy HP, Kidanto H, et al. Short-term and long-term effects of caesarean section on the health of women and children. Lancet. 2018;392(10155):1349–57.
8. Barros FC, Rabello Neto DL, Villar J, Kennedy SH, Silveira MF, Diaz-Rossello JL, Victora CG. Caesarean sections and the prevalence of preterm and early-term births in Brazil: secondary analyses of national birth registration. BMJ Open. 2018;8(8):e021538.
9. Hutcheon JA, Joseph KS, Kinniburgh B, Lee L. Maternal, care provider, and institutional-level risk factors for early term elective repeat cesarean delivery: a population-based cohort study. Matern Child Health J. 2014;18(1):22–8.
10. Forde B, DeFranco EA. Association of prior cesarean delivery with Early Term Delivery and neonatal morbidity. Obstet Gynecol. 2020;135(6):1367–76.
11. do Carmo Leal M, Esteves-Pereira AP, Nakamura-Pereira M, Domingues RMSM, Dias MAB, Moreira ME, Theme-Filha M, da Gama SGN. Burden of early-term birth on adverse infant outcomes: a population-based cohort study in Brazil. BMJ open. 2017;7(12):e017789.
12. Sengupta S, Carrion V, Shelton J, Wynn RJ, Ryan RM, Singhal K, Lakshminrusimha S. Adverse neonatal outcomes associated with early-term birth. JAMA Pediatr. 2013;167(11):1053–9.
13. Brown HK, Speechley KN, Macnab J, Natale R, Campbell MK. Neonatal morbidity associated with late preterm and early term birth: the roles of gestational age and biological determinants of preterm birth. Int J Epidemiol. 2014;43(3):802–14.
14. Dong Y, Chen S, Yu J. A systematic review and Meta-analysis of Long-Term Development of Early Term Infants. Neonatology. 2012;102(3):212–21.
15. Bulut O, Buyukkayhan D. Early term delivery is associated with increased neonatal respiratory morbidity. Pediatr Int. 2021;63(1):60–4.
16. Petrou S. Health economic aspects of late preterm and early term birth. Semin Fetal Neonatal Med. 2019;24(1):18–26.
17. Delnord M, Mortensen L, Hindori-Mohangoo AD, Blondel B, Gissler M, Kramer MR, Richards JL, Deb-Rinker P, Rouleau J, Morisaki N, et al. International variations in the gestational age distribution of births: an ecological study in 34 high-income countries. Eur J Pub Health. 2018;28(2):303–9.
18. Robson MS. Classification of caesarean sections. Fetal and maternal medicine review. 2001;12(1):23–39.

19. WHO. Robson classification: implementation manual. In ed. Geneva: World Health Organization; 2017. 2020.
20. Brasil. Manual de instruções para o preenchimento da Declaração de Nascido Vivo. In. Edited by Departamento de Análise da Situação de Saúde, Saúde. SdVe. Brasília: Ministério da Saúde; 2011.
21. Brasil. Manual de procedimentos do sistema de informaÁies sobre nascidos vivos. In. Brasília: Ministério da Sa˙de: Fundação Nacional de Saúde; 2001: 32.
22. Oliveira MMd, Andrade SSCdA, Dimech GS, Oliveira JCGd, Malta DC. Rabello Neto DdL, Moura Ld: Avaliação do Sistema de Informações sobre Nascidos Vivos. Brasil, 2006 a 2010. Epidemiologia e Serviços de Saúde. 2015;24:629–40.
23. Austin MP, Leader L. Maternal stress and obstetric and infant outcomes: epidemiological findings and neuroendocrine mechanisms. Aust N Z J Obstet Gynaecol. 2000;40(3):331–7.
24. Newson RB. Attributable and unattributable risks and fractions and other scenario comparisons. Stata J. 2013;13(4):672–98.
25. Raspantini PR, Miranda MJd S, ZPd, Alencar GP, Diniz SG. Almeida MFd: O impacto do tipo de hospital e tipo de parto sobre a idade gestacional ao nascer no Município de São Paulo, 2013–2014. Revista Brasileira de Epidemiologia. 2016;19:878–82.
26. Nakamura-Pereira M, do Carmo Leal M, Esteves-Pereira AP, Domingues RM, Torres JA, Dias MA, Moreira ME. Use of Robson classification to assess cesarean section rate in Brazil: the role of source of payment for childbirth. Reproductive health. 2016;13(Suppl 3):128.
27. Paixao ES, Bottomley C, Smeeth L, da Costa MCN, Teixeira MG, Ichihara MY, Gabrielli L, Barreto ML, Campbell OMR. Using the Robson classification to assess caesarean section rates in Brazil: an observational study of more than 24 million births from 2011 to 2017. BMC Pregnancy Childbirth. 2021;21(1):589.
28. Barros FC, Matijasevich A, Maranhão AGK, Escalante JJ, Rabello Neto DL, Fernandes RM, Vilella MEA, Matos AC, Albuquerque C. Ponce de Léon RG: cesarean sections in Brazil: will they ever stop increasing? Revista Panam de Salud Pública. 2015;38:217–25.
29. Eufrásio LS, Souza, DEd. Fonsêca AMCd, Viana EdSR: brazilian regional differences and factors associated with the prevalence of cesarean sections. Fisioterapia em Movimento 2018, 31.
30. Diniz CSG, Miranda MJd, Reis-Queiroz J, Queiroz MR, Salgado HdO. Por que as mulheres no setor privado têm gestações mais curtas no Brasil? Desvio à esquerda da idade gestacional, cesárea e inversão da disparidade esperada. J Hum Growth Dev. 2016;26(1):33–40.
31. Dodd J, Crowther C, Haslam R, Robinson J. Group TToBT: elective birth at 37 weeks of gestation versus standard care for women with an uncomplicated twin pregnancy at term: the twins timing of Birth Randomised Trial. BJOG: An International Journal of Obstetrics & Gynaecology. 2012;119(8):964–74.
32. Bakr AF, Karkour T. What is the optimal gestational age for twin delivery. BMC Pregnancy Childbirth. 2006;6(1):3.
33. Zafman KB, Rebarber A, Melka S, Naqvi M, Fox NS. Induction of Labor versus Cesarean Delivery in Twin Pregnancies. Am J Perinatol. 2020;37(13):1324–34.
34. Tong Y, Sun Q, Shao X, Han F. A randomized trial in comparison between planned cesarean and vaginal delivery on twin pregnancy. Ginekologia polska. 2020;91(10):600–6.
35. Korb D, Deneux-Tharaux C, Seco A, Goffinet F, Schmitz T. Risk of severe acute maternal morbidity according to Planned Mode of Delivery in Twin Pregnancies. Obstet Gynecol. 2018;132(3):647–55.
36. Mylonas I, Friese K. Indications for and risks of Elective Cesarean Section. Deutsches Arzteblatt international. 2015;112(29–30):489–95.
37. ACOG. ACOG Committee Opinion No 579: definition of term pregnancy. Obstet Gynecol. 2013;122(5):1139–40.
38. Vogt SE, Silva KSd, Dias MAB. Comparação de modelos de assistência ao parto em hospitais públicos. Revista de Saúde Pública. 2014;48:304–13.

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