Provider-Initiated Late Preterm Births in Brazil: Differences between Public and Private Health Services

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Abstract

Background

A large proportion of the rise in prematurity worldwide is owing to late preterm births, which may be due to the expansion of obstetric interventions, especially pre-labour caesarean section. Late preterm births pose similar risks to overall prematurity, making this trend a concern. In this study, we describe factors associated with provider-initiated late preterm birth and verify differences in provider-initiated late preterm birth rates between public and private health services according to obstetric risk.

Methods

This is a sub-analysis of a national population-based survey of postpartum women entitled “Birth in Brazil”, performed between 2011 and 2012. We included 23,472 singleton live births. We performed non-conditional multiple logistic regressions assessing associated factors and analysing differences between public and private health services.

Results

Provider-initiated births accounted for 38% of late preterm births; 32% in public health services and 61% in private health services. They were associated with previous preterm birth (s) and maternal pathologies for women receiving both public and private services and with maternal age ≥35 years for women receiving public services. Women receiving private health services had higher rates of provider-initiated late preterm birth (rate of 4.8%) when compared to the ones receiving public services (rate of 2.4%), regardless of obstetric risk–adjusted OR of 2.3 (CI 1.5–3.6) for women of low obstetric risk and adjusted OR of 1.6 (CI 1.1–2.3) for women of high obstetric risk.
Conclusion

The high rates of provider-initiated late preterm birth suggests a considerable potential for reduction, as such prematurity can be avoided, especially in women of low obstetric risk. To promote healthy births, we advise introducing policies with incentives for the adoption of new models of birth care.

Introduction

Numbers of preterm births have recently risen in middle and high-income countries [1]. This leads to increased costs for the healthcare system, as well as potential harm to newborns and their families [2, 3]. In 2005, a committee of experts organized by the National Institute of Child Health and Human Development of the National Institutes of Health (NIH) in the USA suggested the term “late preterm” should be used for newborns with GA between 34 0/7 and 36 6/7 weeks [3]. The rise of preterm births worldwide is largely due to late preterm [4], which is partially related to increased obstetric interventions designed to reduce maternal and fetal complications, such as labour induction and pre-labour caesarean section (C-section) [5]. Nevertheless, there is often not enough evidence to recommend these interventions in many cases where they have been performed [6]; i.e., the medical records fail to show appropriate medical indications, suggesting they are not indicated. Brazil is known for having one of the world’s highest rates of C-section [7]. In 2013, levels reached 56%; 43% among women receiving public healthcare and 88% among women receiving private healthcare at childbirth [8]. Many C-sections are reported as conducted for non-medical reasons [9], including those among preterm births (S1 Table) [10].

The impact of late prematurity on newborn health was long neglected as the length and weight of these infants are similar to full-term infants, and they appear not to require much extra healthcare at birth [11]. However, the last weeks before reaching full-term (39–40 weeks gestation) may have significant implications for newborn health [12]. The first studies to suggest that late prematurity poses similar risks to overall prematurity (although at lower frequency and severity) were published a decade ago [3, 13]. Compared with those born at full-term, late preterm infants are more likely to experience respiratory distress syndrome, intraventricular haemorrhage, neonatal or infant death, and long-term neurodevelopmental problems [14–16].

According to the WHO, Brazil is among the 10 countries that contribute most to the burden of prematurity worldwide [17]. However, the magnitude of late prematurity in the country was unknown until 2012, because official health statistics reported gestational ages (GA) at broad intervals [18]. The first national survey into labour and birth was performed in Brazil in 2011 [19, 20]. This described the prevalence of prematurity, its subtypes and associated factors. The study found a prematurity rate of 11.5%, among which 74% were late-premature and 39% were provider-initiated (either determined by labour induction or pre-labour C-section) (S2 Table) [21].

Public and private health services in Brazil employ the same birth care professionals, but organise obstetric care differently [22]. In public health services, medical practitioners work in shifts and pregnant women receive prenatal care in Health Units with obstetric physicians or nurses. Women receive birth care by the staff on duty in the hospital to which they are referred. In private health services, the same physician who provides prenatal care usually provides birth
care in a hospital with an open clinic staff; a factor associated with its higher C-section rates [22]. It is unknown, however, whether these idiosyncrasies of public and private obstetric care in Brazil lead to differences in the rates of provider-initiated late preterm birth. Therefore, this study aims to verify differences in the rates of provider-initiated late preterm birth between public and private health services, in women of low and high obstetric risk. We also describe the subtypes and factors associated with provider-initiated late preterm birth in both sources of healthcare provision.

Materials and Methods

Data source

The “Birth in Brazil study” was a national population-based study of postpartum women and their newborns, conducted from February 2011 to October 2012. It recruited a complex sample of 266 hospitals, with 90 postpartum women interviewed in each hospital and a total 23,894 women. Further information about the sample is detailed elsewhere [23]. In the sampled hospitals, women were invited to participate if they gave birth to a live newborn (regardless of weight or GA) or to a stillborn (with birth weight ≥500g and/or GA ≥22 weeks) during the observation period.

Face-to-face interviews were held with the postpartum women during their hospital stay. Further data about the women and their newborns were collected from their medical records and extracted from photographs of prenatal care cards. Women and newborns remaining as inpatients, including those transferred to other hospitals, were tracked for up to 28 days and 42 days, respectively. Further details on data collection have been published elsewhere [19].

Participants

For the current analysis, we excluded stillbirths, women with unknown GA and multiple pregnancies.

Our final sample included 23,472 singleton live births with known GA. Of these, 10,443 were full-term, defined as GA at birth between 39 0/7 and 40 6/7 weeks of gestation and 1,785 were late preterm, defined as GA at birth between 34 0/7 and 36 6/7 weeks of gestation. A further 11,244 newborns were of other GA at birth. Gestational age was calculated using an algorithm that primarily relied upon early ultrasound estimates [18]. For analysis of provider-initiated-late-preterm birth associated factors we also excluded premature deliveries at 20–33 weeks gestation, term deliveries at 37, 38 or 41 weeks gestation and all post-term deliveries (≥42 weeks gestation) (Fig 1). Excluding these selected GA ranges ensured a comparison group with a lower prevalence of factors related to early or late GA.

Outcome variable

The primary outcome was the incidence of provider-initiated late preterm births, i.e., those triggered by an obstetric intervention (induction of labour or pre-labour C-section), as opposed to spontaneous late preterm births, which either initiated spontaneously or by premature rupture of membranes (pProm).

Firstly, we analysed factors associated with provider-initiated late preterm births relative to full-term births, stratifying by public and private health services. Secondly, we analysed differences in the rate of provider-initiated late preterm births between public and private health services, stratifying by obstetric risk (described below). The rates were calculated by dividing the number of provider-initiated late preterm births by the number of singleton live births of all gestational ages.
Exposure variables and definitions

We evaluated maternal age, years of schooling, parity, previous preterm birth(s), previous C-section, non-cephalic presentation, and obstetric risk characteristics, which were analysed separately and in combination. Women were classified to have high obstetric risk if they had maternal and/or newborn health problems, as well as obstetric complications. These included...
hypertensive disorders (chronic hypertension, preeclampsia, and HELLP syndrome); eclampsia; pre-existing and gestational diabetes; renal, cardiac or autoimmune diseases; severe infection at admission for birth; placental abruption; placental previa; intrauterine growth restriction (IUGR); or severe newborn malformations (those potentially related to indication for C-section and/or prematurity). Age and schooling were collected through interviewing the mother, and all other variables were extracted from medical records.

The obstetric risk was independently performed and validated by two obstetricians who also classified the prematurity determining factor (as spontaneous, Pprom or provider-initiated).

Women who gave birth in public or mixed-funding hospitals, but who were not covered by private health insurance plans, were classified as receiving public health services/care at childbirth. Women whose birth was covered by a private health insurance plan, and those who gave birth in private hospitals regardless of coverage by a health insurance plan, were classified as receiving private health services/care at childbirth.

Statistical analysis

We analysed differences in participant characteristics between public and private health services using chi square. Differences in the distribution of the determining factor (spontaneous, Pprom or provider-initiated) between public and private health services were also analysed using chi square.

To assess provider-initiated late prematurity associated factors relative to full-term births, we performed non-conditional multiple logistic regressions stratified by source of healthcare provision (public or private). We report the estimated crude odds ratio (OR) and adjusted odds ratio (adjOR) with 95% confidence intervals (CI).

We analysed differences in the rate of provider-initiated late preterm births between public and private health services by means of non-conditional multiple logistic regressions, stratified by maternal obstetric risk (low or high). We report the estimated crude OR and adjOR with 95% CI. We performed two different adjustments for confounders. First, we adjusted for maternal age, years of schooling, parity, previous preterm birth(s), and non-cephalic presentation. Second, we adjusted for all these variables plus previous C-section.

In all statistical analyses, the complex sampling design was taken into consideration. A significance level of 5% was adopted for all analyses. The statistical program used was SPSS, version 20.0 (SPSS Inc., Chicago, IL, USA).

Ethical approval

This study was carried out in accordance with the National Health Council Resolution n. 196/96. The ethics committee of the Sérgio Arouca National School of Public Health, Oswaldo Cruz Foundation (CEP/ENSP), approved this study under the research protocol CAAE: 0096.0.031.000–10 (approval date: May 11th 2010). All hospital directors and postnatal women gave written informed consent.

Results

Of the 1,785 late preterm births identified in this study, 1,107 (62%) were spontaneous: 448 (25%) with spontaneous onset of labour and 659 (37%) with Pprom. The remaining 678 (38%) were provider-initiated, among which 627 (92%) were by pre-labour C-section (Fig 1).

Maternal characteristics varied according to source of healthcare provision, in both late preterm and full-term births. Users of public health services were younger, had lower schooling levels, higher parity, and fewer previous C-sections. There were no differences in maternal and neonatal pathologies, or obstetric complications between the public and private health services,
except for placental abruption, which was higher in public services. Among late preterms, 64% were born to mothers with no obstetric risk, without significant difference between type of health services received (Table 1).

Regarding late preterms in women receiving public healthcare, 28.6% of labours began spontaneously, 39.4% were preceded by PProm, and 31.9% were provider-initiated. In women receiving private healthcare, these values were 11.6%, 27.3%, and 61.1%, respectively. For full-term infants, most births in women receiving public healthcare were spontaneous or preceded by PProm, while in women receiving private healthcare 75.9% were provider-initiated (Table 2).

In public health services, 18.0% of women who went into late preterm spontaneous labour and 25.6% who had a PProm underwent a C-section. In women receiving private care, C-section proportions were three-fold higher for these two groups. C-section procedures were mostly pre-labour, regardless of the determining factor (PProm or provider-initiated), gestational age (late preterm or full term) or type of health services (public or private) (Table 2).

In the adjusted analysis, factors associated with provider-initiated late prematurity were the same in public and private health services, except for age above 35 and previous C-section, which were only associated with public healthcare provision. The strength of the association was higher for almost all pathologies in women receiving private healthcare (Table 3).

The rate of provider-initiated late preterm birth was of 2.9%–2.4% for women receiving public health services and 4.8% for women receiving private health services. After adjusting for confounders, women receiving private healthcare had higher odds of provider-initiated late preterm birth regardless of obstetric risk. For women of low obstetric risk the adjusted OR was of 2.3 (CI 1.5–3.6) and for the ones of high obstetric risk the adjusted OR was of 1.6 (CI 1.1–2.3) (Table 4).

Discussion
Main Findings

In Brazil, one in nine births is preterm (S2 Table) [21]. In this study, late prematurity accounted for 75% of all preterm births, and around 40% of these were provider-initiated births. Labour induction practice was low in public health services, and almost nil in private health services. Provider-initiated late prematurity was associated with previous preterm birth(s) and maternal pathologies in both health services, and with maternal age ≥35 years in public health services only. The higher rate of provider-initiated late preterm birth in women receiving private healthcare compared with the ones receiving public care was independent of obstetric risk.

Strengths and Limitations

The strength of this study is that we have used a representative nationwide survey, with primary data collected from medical records. This allowed, for the first time, a description of the national late prematurity rate and its determinants, as well as a more accurate gestational age estimate calculated by an algorithm that primarily relied upon early ultrasound estimates [18]. Furthermore, we stratified the analysis by source of healthcare provision (public or private) and according to obstetric risk (low or high). The obstetric risk was independently performed and validated by two obstetricians who also classified the prematurity determining factor (as spontaneous, PProm or provider-initiated). Nonetheless, we failed to analyse whether C-section indication was appropriate on a case-by-case basis.

Interpretation

Maternal age, previous C-section, and non-cephalic presentation were not associated with provider-initiated late prematurity in private health services, as in the public services. This could
Table 1. Characteristics of women by gestational age and type of childbirth care in singleton live births. Birth in Brazil, 2011–2012.

|                     | Public Late preterm (34–36 weeks) | Public Full term (39–40 weeks) | Private Late preterm (34–36 weeks) | Private Full term (39–40 weeks) | P-value* Public vs. Private |
|---------------------|-----------------------------------|--------------------------------|-----------------------------------|--------------------------------|-----------------------------|
| n (%)               | n (%)                             | n (%)                          | n (%)                             | n (%)                          |                             |
| **Total**           | 1,415 (100.0)                     | 8,576 (100.0)                  | 370 (100.0)                       | 1,867 (100.0)                  |                             |
| **Age**             |                                   |                                |                                   |                                |                             |
| 12 to 19            | 382 (27.0)                        | 1,845 (21.5)                   | 18 (4.9)                          | 106 (5.7)                      | **<0.001**                  |
| 20 to 34            | 903 (63.8)                        | 6,067 (70.7)                   | 284 (76.8)                        | 1,451 (77.7)                   |                             |
| > 35                | 130 (9.2)                         | 664 (7.7)                      | 68 (18.4)                         | 310 (16.6)                     |                             |
| **Years of schooling** |                                   |                                |                                   |                                |                             |
| ≤ 7                 | 479 (33.9)                        | 2,559 (29.8)                   | 12 (3.2)                          | 73 (3.9)                       | **<0.001**                  |
| 8 to 10             | 440 (31.1)                        | 2,649 (30.9)                   | 41 (11.1)                         | 181 (9.7)                      |                             |
| 11 to 14            | 444 (31.4)                        | 3,128 (36.5)                   | 212 (57.3)                        | 948 (50.8)                     |                             |
| ≥ 15                | 52 (3.7)                          | 240 (2.8)                      | 105 (28.4)                        | 665 (35.6)                     |                             |
| **Previous births** |                                   |                                |                                   |                                |                             |
| 0                   | 680 (48.1)                        | 3,873 (45.2)                   | 191 (51.6)                        | 1,067 (57.2)                   | **<0.001**                  |
| 1 to 2              | 556 (39.3)                        | 3,760 (43.8)                   | 164 (44.3)                        | 767 (41.1)                     |                             |
| ≥ 3                 | 179 (12.7)                        | 943 (11.0)                     | 15 (4.1)                          | 33 (1.8)                       |                             |
| **Previous preterm birth** |                                   |                                |                                   |                                |                             |
| No                  | 549 (74.6)                        | 4,283 (91.1)                   | 130 (72.6)                        | 738 (92.3)                     | 0.874                       |
| Yes                 | 187 (25.4)                        | 421 (9.0)                      | 49 (27.4)                         | 62 (7.8)                       |                             |
| **Previous caesarean section** |                                   |                                |                                   |                                |                             |
| No                  | 513 (69.7)                        | 3,028 (64.4)                   | 65 (36.3)                         | 273 (34.1)                     | **<0.001**                  |
| 1                   | 149 (20.2)                        | 1,232 (26.2)                   | 91 (50.8)                         | 456 (57.0)                     |                             |
| ≥ 2                 | 74 (10.1)                         | 443 (9.4)                      | 23 (12.8)                         | 71 (8.9)                       |                             |
| **Newborn presentation** |                                   |                                |                                   |                                |                             |
| Cefalic             | 1,347 (95.1)                      | 8,299 (96.7)                   | 350 (94.6)                        | 1,797 (96.2)                   | 0.185                       |
| Non-CEFALIC         | 70 (4.9)                          | 279 (3.3)                      | 20 (5.4)                          | 71 (3.8)                       |                             |
| **Obstetric risk**  |                                   |                                |                                   |                                |                             |
| Hypertensive disorders | 265 (18.7)                       | 765 (8.9)                      | 91 (24.6)                         | 136 (7.3)                      | 0.822                       |
| Eclampsia           | 21 (1.5)                          | 34 (0.4)                       | 10 (2.7)                          | 7 (0.4)                        | 0.242                       |
| Preexisting Diabetes | 33 (2.3)                          | 82 (1.0)                       | 4 (1.1)                           | 14 (0.7)                       | 0.144                       |
| Gestational Diabetes | 157 (11.1)                       | 707 (8.2)                      | 47 (12.7)                         | 128 (6.9)                      | 0.207                       |
| Severe chronic diseases | 18 (1.3)                          | 49 (0.6)                       | 4 (1.1)                           | 23 (1.2)                       | 0.090                       |
| Infection at hospital admission for birth | 10 (0.7)                         | 20 (0.2)                       | 4 (1.1)                           | 2 (0.1)                        | 0.860                       |
| Abruptio placentae  | 45 (3.2)                          | 91 (1.1)                       | 8 (2.2)                           | 6 (0.3)                        | 0.004                       |
| Placental praevia   | 13 (0.9)                          | 33 (0.4)                       | 10 (2.7)                          | 4 (0.2)                        | 0.311                       |
| IUGR                | 101 (7.1)                         | 395 (4.6)                      | 51 (13.8)                         | 64 (3.4)                       | 0.713                       |
| Major newborn malformation | 4 (0.3)                          | 5 (0.1)                       | 1 (0.3)                           | 1 (0.1)                        | 0.993                       |
| **Any of the above** | 485 (34.3)                        | 1,818 (21.2)                   | 160 (43.2)                        | 336 (18.0)                     | 0.405                       |
| **Determining factor** |                                   |                                |                                   |                                |                             |
| Spontaneous         | 638 (45.1)                        | 4,725 (55.1)                   | 53 (14.3)                         | 298 (16.0)                     | **<0.001**                  |
| Prom                | 290 (20.5)                        | 873 (10.2)                     | 91 (24.6)                         | 120 (6.4)                      | 0.405                       |
| Provider initiated   | 489 (34.6)                        | 2,980 (34.7)                   | 226 (61.1)                        | 1,450 (77.7)                   |                             |

* χ² test.  
1 Considering women with at least one previous birth (public 34–36, n: 736; public 39–40, n:4704; private 34–36 n:179; private 39–40 n:800).  
2 Chronic hypertension, pre-eclampsia and hellp syndrome.  
3 Chronic renal diseases, chronic cardiac diseases and auto-immune diseases.  
4 Malformations potentially related to caesarean section indication and/or prematurity.

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be attributed to the indiscriminate use of interventions in private health services, independent of a patient’s characteristics, as well as the high prevalence of the interventions in the full-term comparison group. Nakamura-Pereira et al. (2016) have previously observed that in private health services C-section rate in cephalic presentation preterms was 77%, even among women at low obstetric risk (S1 Table) [10].

Women receiving public healthcare live in poorer socioeconomic conditions and face barriers of access to prenatal care more frequently [24, 25]. However, the prevalence of maternal morbidities was comparable to women receiving private healthcare. On the other hand, we observed a stronger association between these morbidities and provider-initiated late prematurity in private health services. This may indicate greater anticipation of birth even under the same health conditions. Possible explanations would be the easier access to neonatal ICU in private hospitals, as well as unawareness or minimization of the risks of late preterm infants, who are generally still immature [22].

In the short term, late preterm infants are vulnerable to thermal instability, breastfeeding difficulties, hypoglicemia, hyperbilirubinemia, infections, and respiratory morbidities. This leads to a greater need for neonatal ICU and readmission after birth [26, 27]. In the long term, they have a higher risk of respiratory diseases, infant hospitalisation, neurodevelopmental

| Table 2. Determining factor and type of delivery by gestational age and type of childbirth care in singleton live births. Birth in Brazil, 2011–2012. |
|---------------------------------|--------------|--------------|-----------------|-----------------|
|                                | Public n (%) | Private n (%) | P-value*        | Total n (%)     |
|--------------------------------|--------------|--------------|-----------------|-----------------|
| **34–36 weeks**                |              |              |                 |                 |
| Total                          | 1,415 (100.0)| 370 (100.0)  | <0.001          | 1,785 (100.0)   |
| Spontaneous                    | 405 (28.6)   | 43 (11.6)    |                 | 448 (25.1)      |
| Vaginal                        | 332          | 19           |                 | 351             |
| Caesarean                      | 73 (18.0)    | 24 (55.8)    |                 | 97 (21.7)       |
| Pprom                           | 558 (39.4)   | 101 (27.3)   | 0.001           | 659 (36.9)      |
| Vaginal                        | 415          | 22           |                 | 437             |
| Caesarean                      | 143 (25.6)   | 79 (78.2)    |                 | 222 (33.7)      |
| Pre-labour CS                  | 115 (80.2)   | 70 (88.5)    |                 | 185 (83.4)      |
| Provider initiated             | 452 (31.9)   | 226 (61.1)   | <0.001          | 678 (38.0)      |
| Vaginal                        | 46           | 5            |                 | 51              |
| Caesarean                      | 406 (89.8)   | 221 (97.8)   |                 | 627 (92.5)      |
| Pre-labour CS                  | 404 (99.5)   | 221 (100.0)  |                 | 625 (99.7)      |
| **39–40 weeks**                |              |              |                 |                 |
| Total                          | 8,576 (100.0)| 1,867 (100.0)|                 | 10,443 (100.0)  |
| Spontaneous                    | 3,171 (37.0) | 220 (11.8)   | <0.001          | 3,391 (32.5)    |
| Vaginal                        | 2,639        | 153          |                 | 2,792           |
| Caesarean                      | 532 (16.8)   | 67 (30.5)    |                 | 599 (17.7)      |
| Pprom                           | 2,576 (30.0) | 230 (12.3)   | <0.001          | 2,806 (26.9)    |
| Vaginal                        | 2,036        | 110          |                 | 2,146           |
| Caesarean                      | 540 (21.0)   | 120 (52.2)   |                 | 660 (23.5)      |
| Pre-labour CS                  | 426 (78.8)   | 95 (79.2)    |                 | 521 (78.9)      |
| Provider initiated             | 2,829 (33.0) | 1,417 (75.9) | <0.001          | 4,246 (40.7)    |
| Vaginal                        | 398          | 22           |                 | 420             |
| Caesarean                      | 2,431 (85.9) | 1,395 (98.4) |                 | 3,826 (90.1)    |
| Pre-labour CS                  | 2,415 (99.3) | 1,392 (99.8) |                 | 3,807 (99.5)    |

* χ2 test.

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problems, and poorer school performance [26–28]. Probably many infants in Brazil are unnecessarily being placed at risk for these outcomes.

Our data reaffirm that the prevalence of provider-initiated births in Brazil is one of the highest worldwide. This is especially true in private health services, which shows an inverted pattern of two thirds of births determined by an obstetric intervention. In contrast, two thirds of

| Exposure variables | Public (n = 452 provided-initiated late preterm vs. 8,576 full term) | Private (n = 226 provided-initiated late preterm vs. 1,867 full term) |
|--------------------|-------------------------------------------------------------------|------------------------------------------------------------------|
| Age                | OR                      | OR adj.¹                | CI                       | OR                      | OR adj.¹                | CI                       |
| 12 to 19           | 1.03                   | 1.07                   | (0.79–1.44)               | 0.90                    | 1.03                   | (0.41–2.60)               |
| 20 to 34           | 1.00                   | 1.00                   | -                        | 1.00                    | 1.00                   | -                        |
| ≥ 35               | 1.76                   | 1.69                   | (1.20–2.39)               | 1.25                    | 1.20                   | (0.75–1.93)               |
| Years of schooling | ≤ 7                   | 0.59                   | 0.59 (0.33–1.04)          | 0.42                    | 0.37                   | (0.14–1.00)               |
|                    | 8 to 10                | 0.59                   | 0.63 (0.35–1.13)          | 1.03                    | 1.03                   | (0.57–1.88)               |
|                    | 11 to 14               | 0.66                   | 0.70 (0.41–1.20)          | 1.07                    | 1.07                   | (0.77–1.49)               |
|                    | ≥ 15                  | 1.00                   | 1.00                   | 1.00                   | 1.00                   | -                        |
| Previous births    | 0                     | 1.12                   | 1.12 (0.84–1.50)          | 0.82                    | 0.81                   | (0.60–1.09)               |
|                    | 1 to 2                | 1.00                   | 1.00                   | -                      | 1.00                    | 1.00                   |
|                    | ≥ 3                   | 1.38                   | 1.33 (0.87–2.04)          | 1.77                    | 1.51                   | (0.44–5.13)               |
| Previous preterm birth | No               | 1.00                   | 1.00                   | -                      | 1.00                    | 1.00                   |
|                    | Yes                  | 4.09                   | 3.74                   | (2.54–5.52)             | 4.40                    | 4.53                   | (2.35–8.75)               |
| Previous caesarean section | No      | 1.00                   | 1.00                   | -                      | 1.00                    | 1.00                   |
|                    | Yes                 | 1.78                   | 1.64                   | (1.21–2.22)             | 1.13                    | 1.04                   | (0.52–2.12)               |
| Newborn presentation | Cefalic         | 1.00                   | 1.00                   | -                      | 1.00                    | 1.00                   |
|                    | Non-cefalic          | 2.78                   | 2.67                   | (1.76–4.06)             | 1.01                    | 0.95                   | (0.52–1.73)               |
| Obstetric risk     | Hypertensive disorders² | 6.56                   | 5.99                   | (4.33–8.29)             | 7.37                    | 8.18                   | (5.68–11.8)               |
|                    | Eclampsia            | 10.16                  | 9.54                   | (4.90–18.57)            | 11.51                   | 11.82                   | (3.38–41.39)              |
|                    | Preexisting Diabetes | 5.01                   | 4.73                   | (2.38–9.43)             | 1.64                    | 1.38                   | (0.31–6.26)               |
|                    | Gestational Diabetes | 2.51                   | 2.36                   | (1.69–3.29)             | 2.80                    | 2.66                   | (1.73–4.08)               |
|                    | Severe chronic diseases³ | 3.98                   | 3.66                   | (1.06–12.64)            | 1.62                    | 1.59                   | (0.59–4.32)               |
|                    | Infection at hospital admission for birth | 2.92                   | 1.78                   | (0.53–6.02)             | 14.60                   | 12.74                   | (2.33–69.55)              |
|                    | Placental abruptio    | 6.11                   | 5.40                   | (3.01–9.75)             | 10.40                   | 9.25                   | (3.09–27.67)              |
|                    | Placental praevia     | 4.85                   | 3.55                   | (1.08–11.68)            | 16.73                   | 15.02                   | (4.63–48.81)              |
|                    | IUOG                 | 3.88                   | 3.83                   | (2.51–5.82)             | 6.95                    | 6.73                   | (2.96–15.28)              |
|                    | Severe newborn malformation⁴ | 9.76                   | 5.08                   | (0.64–39.98)            | 7.33                    | 7.67                   | (0.55–106.42)             |
|                    | Any of the above (high obstetric risk) | 6.63                   | 6.34                   | (4.63–8.69)             | 7.00                    | 7.10                   | (5.32–9.48)               |

¹ Adjusted for age, years of schooling, parity, previous preterm birth, previous CS, non-cefalic presentation and obstetric risk.
² Chronic hypertension, pre-eclampsia and hellp syndrome.
³ Chronic renal diseases, chronic cardiac diseases and auto-imune diseases.
⁴ Malformations potentially related to caesarean section indication and/or prematurity.

Table 3. Factors associated with provider-initiated late preterm birth (34–36 wks) relative to full term birth (39–40 wks) by type of childbirth care in singleton live births. Birth in Brazil, 2011–2012.

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preterm births from high-income countries occur spontaneously [6, 15]. The major intervention characterising Brazilian obstetric care is C-section. We observed that 53% of late preterm births were by C-section, among which 86% were pre-labour C-section. Unsurprisingly, labour induction practice corresponded to less than 10% of births; around 20% in public health services and only 4% in the private.

Brazilian private health services schedule birth care to optimise physician’s time and usually the same physician provides both prenatal and birth care. As such, several deliveries are set for the same date, in agreement with the pregnant women [8, 29, 30]. Thus, receiving prenatal and birth care from the same practitioner turned out to be the highest risk factor for having a C-section [22]. This is probably the main reason rates of pre-labour C-section are particularly high in Brazilian private health services [7, 10, 22, 29].

C-section can impact negatively woman’s obstetric life. There is substantial evidence that C-section increases the risk of placenta previa and accreta in subsequent pregnancies [31], severe acute maternal morbidity [32], and mortality [33]. In addition, newborns endure losses in breastfeeding [12] and have smaller diversification of the intestinal microbiota [34], which has been related to chronic diseases in adult life [35–38].

We found higher odds of provider-initiated late preterm birth in women receiving private care compared with the ones receiving public healthcare. This was regardless of the obstetric risk classification of the women (low or high) and adjustment for confounding variables. However, when adjusted for previous C-section, there was a reduction in the OR for low-risk women. This implies that, for low-risk women, the association was partially explained by a higher prevalence of previous C-section in private health services. This was not evident in the adjusted model of Table 3 owing to the extremely high frequency of mothers with previous C-section in the full-term comparison group from private health services.

According to recommendations from the American Congress of Obstetricians and Gynecologists [39], most women with one previous C-section with a low-transverse incision are

| Table 4. Private childbirth care associated with provider-initiated late preterm rate (%) in singleton live births. Birth in Brazil, 2011–2012. |
|---------------------------------------------------------------|
| Singleton live births | Provider-initiated late preterm birth | Absolute rate differences | Crude OR | adj. OR¹ (CI) | adj. OR² (CI) |
|----------------------|----------------------------------|-----------------------------|---------|--------------|--------------|
| All women            | 23,472                           | 678                         | 2.9     |              |              |
| Public               | 18,809                           | 452                         | 2.4     |              |              |
| Private              | 4,663                            | 226                         | 4.8     | 2.4          | 2.07 (1.27–2.40) | 1.65 (1.21–2.25) |
| Low obstetric risk women | 17,945                          | 248                         | 1.4     |              |              |
| Public               | 14,443                           | 159                         | 1.1     |              |              |
| Private              | 3,502                            | 89                          | 2.5     | 1.4          | 2.35 (1.53–3.58) | 2.15 (1.41–3.30) |
| High obstetric risk women | 5,527                           | 430                         | 7.8     |              |              |
| Public               | 4,366                            | 293                         | 6.7     |              |              |
| Private              | 1,161                            | 137                         | 11.8    | 5.1          | 1.86 (1.10–2.32) | 1.58 (1.09–2.27) |

1 Adjusted for age, years of schooling, parity, previous preterm birth and non-cefalic presentation.
2 Adjusted for age, years of schooling, parity, previous preterm birth, non-cefalic presentation and previous CS.

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candidates for and should be counselled about vaginal birth after cesarean (VBAC) and offered a trial of labour after C-section [40]. Studies have referred to a 70% VBAC success rate [41], which should be incorporated into Brazilian obstetric practice, as repetitive C-section further increases the risk of haemorrhage, abnormal placenta [31], and uterine rupture [42] in subsequent pregnancies.

In the USA, it has been quantified that one in five late preterm births were not registered as indicated for an intervention in the medical records [6]. Therefore, it was suggested that other non-clinical factors might have influenced the decision at the moment of intervention. The authors of the study strongly recommended the reduction of iatrogenic interventions, and suggested the use of guidelines to optimise and plan the timing and route of delivery. The Institute of Medicine (IOM) estimated a burden of prematurity in the USA of about $26 billion or $51,600 per child [43]. It is worth noting that provider-initiated prematurity has been reduced recently in the USA [44].

Excessive perinatal interventions (in mothers and newborns), independent of obstetric/fetal risks, have previously been reported in private health services of Brazil [9, 12] and Australia [45]. Our study estimated the effect on rates of prematurity if, among low-risk women, rates of provider-initiated late preterm births were the same in private services as in public services. We found that the prematurity rate would decrease to 11% (from 9.5% to 8.4%) in private health services. This would indicate an annual reduction of approximately 6,600 preterm births nationally. It is essential to highlight that there would be a higher impact on preterm birth rates if provider-initiated late preterm births were prevented in women of high obstetric risk as well. Although this group corresponded to 24% of women, provider-initiated late preterm birth rate was more than five times higher when compared to women of low obstetric risk; with additional differences between public and private services. Moreover, the potential for reduction of preterm birth rates in Brazil can be of greater magnitude if the comparison group is external (from high-income European countries) rather than Brazilian public health services, which is yet quite interventionist.

Conclusion

We found a very high rate of provider-initiated late preterm births in Brazil, mostly performed by pre-labour C-section. It has been demonstrated that many of the indications for interventions to anticipate birth were not based on scientific evidence. This suggests a considerable potential for reduction as such prematurity can be avoided, as opposed to cases of spontaneous occurrence with an unknown cause. Excessive use of C-section will likely lead directly to increased costs for the healthcare system due to surgery, greater use of neonatal ICU, and maternal near misses. A further indirect cost is the association with short- and long-term morbidity of women and children. To reduce iatrogenic prematurity and promote healthy births, it is advisable to introduce policies with incentives for the adoption of new models of birth care in Brazil. In particular, these should be directed to adequate prenatal care for women with obstetric pathologies and appropriate indication of the timing of birth.

Supporting Information

S1 File. Database.
(ZIP)

S1 Table. Proportion of caesarean section by source of payment of childbirth and obstetric risk. Birth in Brazil study, 2011–2012.
(DOCX)
S2 Table. Preterm delivery according to gestational age and determining factor. Birth in Brazil study, 2011–2012.

(DOCX)

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Author Contributions
Conceived and designed the experiments: MCL APE MN JAT RMSMD MABD MEM MT SGNG. Performed the experiments: MCL APE MN JAT RMSMD MABD MEM MT SGNG. Analyzed the data: MCL APE MN. Contributed reagents/materials/analysis tools: MCL APE MN JAT RMSMD MABD MEM MT SGNG. Wrote the paper: MCL APE MN JAT RMSMD MABD MEM MT SGNG.

References
1. Chang HH, Larson J, Blencowe H, Spong CY, Howson CP, Cairns-Smith S, et al. Preventing preterm births: analysis of trends and potential reductions with interventions in 39 countries with very high human development index. Lancet. 2013; 381(9862):223–34. doi:10.1016/S0140-6736(12)61856-X PMID: 23158883; PubMed Central PMCID: PMC3572865.
2. Loftin RW, Habli M, Snyder CC, Cormier CM, Lewis DF, Defranco EA. Late preterm birth. Rev Obstet Gynecol. 2010; 3(1):10–9. PMID: 20508778; PubMed Central PMCID: PMC2876317.
3. Raju TN, Higgins RD, Stark AR, Leveen KJ. Optimizing care and outcome for late-preterm (near-term) infants: a summary of the workshop sponsored by the National Institute of Child Health and Human Development. Pediatrics. 2006; 118(3):1207–14. doi:10.1542/peds.2006-0018 PMID: 16951017.
4. Spong CY, Mercer BM, D’Alton M, Kilpatrick S, Blackwell S, Saade G. Timing of indicated late-preterm and early-term birth. Obstetrics and gynecology. 2011; 118(2 Pt 1):323–33. doi:10.1097/AOG. 0b013e3182255999 PMID: 21775849; PubMed Central PMCID: PMC3160133.
5. Morisaki N, Togoobaatar G, Vogel JP, Souza JP, Rowland Hogue CJ, et al. Risk factors for spontaneous and provider-initiated preterm delivery in high and low Human Development Index countries: a secondary analysis of the World Health Organization Multicountry Survey on Maternal and Newborn Health. BJOG: an international journal of obstetrics and gynaecology. 2014; 121 Suppl 1:101–8. doi: 10.1111/1471-0528.12631 PMID: 24641540.
6. Reddy UM, Ko CW, Raju TN, Willinger M. Delivery indications at late-preterm gestations and infant mortality rates in the United States. Pediatrics. 2009; 124(1):234–40. doi:10.1542/peds.2008-3232 PMID: 19564305; PubMed Central PMCID: PMC2802276.
7. Victora CG, Aquino EM, do Carmo Leal M, Monteiro CA, Barros FC, Szwarcwald CL. Maternal and child health in Brazil: progress and challenges. Lancet. 2011; 377(9780):1863–76. doi:10.1016/S0140-6736(11)60138-4 PMID: 21561656.
8. Domingues RM, Dias MA, Nakamura-Pereira M, Torres JA, d’Orsi E, Pereira AP, et al. Process of decision-making regarding the mode of birth in Brazil: from the initial preference of women to the final mode of birth. Cadernos de saude publica. 2014; 30 Suppl 1:S1–16. PMID: 25167169.
9. Carro Leal M, Pereira AP, Domingues RM, Theme Filha MM, Dias MA, Nakamura-Pereira M, et al. Obstetric interventions during labor and childbirth in Brazilian low-risk women. Cadernos de saude publica. 2014; 30 Suppl 1:S1–16. PMID: 25167177.
10. Nakamura-Pereira M, Leal MC, Esteves-Pereira AP, Domingues RMS, Torres JA, Moreira ME, et al. Use of Robson classification to assess caesarean section rate in Brazil: the role of source of payment for childbirth. Reproductive health. 2016; IN PRESS.
11. Goldenberg RL, Gravett MG, Iams J, Papageorghiou AT, Waller SA, Kramer M, et al. The preterm birth syndrome: issues to consider in creating a classification system. American journal of obstetrics and gynecology. 2012; 206(2):113–8. doi: 10.1016/j.ajog.2011.10.865 PMID: 22177186.
12. Moreira ME, Gama SG, Pereira AP, Silva AA, Lansky S, Souza Pinheiro R, et al. Clinical practices in the hospital care of healthy newborn infant in Brazil. Cadernos de saude publica. 2014; 30 Suppl 1:S1–12. PMID: 25167172.
13. Raju TN. Epidemiology of late preterm (near-term) births. Clin Perinatol. 2006; 33(4):751–63; abstract vii. doi: 10.1016/j.clp.2006.09.009 PMID: 17148002.

14. Engle WA. Morbidity and mortality in late preterm and early term newborns: a continuum. Clin Perinatol. 2011; 38(3):493–516. doi: 10.1016/j.clp.2011.06.009 PMID: 21890021.

15. Shapiro-Mendoza CK, Lackritz EM. Epidemiology of late and moderate preterm birth. Semin Fetal Neonatal Med. 2012; 17(3):120–5. doi: 10.1016/j.siny.2012.01.007 PMID: 22645822.

16. Teune MJ, Bakhuizen S, Gyskens Bannerman C, Opmeer BC, van Kaam AH, van Wassenaer AG, et al. A systematic review of severe morbidity in infants born late preterm. American journal of obstetrics and gynecology. 2011; 205(4):374 e1-9. doi: 10.1016/j.ajog.2011.07.015 PMID: 21864824.

17. Blencowe H, Cousens S, Chou D, Oestergaard M, Say L, Moller AB, et al. Born too soon: the global epidemiology of 15 million preterm births. Reproductive health. 2013; 10 Suppl 1:S2. doi: 10.1186/1742-4755-10-S1-S2 PMID: 24625129; PubMed Central PMCID: PMC3828585.

18. Pereira AP, Leal Mdo C, da Gama SG, Domingues RM, Schilitzh AO, Bastos MH. Determining gestational age based on information from the Birth in Brazil study. Cadernos de saude publica. 2014; 30 Suppl 1:S1–12. PMID: 25167191.

19. Leal MC, Moura da Silva AA, Dias MA, Nogueira da Gama SG, Rattner D, Moreira ME, et al. Birth in Brazil: national survey into labour and birth. Reproductive health. 2012; 9(1).15. Epub 2012/08/24. 1742-4755-9-15 [pii] doi: 10.1186/1742-4755-9-15 PMID: 22913663.

20. Declerq E. Is medical intervention in childbirth inevitable in Brazil? Cadernos de saude publica. 2014; 30 Suppl 1:S2–4. PMID: 25167186.

21. Leal MC, Esteves-Pereira AP, Nakamura-Pereira M, Torres JA, Theme-Filha M, Domingues RMS, et al. Prevalence and risk factors related to preterm birth in Brazil Reproductive health. 2016; IN PRESS.

22. Torres JA, Domingues RM, Sandall J, Hartz Z, Gama SG, Theme Filha MM, et al. Caesarean section and neonatal outcomes in private hospitals in Brazil: comparative study of two different perinatal models of care. Cadernos de saude publica. 2014; 30 Suppl 1:S1–12. PMID: 25167181.

23. Vasconcellos MT, Silva PL, Pereira AP, Schilitzh AO, Souza Junior PR, Szwarcwald CL. Sampling design for the Birth in Brazil: National Survey into Labor and Birth. Cadernos de saude publica. 2014; 30 Suppl 1:S1–10. PMID: 25167189.

24. d’Ori E, Bruggemann OM, Diniz CS, Gusman CR, Torres JA, et al. Social inequalities and women’s satisfaction with childbirth care in Brazil: a national hospital-based survey. Cadernos de saude publica. 2014; 30 Suppl 1:S1–15. PMID: 25167175.

25. Viellas EF, Domingues RM, Dias MA, Gama SG, Theme Filha MM, Costa JV, et al. Prenatal care and neonatal outcomes in private hospitals in Brazil. Cadernos de saude publica. 2014; 30 Suppl 1:S1–15. PMID: 25167194.

26. Mahoney AD, Jain L. Respiratory disorders in moderately preterm, late preterm, and early term infants. Clin Perinatol. 2013; 40(4):665–78. doi: 10.1016/j.clp.2013.07.004 PMID: 24182954.

27. Colin AA, McEvoy C, Castille RG. Respiratory morbidity and lung function in preterm infants of 32 to 36 weeks’ gestational age. Pediatrics. 2010; 126(1):115–28. doi: 10.1542/peds.2009-1381 PMID: 20530073; PubMed Central PMCID: PMC300351.

28. Lipkind HS, Slopen ME, Pfeiffer MR, McVeigh KH. School-age outcomes of late preterm infants in New York City. American journal of obstetrics and gynecology. 2012; 206(3):222 e1-6. doi: 10.1016/j.ajog.2012.01.007 PMID: 22381605.

29. Ramires de Jesus G, Ramires de Jesus N, Peixoto-Filho FM, Lobato G. Caesarean rates in Brazil. Cadernos de saude publica. 2014; 30 Suppl 1:S1–15. PMID: 25167176.

30. Torres JA. Análise da contribuição de um programa perinatal multifacetado para a redução da prevalência de cesarianas em um hospital privado: um subprojeto da pesquisa “Nascer no Brasil”, PhD. Thesis, National School of Public Health, Oswaldo Cruz Foundation. 2014. Available: http://www.ans.gov.br/images/stories/Materiais_p/para_pessoa/Materiais_p рождения анализа da contribuicao de um programa perinatal multifacetado para a reducao da prevalencia.pdf

31. Silver RM, Landon MB, Rouse DJ, Leveno KJ, Spong CY, Thomsen EA. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstetrics and gynecology. 2006; 107(6):1226–32. doi: 10.1097/01.AOG.0000233154.62729.24 PMID: 16738145.

32. Dias MA, Domingues RM, Schilitzh AO, Nakamura-Pereira M, Diniz CS, Brum IR, et al. Incidence of maternal near miss in hospital childbirth and postpartum: data from the Birth in Brazil study. Cadernos de saude publica. 2014; 30 Suppl 1:S1–12. PMID: 25167176.

33. Deneux-Tharaux C, Carmona E, Bouvier-Colle MH, Breart G. Postpartum maternal mortality and cesarean delivery. Obstetrics and gynecology. 2006; 108(3 Pt 1):541–8. doi: 10.1097/01.AOG.0000233154.62729.24 PMID: 16946213.
34. Gronlund MM, Lehtonen OP, Eerola E, Kero P. Fecal microflora in healthy infants born by different methods of delivery: permanent changes in intestinal flora after cesarean delivery. Journal of pediatric gastroenterology and nutrition. 1999; 28(1):19–25. PMID: 9890463.

35. Horta BL, Gigante DP, Lima RC, Barros FC, Victora CG. Birth by caesarean section and prevalence of risk factors for non-communicable diseases in young adults: a birth cohort study. PloS one. 2013; 8(9): e74301. doi: 10.1371/journal.pone.0074301 PMID: 24040224; PubMed Central PMCID: PMC3767800.

36. Cardwell CR, Stene LC, Joner G, Cinek O, Svensson J, Goldacre MJ, et al. Caesarean section is associated with an increased risk of childhood-onset type 1 diabetes mellitus: a meta-analysis of observational studies. Diabetologia. 2006; 51(5):726–35. doi: 10.1007/s00125-006-0941-z PMID: 18292986.

37. Thavagnanam S, Fleming J, Bromley A, Shields MD, Cardwell CR. A meta-analysis of the association between Caesarean section and childhood asthma. Clinical and experimental allergy: journal of the British Society for Allergy and Clinical Immunology. 2008; 38(4):629–33. doi: 10.1111/j.1365-2222.2007.02780.x PMID: 18352976.

38. Mesquita DN, Barbieri MA, Goldani HA, Cardoso VC, Goldani MZ, Kac G, et al. Cesarean Section Is Associated with Increased Peripheral and Central Adiposity in Young Adulthood: Cohort Study. PloS one. 2013; 8(6):e66827. doi: 10.1371/journal.pone.0066827 PMID: 23826150; PubMed Central PMCID: PMC3694972.

39. American College of O, Gynecologists. ACOG Practice Bulletin: Clinical Management Guidelines for Obstetrician-Gynecologists: Number 38, September 2002. Perinatal care at the threshold of viability. Obstetrics and gynecology. 2002; 100(3):617–24. PMID: 12220792.

40. Scott JR. Intrapartum management of trial of labour after caesarean delivery: evidence and experience. BJOG: an international journal of obstetrics and gynaecology. 2014; 121(2):157–62. doi: 10.1111/1471-0528.12449 PMID: 24044780.

41. Guise JM, Denman MA, Emeis C, Marshall N, Walker M, Fu R, et al. Vaginal birth after cesarean: new insights on maternal and neonatal outcomes. Obstetrics and gynecology. 2010; 115(6):1267–78. doi: 10.1097/AOG.0b013e3181df925f PMID: 20502300.

42. Al-Zirqi I, Stray-Pedersen B, Forsen L, Daltveit AK, Vangen S. Uterine rupture: trends over 40 years. BJOG: an international journal of obstetrics and gynaecology. 2015. doi: 10.1111/1471-0528.13394 PMID: 25846698.

43. McCabe ER, Carrino GE, Russell RB, Howse JL. Fighting for the next generation: US Prematurity in 2030. Pediatrics. 2014; 134(6):1193–9. doi: 10.1542/peds.2014-2541 PMID: 25367536.

44. Martin JA, Hamilton BE, Osterman MJ, Curtin SC, Matthews TJ. Births: final data for 2013. Natl Vital Stat Rep. 2015; 64(1):1–65. PMID: 25603115.

45. Dahlen HG, Tracy S, Tracy M, Bisits A, Brown C, Thornton C. Rates of obstetric intervention among low-risk women giving birth in private and public hospitals in NSW: a population-based descriptive study. BJM open. 2012; 2(5). doi: 10.1136/bmjopen-2012-001723 PMID: 22964120; PubMed Central PMCID: PMC3467614.