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Cesarean delivery in antepartum fetal death in Brazil: temporal trends and maternal and facility characteristics, 2014–2023

Roxana Knobel [1]
https://orcid.org/0000-0001-9180-4685

Maria Eliza Back [2]
https://orcid.org/0009-0000-2529-2554

Thais Carloto Todeschini [3]
https://orcid.org/0009-0005-7759-2037

Alberto Trapani Júnior [4]
https://orcid.org/0000-0003-0196-4488

Cláudia Garcia Magalhães [5]
https://orcid.org/0000-0001-7033-1807

Carla Betina Andreucci [6]
https://orcid.org/0000-0002-5590-108X

[1-4] Departamento de Ginecologia e Obstetrícia. Universidade Federal de Santa Catarina (UFSC). Campus Universitário Reitor João David Ferreira Lima, s.n. Trindade. Florianópolis, SC, Brazil. CEP: 88.040-900. E-mail: rknobel@gmail.com
[5] Faculdade de Medicina. Universidade Estadual Paulista Júlio de Mesquita Filho. Campus de Botucatu. Botucatu, SP, Brazil.
[6] Universidade Federal de São Carlos (UFSCar). São Carlos, SP, Brazil.

Abstract

Objectives: to describe cesarean section (CS) rates in antepartum fetal deaths (FD) in Brazil from 2014 to 2023, assess temporal trends, and examine maternal and institutional factors associated with CS.

Methods: population-based ecological study using individual-level SIM-DOFET microdata linked to facility registry data from the National Registry of Health Establishments (CNES). Temporal trends were evaluated using linear regression. Adjusted prevalence ratios (aPR) were estimated through Poisson regression with robust variance, restricted to term antepartum FD (≥37 weeks).

Results: among 282,327 registered fetal deaths, 95.3% were antepartum. CS rates showed a significant increase across all gestational ages, except for those < 27 weeks; in term FD, rates rose from 43.7% to 51.5%. Higher CS rates were independently associated with maternal age 30–39 years (aPR=1.09), education ≥12 years (aPR=1.17), multiple pregnancy (aPR=1.59), philanthropic (aPR=1.25) and private hospitals (aPR=1.47), and higher municipal HDI (aPR=1.07). Race/skin color could not be evaluated (99.8% missing).

Conclusions: CS rates in antepartum FD were persistently high and increasing, driven by factors beyond clinical indication. The FD certificate lacks key obstetric variables, which limits the analysis of care provided to this population. Revising this instrument is necessary to improve both surveillance and obstetric care of people who have experienced a stillbirth.

Key words *Brazil, Cesarean section, Delivery obstetric, Stillbirth, Fetal death*

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Introduction

Cesarean section (CS) entails greater risks than vaginal delivery, and its use should be restricted to situations where the benefits of surgical intervention outweigh the risks of vaginal delivery for both mother and fetus.[1] Although the optimal population-level CS rate remains debated, there is broad international consensus that rates exceeding 20% are not associated with additional improvements in maternal or perinatal outcomes and may, instead, increase adverse outcomes for women and newborns.[2]

In Brazil, CS rates significantly exceed ideal levels, reaching 59.6% for live births. These rates reflect indications that go beyond clinical and obstetric criteria, influenced by multiple interrelated factors: the disparity between the public and private health sectors, where rates in the latter can exceed 84%;[3,4] the prevalent fear of labor pain, often exacerbated by a chronic lack of pharmacological pain management; the convenience of elective scheduling and a "cesarean culture" that frequently perceives the surgery as a higher standard of care; the shortage of appropriate birthing environments and qualified professionals for adequate labor support; the predominance of physician-led deliveries — accounting for over 80% of births in the country — despite evidence that midwife- and obstetric nurse-led care in low-risk pregnancies is associated with reduced CS rates; and institutional barriers such as the practice of defensive medicine to avoid litigation, and the recurring cycle of "*once a cesarean, always a cesarean*".[5–7]

While CS rates in live births are widely debated, CS rates in fetal deaths (FD) are scarcely addressed in the scientific literature. Globally, approximately 3 million FD occurred in 2021, representing 23 FD per 1,000 births, with higher concentrations in low- and middle-income countries.[8] In Brazil, FD rates have remained at approximately 10 per 1,000 births,[9] representing a significant public health challenge and underscoring the need to better understand the obstetric care practices provided to this vulnerable population. When severe fetal heart rate abnormalities are identified during labor at a viable gestational age and with available resources, emergency CS may be performed in an attempt to save the fetus, depending on the stage of labor, maternal clinical condition, and institutional capacity; intrapartum FD is confirmed retrospectively by the absence of vital signs at birth. In cases of confirmed antepartum FD, cesarean section may still be indicated when maternal complications require expedited delivery — such as severe hypertensive disorders — or when vaginal delivery is formally contraindicated, as in cases of placenta previa. However, in the absence of such conditions, vaginal delivery remains the preferred route, given its association with lower maternal morbidity, shorter recovery, and better preservation of future reproductive capacity.[10,11]

Care for pregnant individuals facing the diagnosis of intrauterine FD presents additional challenges, as pregnancy loss profoundly affects the family, especially the pregnant individual, who faces increased risk of pathological grief, depression, financial impact, trauma, and stigmatization.[12,13]

Analysis of CS rates for antepartum FD can provide important insights about the Brazilian health system and its capacity to provide adequate obstetric care for this specific group of pregnant individuals. Given this scenario and the scarcity of evidence on the topic, this study aims to describe cesarean section rates among antepartum FD in Brazil from 2014 to 2023, evaluate temporal trends, and compare these rates by sociodemographic, gestational, and place-of-care characteristics.

Methods

This population-based ecological study with a mixed design combined time-series analysis (Analysis 1) and cross-sectional aggregate analysis (Analysis 2) of Brazilian national secondary data from 2014 to 2023. This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Individual-level microdata from the Mortality Information System (SIM) were downloaded in April 2026 from the DATASUS file transfer platform https://datasus.saude.gov.br/transferencia-de-arquivos/), specifically the Fetal Death files (SIM-DOFET) for each year of the study period. Data on live births at term were obtained in April 2026 from the Live Birth Information System (SINASC), accessed through TABNET/DATASUS (https://tabnet.datasus.gov.br/cgi/tabcgi.exe?sinasc/cnv/nvuf.def).

These information systems are populated from birth and death certificates completed by healthcare professionals at delivery facilities, in accordance with national standards established by the Ministry of Health. Although underreporting may occur, all births in Brazil – whether live births or FD – must be registered by national law; completion of a death certificate is mandatory for every birth meeting at least one of the following criteria: gestational age of 22 weeks or more, birth weight of 500 g or more, or crown-heel length of 25 cm or more.

To characterize delivery facilities, data from the National Registry of Health Establishments (*Cadastro Nacional de Estabelecimentos de Saúde*, CNES) were obtained via the PCDaS platform (*Plataforma de Ciência de Dados aplicada à Saúde*, Fiocruz; https://pcdas.icict.fiocruz.br/), which indexes monthly CNES competency files through an ElasticSearch infrastructure. For each FD record,

the corresponding CNES competency file — matched by establishment code (CODESTAB) and month/year of death — was queried to retrieve the facility's legal nature (public, private, or philanthropic). This approach captures changes in facility classification over the study period.

Municipal Human Development Index (HDI) data for 2010 were obtained from the Atlas do Estado Brasileiro (IPEA; https://www.ipea.gov.br/atlasestado/consulta/179). The 2010 HDI was used as a proxy for municipal socioeconomic development, as it represents the most recent census-based municipal-level estimate available for Brazil. Each FD record was linked to its municipality of maternal residence using the six-digit IBGE municipal code (CODMUNRES).

The study included all SIM-DOFET records for the period 2014–2023 in which the timing of FD was documented as either antepartum or intrapartum; records with missing timing or classified as postpartum were excluded. This constitutes a near-complete census of registered FDs in Brazil with known timing of death, and no sample size calculation was required. The proportion of antepartum versus intrapartum deaths within this eligible group is reported descriptively.

All subsequent analyses were restricted to antepartum FDs, as this subgroup more reliably reflects obstetric decisions regarding mode of delivery made prior to labor onset, minimizing the influence of intrapartum events on cesarean indication. Records without information on mode of delivery were excluded from all analyses.

For Analysis 1, antepartum FDs were stratified into four gestational age categories: 22–27, 28–31, 32–36, and ≥37 weeks.

For Analysis 2, only antepartum FDs at term (≥37 weeks of gestation, including post-term ≥42 weeks) were selected. This restriction minimizes confounding from clinical indications for cesarean section specific to preterm deliveries that cannot be controlled for using secondary administrative data. FDs occurring outside a hospital setting were excluded from analyses involving facility characteristics. Records with missing covariate values were excluded from the multivariate model; the extent of missingness for each variable is reported in Table 1.

Table 1

Antepartum Fetal Death at term (≥37 weeks) by mode of delivery and selected characteristics — Brazil, 2014–2023 (N=58,927).

Variable	n	% of valid	% missing	Vaginal births,n	Cesarean births,n	Cesarean rate,%
Maternal age (years)						
15 years or less	1,010	1.8%		684	326	32.3%
16 to 19 years	6,381	11.4%		4,115	2,266	35.5%
20 to 29 years	24,847	44.3%		13,780	11,067	44.5%
30 to 39 years	20,197	36.0%		9,973	10,224	50.6%
40 years or more	3,593	6.4%		1,904	1,689	47.0%
Unknown/Not informed	2,899		4.9%	1,424	1,475	50.9%
Maternal education (years of schooling)						
None or less than 1 year	2,157	4.3%		1,296	861	39.9%
1 to 3 years	3,779	7.5%		2,338	1,441	38.1%
4 to 7 years	12,565	24.9%		7,414	5,151	41.0%
8 to 11 years	26,342	52.2%		14,351	11,991	45.5%
12 years or more	5,609	11.1%		2,145	3,464	61.8%
Unknown/Not informed	8,475		14.4%	4,336	4,139	48.8%
Type of pregnancy						
Single	57,371	97.6%		31,455	25,916	45.2%
Multiple (twin/triplet)	1,420	2.4%		354	1,066	75.1%
Unknown/Not informed	136		0.2%	71	65	47.8%
Previous fetal/infant deaths						
0	32,004	58.7%		17,259	14,745	46.1%
1**	17,702	32.5%		9,695	8,007	45.2%
2 or more	4,838	8.9%		2,562	2,276	47.0%
Unknown/Not informed	4,383		7.4%	2,364	2,019	46.1%

Variable	n	% of valid	% missing	Vaginal births,n	Cesarean births,n	Cesarean rate,%
Previous live children						
0	21,399	38.0%		12,358	9,041	42.2%
1	15,651	27.8%		7,405	8,246	52.7%
2	9,035	16.0%		4,434	4,601	50.9%
3 or more	10,280	18.2%		6,252	4,028	39.2%
Unknown/Not informed	2,562		4.3%	1,431	1,131	44.1%
Hospital nature						
Public	29,532	59%		17,437	12,095	41%
Philanthropic	15,569	31.1%		7,345	8,224	52.8%
Private	4,995	10.0%		1,621	3,374	67.5%
Unknown/Not linked*	8,831		15%	5,477	3,354	38%
Geographic region						
North (Norte)	8,271	14.1%		4,622	3,649	44.1%
Northeast (Nordeste)	22,484	38.2%		13,067	9,417	41.9%
Southeast (Sudeste)	17,906	30.4%		9,472	8,434	47.1%
South (Sul)	5,672	9.6%		2,546	3,126	55.1%
Central-West (Centro Oeste)	4,505	7.7%		2,125	2,380	52.8%
Unknown/Not informed	89		0.2%	48	41	46.1%
Municipal Human Development Index (HDI-M, 2010)						
Very low (<0.500)	514	0.9%		341	173	33.7%
Low (0.500–0.599)	11,531	19.6%		7,037	4,494	39.0%
Medium (0.600–0.699)	16,090	27.3%		8,726	7,364	45.8%
High (0.700–0.799)	25,229	42.9%		12,529	12,700	50.3%
Very high (≥0.800)	5,470	9.3%		3,197	2,273	41.6%
Unknown/Not linked	93		0.2%	50	43	46.2%

% of valid: proportion of each category relative to the number of cases with known/recorded data for that variable (excluding missing, unknown, or unlinked records);
% missing: proportion of missing/unknown cases relative to the grand total (N=58,927).
Race/skin color was not recorded in 58,833 cases (99.8%) and was therefore not included as a variable in the analysis.
Hospital nature was linked via establishment code (CNES), matched to the month of death.
*Two distinct groups: 3,780 fetal deaths occurring outside hospital settings (home, n=1,777; other health facilities, n=713; location ignored, n=581; other settings, n=552; public thoroughfare, n=126; indigenous village, n=31), and 5,051 hospital-based cases whose establishment code could not be matched in the CNES database.
**It is likely that the current stillbirth being registered is counted among previous deceased children in the death certificate, introducing inconsistency in this variable; results should be interpreted with caution.

The number of records excluded at each step is presented in a flow diagram to allow assessment of potential selection bias.

The main outcome was the cesarean section rate, defined as (number of cesarean sections / total deliveries) × 100.

In Analysis 1, the variables of interest were calendar year (2014–2023, treated as continuous in regression models and as categorical for descriptive presentation) and gestational age group (22–27, 28–31, 32–36, and ≥37 weeks). Cesarean section rates were computed separately for each combination of year and gestational age group in antepartum FDs, and also for term live births (≥37 weeks) by year for comparison.

For Analysis 2, the following variables were included in both the crude and adjusted analyses: maternal age (under 20, 20–29 [reference], 30–39, and ≥40 years); maternal education (≤7 years, 8–11 years [reference], and ≥12 years of schooling); type of pregnancy (singleton [reference] or multiple gestation); delivery facility type by legal nature (public [reference], philanthropic, or private); geographic region (North, Northeast [reference], Southeast, South, and Central-West); and Municipal HDI (low/very low <0.600 [reference], medium 0.600–0.699, and high/very high ≥0.700). Race/skin color was not included due to missingness in 99.8% of records. The distribution of the variables in the study population is presented in Table 1, which also includes additional categories for a comprehensive visualization of the dataset's composition.

Two variables were excluded from both crude and adjusted analyses for substantive reasons: number of previous live births, because this variable conflates prior vaginal deliveries with prior cesarean sections — groups with fundamentally different probabilities of repeat

cesarean; and number of previous fetal/infant deaths, because the current FD is likely counted among previous deaths in a substantial proportion of records, introducing systematic measurement error.

To minimize confounding from clinical indications for preterm cesarean delivery, Analysis 2 was restricted to term gestations (≥ 37 weeks). Analysis 2 was further restricted to antepartum deaths to reduce the influence of intrapartum events — which may themselves precipitate both the FD and the indication for cesarean section — on the estimated associations. Linkage between SIM and CNES records was based on establishment codes, which may be missing or inconsistently recorded in a minority of cases; this could introduce non-differential misclassification of facility type, likely attenuating the estimated associations. The ecological design precludes individual-level causal inference and prevents adjustment for unobserved clinical indications for cesarean section (ecological fallacy).

In Analysis 1, cesarean section rates were described year by year for each gestational age category in antepartum FDs, and for term live births. Simple linear regression was used to evaluate temporal trends, with the calendar year treated as a continuous variable (Cesarean rate = $\beta 0 + \beta 1 \times \text{Year} + \varepsilon$). The coefficient $\beta 1$ represents the annual percentage-point change in the cesarean rate; R^2 indicates the proportion of variance explained by the model; and statistical significance was assessed using an ANOVA F-test ($\alpha = 0.05$). Trends were classified as increasing ($\beta 1 > 0$, $p < 0.05$), decreasing ($\beta 1 < 0$, $p < 0.05$), or stable ($p \geq 0.05$). Results are presented in Table 2.

In Analysis 2, data on antepartum term FDs were pooled across the entire study period (2014–2023). Crude and adjusted prevalence ratios (PRs and aPRs) with 95% confidence intervals were estimated using Poisson regression with a log-link function and robust variance estimation (HC3). All variables were entered simultaneously into the multivariate model. Collinearity was assessed using the Variance Inflation Factor (VIF), with values below 5 considered acceptable. Statistical significance was set at $\alpha = 0.05$. Results are presented in Table 3.

Table 2

Temporal trend analysis of cesarean section rates by gestational age group, Brazil, 2014-2023.

Group	β (95%CI) (pp/year)	*p*	R^2	Observed Change 2014-2023 (pp)
Fetal Death 22-27 weeks	−0.080 (−0.233; +0.073)	0.263	0.153	-1.4
Fetal Death 28-31 weeks	+0.525 (+0.320; +0.730)	<0.001	0.813	+4.2
Fetal Death 32-36 weeks	+0.846 (+0.480; +1.212)	<0.001	0.780	+7.2
Fetal Death ≥37 weeks	+0.722 (+0.460; +0.984)	<0.001	0.834	+7.6
All Fetal Death	+0.304 (+0.109; +0.499)	0.007	0.617	+2.1
Live Birth ≥37 weeks	+0.251 (+0.000; +0.502)	0.05	0.400	+1.9

pp= percentage points; β= regression coefficient (annual change); Linear regression analysis was performed with year as the independent variable.

Table 3

Prevalence ratios for cesarean delivery among antepartum term Fetal Death — Brazil, 2014–2023.

Variable	Crude PR (95%CI)		Adjusted PR (95%CI) *	
	PR (95% CI)	*p*	PR (95% CI)	*p*
Maternal age				
Under 20	0.79 (0.76–0.81)	<0.001	0.82 (0.79–0.85)	<0.001
20–29 years (ref.)	1.00 (ref.)	—	1.00 (ref.)	—
30–39 years	1.14 (1.11–1.16)	<0.001	1.09 (1.07–1.11)	<0.001
≥40 years	1.06 (1.02–1.10)	0.005	1.04 (0.99–1.08)	0.093
Maternal education (years)				
≤7 years	0.88 (0.87–0.90)	<0.001	0.93 (0.91–0.96)	<0.001
8–11 years (ref.)	1.00 (ref.)	—	1.00 (ref.)	—
≥12 years	1.36 (1.32–1.39)	<0.001	1.17 (1.14–1.20)	<0.001
Type of pregnancy				
Single (ref.)	1.00 (ref.)	—	1.00 (ref.)	—
Multiple	1.66 (1.61–1.71)	<0.001	1.59 (1.53–1.65)	<0.001

Variable	Crude PR (95%CI)		Adjusted PR (95%CI) *	
	PR (95% CI)	*p*	PR (95% CI)	*p*
Hospital type				
Public (ref.)	1.00 (ref.)	—	1.00 (ref.)	—
Philanthropic	1.29 (1.26–1.32)	<0.001	1.25 (1.22–1.28)	<0.001
Private	1.65 (1.61–1.69)	<0.001	1.47 (1.43–1.51)	<0.001
Geographic region				
Northeast (ref.)	1.00 (ref.)	—	1.00 (ref.)	—
North	1.05 (1.02–1.08)	<0.001	1.11 (1.08–1.15)	<0.001
Southeast	1.12 (1.10–1.15)	<0.001	0.99 (0.96–1.02)	0.453
South	1.32 (1.28–1.35)	<0.001	1.10 (1.06–1.15)	<0.001
Central-West	1.26 (1.22–1.30)	<0.001	1.15 (1.10–1.19)	<0.001
Municipal HDI				
Low/Very low (<0.600) (ref.)	1.00 (ref.)	—	1.00 (ref.)	—
Medium (0.600–0.699)	1.18 (1.15–1.21)	<0.001	1.09 (1.05–1.13)	<0.001
High/Very high (≥0.700)	1.26 (1.23–1.29)	<0.001	1.07 (1.03–1.10)	<0.001
N (multivariate model)			42,239	

* Adjusted simultaneously for all variables in the table. Poisson regression with robust variance (HC3).
PR= prevalence ratio; CI= confidence interval; HDI= Human Development Index; Ref=reference categories.

Missing data were handled by complete-case analysis. The proportion of missing values for each variable is reported in Table 1. Variables with more than 20% missing data were excluded from the multivariate model to minimize information bias.

Sensitivity analyses were performed using the same Poisson regression approach: (1) restricted to the 2019–2023 period; (2) restricted to singleton pregnancies; and (3) stratified by macro-region.

All statistical analyses were conducted in R version 4.x (R Core Team, Vienna, Austria), using the following packages: read.dbc, dplyr, tidyr, ggplot2, sandwich, lmtest, and car. As this study uses publicly available, anonymized secondary data without individual identification, approval from a Research Ethics Committee was not required in accordance with Brazilian National Health Council Resolution 510/2016.

Results

Between 2014 and 2023, 282,327 FDs were registered in Brazil, of which 95.3% were diagnosed before delivery. This corresponds to a fetal mortality rate of 10.5 per 1,000 births and 9.49 per 1,000 births when considering only antepartum deaths. The flowchart of the analyzed cases is presented in Figure 1.

No statistically significant temporal trend in fetal mortality rate was observed over the study period. The cesarean section rate in antepartum FDs ranged from 31.3% (in 2017) to 35.2% (in 2023). There was a significant increase in the cesarean section rate during the period (β = +0.3 pp/year; $p = 0.007$) (Table 2).

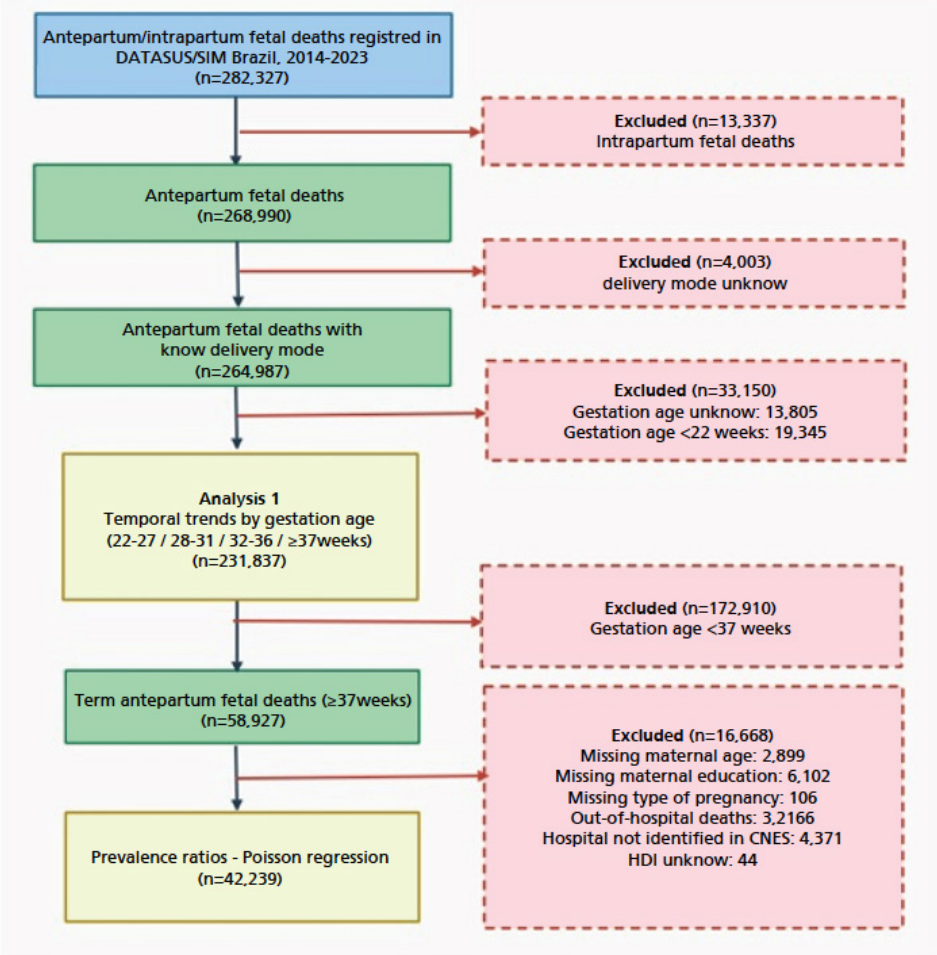
When stratified by gestational age, cesarean section rates varied considerably throughout the study period (Figure 2). In pregnancies of 22 to 27 weeks, the lowest mean cesarean rate was observed (13.3%), with a minimum value of 12.5% in 2016 and a maximum of 14.5% in 2014. In pregnancies of 28 to 31 weeks, the mean rate was 29.1%, ranging from 27.1% in 2016 to 32.2% in 2023. In pregnancies at 32 to 36 weeks, the mean rate was 41.6%, ranging from 37.4% in 2015 to 47.3% in 2023. Term pregnancies (≥37 weeks) presented the highest mean cesarean rate in FDs (46.2%), ranging from 43.7% in 2015 to 51.5% in 2023 (Supplementary Table 1).

The temporal trend of cesarean section in FDs varied according to gestational age group (Figure 2, Table 2). Pregnancies at 22–27 weeks showed a slight, non-significant reduction over the period (β = −0.080 pp/year; $p = 0.263$), whereas all other gestational age categories showed significant increases ($p < 0.001$). The greatest increments were observed in the two most advanced gestational age groups (32–36 weeks and ≥37 weeks), with models explaining 78%–83% of the temporal variability ($R^2 = 0.780$ and 0.834), compared with only 15.3% in pregnancies at 22–27 weeks.

Table 1 presents the distribution of antepartum FD at term according to mode of delivery and selected maternal and institutional characteristics. The completeness of data varied across variables. Race/skin color was unavailable for 99.8% of cases and was therefore excluded from the analysis. Maternal education and hospital nature presented the highest proportions of missing data among the remaining variables (14.4% and 13.9%, respectively), which should be considered when interpreting findings for these variables.

Figure 1

Flowchart of inclusion and exclusion criteria - Cesarean section in antepartum stillbirths — Brazil, 2014–2023.

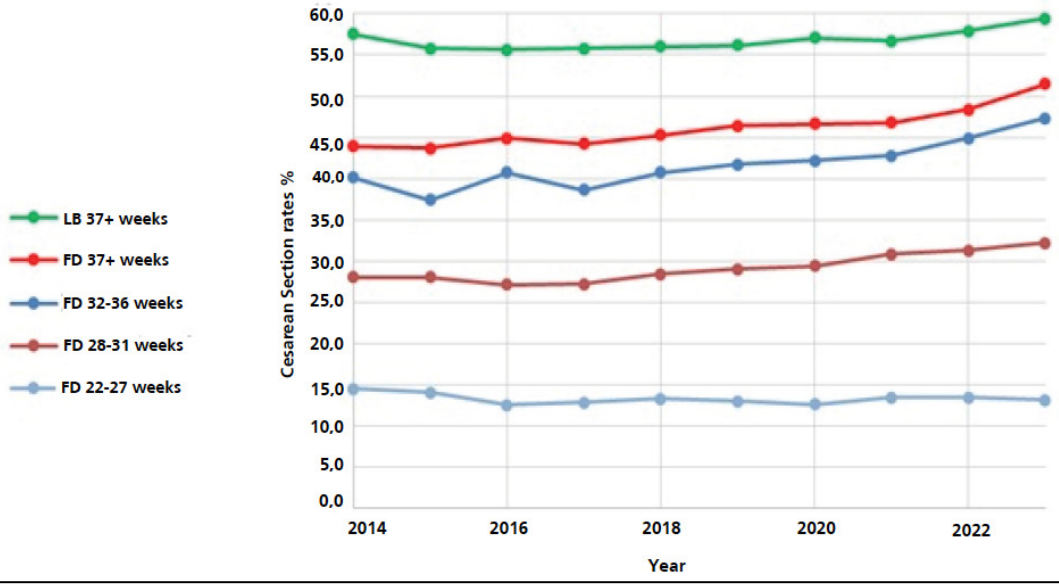


SIM = Sistema de Informações sobre Mortalidade; SINASC = Sistema de Informações sobre Nascidos Vivos; DATASUS = Departamento de Informática do SUS. Skin color/ race excluded from Analysis 2 (>20% missing: 99.87% in SIM).

Missing data for each variable are reported in Table 1 relative to the full term antepartum fetal deaths sample (N = 58,927). Exclusions shown here were applied sequentially to define the analytic sample for multivariable analysis (Table 3) and are therefore not directly comparable to the missing counts in Table 1.

Figure 2

Cesarean section rates in term live births and antepartum fetal deaths according to gestational age - Brazil, 2014-2023.



LB=live birth; FD= fetal death.

Among the characteristics with complete or near-complete data, cesarean section rates varied markedly. Regarding maternal age, rates increased progressively from 32.3% in adolescents aged 15 years or younger to 50.6% in women aged 30–39 years. A similar gradient was observed for maternal education, with cesarean rates ranging from 38.1% among women with 1–3 years of schooling to 61.8% among those with 12 or more years. Multiple pregnancies were associated with a substantially higher cesarean rate (75.1%) compared to singleton gestations (45.2%). Women with one previous live child had the highest cesarean rate among parity categories (52.7%), whereas those with three or more children had the lowest (39.2%), though this variable does not distinguish between prior vaginal deliveries and cesarean sections.

The variable recording previous fetal or infant deaths showed little variation in cesarean rates across categories; however, the finding that over 40% of cases had at least one previous fetal or infant death recorded suggests a systematic data entry error, likely reflecting the current FD being registered as a prior death, which compromises the reliability of this variable. Regarding hospital nature, cesarean rates increased from 41.0% in public facilities to 67.5% in private hospitals. Marked regional variation was also observed, with the lowest rates in the Northeast (41.9%) and the highest in the South (55.1%) and Central-West (52.8%) regions.

Municipal HDI showed a direct association with cesarean rates, which were higher in municipalities with high and very high HDI compared to those with low or medium HDI; the highest rate was observed in the high HDI category (50.3%), with a slight attenuation in the very high HDI group (41.6%), though still above low and medium HDI levels.

After simultaneous adjustment for all variables, several factors remained independently associated with cesarean delivery in antepartum term FD (Table 3). Younger maternal age, lower education, and delivery in public hospitals were associated with lower probability of cesarean, while older age, higher education, and multiple pregnancy were associated with higher probability. Hospital type showed the strongest association: compared to public hospitals, the probability of cesarean delivery was 25% higher in philanthropic facilities and 47% higher in private hospitals. Among geographic regions, the Southeast did not differ significantly from the Northeast after adjustment, while all other regions showed modestly higher probabilities. Higher municipal HDI was associated with a greater probability of cesarean delivery, though the magnitude was attenuated after adjustment.

Sensitivity analyses yielded consistent results. Restriction to 2019–2023 (n=19,103) and to singleton pregnancies (n=41,218) produced results virtually identical to the main model regarding adjusted PRs for maternal age and education. Regional stratification confirmed that the direction of all associations was preserved across the five macro-regions, with some variation in magnitude (Supplementary Table 2).

The multivariate model included 42,239 of the 58,927 cases in the full dataset. Losses resulted from missing data in key variables – particularly maternal education (14.4%) and hospital type (13.9%) – as well as from the deliberate exclusion of out-of-hospital deliveries, which, by definition, would not include cesarean sections and would therefore introduce systematic bias if retained.

Discussion

Mode of delivery in antepartum FD remains one of the most underexplored dimensions of obstetric care quality worldwide. While FD epidemiology has received growing attention – particularly regarding rates, causes, and disparities – the clinical management of delivery in these cases and its variation across health systems have been largely overlooked in the scientific literature. Information on mode of delivery following intrauterine FD is rarely captured in national demographic surveillance systems, limiting the ability to evaluate practices that directly affect maternal safety and the bereavement experience.[11,14] This gap extends to clinical guidance: the American College of Obstetricians and Gynecologists acknowledges that there are limited data to guide clinical practice in managing stillbirth,[15] underscoring that the invisibility of this population in surveillance systems translates directly into uncertainty at the bedside. This study provides a ten-year characterization of cesarean section rates in antepartum FDs in Brazil, using individual-level microdata linked to facility registry data, and its findings suggest that the forces shaping obstetric decision-making in Brazil extend well beyond clinical indication.

Our study identified cesarean rates above 32.5% across all years evaluated, with a significant upward trend over the period. These rates are superior to those described in the United States (16% to 18.9%),[10,16] Ghana (19.3%),[14] other sub-Saharan African countries (Benin, Malawi, Uganda, and United Republic of Tanzania) (19%)[17]; they are more comparable to the CS rates reported for FD at 28 weeks or more in Latin America (27.3%).[18] These comparisons should be interpreted with caution: the studies differ in their definitions of stillbirth and FD – particularly regarding gestational age thresholds and the inclusion or exclusion of intrapartum deaths – and several do not distinguish antepartum from intrapartum cases, as the present study does. Nevertheless, even accounting for these methodological differences, Brazil's figures are more closely aligned with those of lower-income settings than

with countries at a similar level of economic development, suggesting that system-level factors – rather than clinical case mix alone – drive the observed rates.

The increasing temporal trend in cesarean delivery observed in this study in FD mirrors the well-documented global rise in cesarean rates in live births,[19,20] and parallels trends previously reported in FDs in the United States and Ghana.[14,16] In Brazil, the overall cesarean rate in antepartum FDs increased significantly over the decade (β = +0.304 pp/year; *p*=0.007), with the most pronounced increments observed in pregnancies of 32–36 weeks and at term (≥37 weeks). The pattern varied notably by gestational age: while all groups at 28 weeks or more showed significant increases, pregnancies at 22–27 weeks exhibited a slight, non-significant decrease over the period — a distinct trajectory that may reflect the lower feasibility and higher maternal risk of cesarean delivery at periviable gestational ages, as well as greater clinical consensus around vaginal delivery in this group. The cesarean rate in this earliest group (~13%) remains lower than the 16.2% reported for antepartum FD in the United States in 2014,[16] though its stability over time is a relatively favorable finding within an otherwise uniformly increasing picture. The rate was highest among term pregnancies, consistent with the higher prevalence of maternal conditions that may justify surgical delivery at advanced gestational ages – such as severe hypertensive disorders and placental abruption — but also with the greater exposure of term pregnancies to the institutional and cultural pressures that drive cesarean rates in live births.[5,6]

CS rates in antepartum FD varied systematically according to maternal and socioeconomic characteristics, following gradients strikingly similar to those documented for live births in Brazil.[4,20–23] Maternal age showed a progressive increase in cesarean rates from 32.3% in adolescents aged 15 years or younger to 50.6% in women aged 30–39 years, consistent with patterns observed in live births,[4,21,23] A similar gradient was observed for maternal education: women with 12 or more years of schooling had a cesarean rate of 61.8% – nearly double that of women with fewer than four years of schooling. After multivariate adjustment, this association was attenuated but remained statistically significant (aPR=1.17), suggesting that part of the effect is explained by correlated factors such as age and access to private health care, but that maternal education captures additional dimensions that are not fully accounted for by the model.[20,23,24] Multiple pregnancy was associated with a substantially higher cesarean rate (75.1%; aPR=1.59), slightly lower than the 82% reported for live births in Brazil,[23] though direct comparison is limited as the vital status of the co-fetus at delivery cannot be ascertained.

Race and skin color could not be evaluated, as this information was recorded as unknown in 99.8% of cases in the SIM-DOFet database. This figure is not a technical limitation in the conventional sense — it is a finding in its own right. The near-total absence of race data in the FD certificate represents a structural gap in Brazil's vital statistics system that disproportionately affects a population already rendered invisible by perinatal loss. Racial inequalities in access to obstetric care are well documented in Brazil,[3,4,21] and their assessment in the context of FD is precisely where they would be most informative and most absent.

Hospital ownership is one of the strongest predictors of cesarean rates in live births in Brazil, with rates in the private sector exceeding 84% of deliveries.[3,4,19,20] In our analysis, hospital ownership was the strongest independent predictor of CS delivery in antepartum FD after multivariate adjustment, with rates of 41% in public facilities rising to 52.8% in philanthropic hospitals and 67.5% in private hospitals (aPR=1.25 and 1.47, respectively). The magnitude of the private-sector effect on cesarean rates in a context where fetal well-being is no longer a clinical consideration underscores the degree to which institutional and financial dynamics shape mode-of-delivery decisions independently of obstetric indication. Geographic region showed significant crude variation, with the lowest rates in the Northeast (41.9%) and the highest in the South (55.1%) and Central-West (52.8%); however, after adjustment, regional differences were substantially attenuated and the Southeast lost statistical significance entirely – reflecting the unequal geographic distribution of private hospitals, maternal education levels, and municipal HDI across Brazil, rather than independent regional effects. Municipal HDI showed a direct association with cesarean delivery, with higher rates in municipalities with higher development indices – a pattern mirroring the well-documented socioeconomic gradient in live births,[23] and substantially attenuated after adjustment for hospital type and region, reflecting the geographic concentration of private facilities in wealthier municipalities.

Beyond the rates themselves, this study exposes a structural limitation of Brazil's FD surveillance system that deserves recognition as a substantive finding, not merely a methodological caveat. The FD certificate (*Declaração de Óbito Fetal, DO-Fetal*) lacks several variables that are routinely collected in the live birth certificate (*Declaração de Nascido Vivo, DN*) and that are essential for understanding mode-of-delivery decisions: prior cesarean delivery, fetal presentation, labor induction, planned versus emergency cesarean, and clinical indication for the procedure. The WHO-endorsed Robson classification,[19,23] could not be applied to this dataset precisely because the DO-Fetal does not capture the variables it requires – most critically, the distinction

between prior vaginal deliveries and prior cesarean sections, which is central to the system and which, in the DO-Fetal, cannot be reconstructed from the available fields. This distinction is central to the Robson system: a history of cesarean delivery (Robson Group 5) increases the likelihood of repeat cesarean even in the setting of FD, whereas a history of vaginal delivery (Group 3) is expected to reduce it.[19,23] This structural poverty of the instrument is compounded by the quality problems encountered in practice: extensive missingness and inconsistencies in key fields – most strikingly, the 99.8% absence of race/skin color data – that further narrow the analytical possibilities available to researchers working with these records. The two problems reinforce each other: an instrument that was already poor in obstetric content is further undermined by incomplete and unreliable data collection in the field, resulting in a dataset that renders bereaved women statistically invisible within Brazil's own vital statistics infrastructure, as happens in other countries.[11,12] The absence of detailed obstetric information in fetal death surveillance systems can also be interpreted as part of the historically peripheral position of stillbirth within maternal and perinatal health agendas, despite its substantial epidemiological and psychosocial burden.

We recommend that the Brazilian Ministry of Health consider revising the DO-Fetal instrument to include the obstetric variables already present in the DN. This change would be technically feasible, would impose no additional burden on health professionals beyond what is already required for live births, and would substantially expand the capacity of Brazil's FD surveillance system to evaluate and improve obstetric care for one of its most vulnerable populations.

Beyond surveillance and research, these findings have immediate implications for clinical practice. The systemic, socioeconomic, cultural, and institutional barriers to vaginal birth that are well-documented in Brazil,[3,5,6,19,20] do not disappear when the fetus dies. The same hospitals, teams, and institutional dynamics remain in place – and so does the broader cultural and financial context that sustains them. The hospital ownership model, the higher exposure of women in private settings to cesarean delivery, and the institutional incentives of the private sector continue to shape obstetric decision-making even in the absence of a live birth.

In antepartum FD, the clinical rationale for cesarean section is substantially narrowed: fetal well-being – one of the most common justifications for surgical delivery – is no longer a factor, and vaginal delivery carries the lowest maternal risk and better preserves future reproductive capacity. In this context, the maternal consequences of unnecessary cesarean delivery acquire particular ethical relevance, since the short- and long-term reproductive risks of surgery are incurred without the possibility of fetal benefit. Cesarean section should therefore be reserved for cases with formal maternal or obstetric indications.[10,15,25] Beyond individual clinical decisions, persistently high cesarean rates in antepartum FD may also reflect broader structural changes in obstetric practice, including possible reductions in professional familiarity with complex labor management, limited availability of continuous labor support, and growing reliance on surgical delivery as the dominant mode of birth – trends that may gradually erode institutional capacity to support vaginal delivery even when it is the preferred option.

In addition to these structural determinants, the context of FD introduces specific layers that may further contribute to surgical delivery: difficulties in communicating with bereaved families; uncertainty and moral distress among care teams regarding the most appropriate mode of delivery, including the misperception – however compassionate in intent – that vaginal delivery may be cruel or inappropriate for a grieving patient; and the discomfort or sense of perceived therapeutic failure experienced by healthcare professionals when supporting bereaved families through labor.[26–28]

Addressing these barriers requires institutional and interpersonal responses. Care teams should be equipped with communication skills to discuss mode-of-delivery options clearly and compassionately – providing honest information about risks and benefits, eliciting preferences, and supporting autonomy without abandoning clinical guidance.[12,13,27,28] In the emotionally charged context of FD, where families may be particularly vulnerable to deference, ensuring that shared decision-making is genuine rather than nominal becomes even more critical. Institutional protocols for the management of antepartum FD – including access to continuous labor support, effective pharmacological analgesia, psychological and bereavement counseling, and multidisciplinary team coordination – are essential to creating conditions in which vaginal delivery is not only clinically indicated but genuinely accessible; when adequately supported, it may also play a meaningful role in grief processing and mental health outcomes for bereaved families.[28,29]

Families bereaved by pregnancy loss frequently report feeling deprioritized in obstetric care compared to those with live births[27] – and this neglect appears to be mirrored in the scientific literature. Little is known about the preferences of women and families regarding mode of delivery in this context, the extent to which those preferences are elicited and respected, the attitudes and barriers that shape care team decisions, or the consequences of delivery route for grief and bereavement outcomes. A future research agenda centered on the perspectives and autonomy of women and families facing

antepartum FD is urgently needed. The indicator proposed here – cesarean section rate in antepartum FDs – could be integrated into existing frameworks for monitoring obstetric care quality in Brazil, alongside established measures such as Robson group-specific cesarean rates and severe maternal morbidity indicators. Ensuring access to evidence-based and respectful care after fetal death should also be understood as part of the broader framework of reproductive rights and obstetric justice.

This study has several limitations inherent to the use of secondary administrative data, including underreporting and incomplete recording. The exclusion of intrapartum FDs and out-of-hospital deliveries limits generalizability to institutional antepartum FDs. Missing data limited the multivariate analysis to 71.7% of term cases, introducing potential selection bias if missingness is non-random; furthermore, it made it impossible to use race/ethnicity, as discussed above. The DO-Fetal lacks key obstetric variables – including prior cesarean delivery, fetal presentation, labor induction, and clinical indication for cesarean. The ecological design precludes individual-level causal inference.

Several methodological strengths distinguish this study from prior work in the field. The use of individual-level microdata from Brazil's national mortality information system – covering a ten-year period and linked to facility registry data from CNES – allowed adjustment for hospital type by ownership, a variable that is rarely available in studies of this kind and that proved to be the strongest independent predictor of CS in the multivariate model.

The restriction of multivariate analyses to antepartum term FDs minimized confounding from gestational-age-specific clinical indications. Sensitivity analyses across time periods, pregnancy types, and macro-regions confirmed the robustness of the main findings. Beyond its specific results, this study makes a broader contribution: it proposes CS rate in antepartum FDs as an indicator of obstetric care quality that is both measurable with existing data systems and clinically meaningful – one that reflects the capacity of health institutions to support vaginal delivery even when the most common justification for surgical intervention, fetal well-being, is no longer present. Incorporating this indicator into national monitoring frameworks, alongside efforts to expand the analytical content of the DO-Fetal instrument, would strengthen Brazil's ability to evaluate and improve care for one of the most vulnerable and underserved groups in obstetric practice.

Artificial intelligence use

In accordance with current recommendations for transparency in scholarly publishing, the authors declare that a generative artificial intelligence tool – Claude (Anthropic, San Francisco, CA, USA) – was used during the preparation of this manuscript as an editorial and technical assistance tool. Its use was restricted to the following purposes: correction of spelling, grammar, and syntax errors; improvement of fluency and clarity of academic English prose; support in the selection and application of statistical methods, including the choice of regression models, correlation coefficients, and criteria for variable inclusion – all of which were executed exclusively by the authors using validated statistical software (R version 4.x R Core Team, Vienna, Austria), utilizing the packages read.dbc, dplyr, tidyr, ggplot2, sandwich, lmtest, and car; cross-checking of reported statistical values (β coefficients, *p*-values, R^2, adjusted prevalence ratios, 95% confidence intervals, and percentage-point changes) for internal consistency with the results tables and text; verification of item-by-item compliance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist and preparation of the associated supplementary material; and review of manuscript structure and reference list formatting for consistency with journal guidelines.

The AI tool was not involved in any of the following: study design or conceptualization; data collection, extraction, or management; execution of statistical analyses; literature search or selection of references; formulation of scientific conclusions; or any component of the intellectual content of the manuscript.

All intellectual content, scientific analyses, interpretation of findings, and conclusions presented in this manuscript are entirely the work of the human authors and remain their sole responsibility. The final version of the manuscript was reviewed and approved by all authors prior to submission. Consistent with current guidance from the International Committee of Medical Journal Editors (ICMJE) and the Committee on Publication Ethics (COPE), the AI tool is not listed as an author, as authorship requires accountability that cannot be attributed to a software tool.

Authors' contributions

Knobel R and Back ME: participated in all phases of the study, including conception and design, data collection and analysis, interpretation of results, and drafting of the manuscript.

Todeschini TC: data collection, drafting, and critical review of the manuscript.

Trapani Júnior A, Magalhães CG, and Andreucci CB: drafting of the manuscript, critical review, and data analysis.

All authors approved the final version of the article and declare conflicts of interest.

Data availability

Databases that support this study are publicly available at https://datasus.saude.gov.br/

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Supplementary Table 1

Sensitivity analyses — adjusted prevalence ratios (aPR; 95%CI) from Poisson regression with robust variance.

Variables	S0: Main model 2014–2023 (n=42,239)	S1: Restricted to 2019–2023 (n=19,103)	S2: Singleton pregnancies only (n=41,218)
Maternal age (years)			
20–29 (ref.)	1.00	1.00	1.00
<20 years	0.82 (0.79–0.85)	0.82 (0.77–0.87)	0.81 (0.78–0.84)
30–39 years	1.09 (1.07–1.11)	1.08 (1.05–1.11)	1.09 (1.07–1.12)
≥40 years	1.04 (0.99–1.08)	1.04 (0.98–1.10)	1.04 (1.00–1.08)
Maternal education (years)			
8–11 (ref.)	1.00	1.00	1.00
≤7 years	0.93 (0.91–0.96)	0.90 (0.87–0.93)	0.93 (0.91–0.96)
≥12 years	1.17 (1.14–1.20)	1.13 (1.08–1.17)	1.17 (1.14–1.20)
Plurality			
Singleton (ref.)	1.00	1.00	—[a]
Multiple	1.59 (1.53–1.65)	1.53 (1.44–1.62)	—[a]
Hospital type			
Public (ref.)	1.00	1.00	1.00
Philanthropic	1.25 (1.22–1.28)	1.24 (1.20–1.28)	1.25 (1.22–1.28)
Private	1.49 (1.44–1.53)	1.45 (1.39–1.51)	1.49 (1.44–1.53)
Macro-region			
Northeast (ref.)	1.00	1.00	1.00
North	1.11 (1.08–1.15)	1.10 (1.06–1.16)	1.11 (1.08–1.15)
Central-West	1.15 (1.10–1.19)	1.12 (1.06–1.18)	1.15 (1.10–1.20)
Southeast	0.99 (0.96–1.02)	0.95 (0.91–0.99)	0.99 (0.96–1.02)
South	1.10 (1.06–1.15)	1.06 (1.01–1.12)	1.10 (1.06–1.15)
Municipal HDI			
Low/Very low (ref.)	1.00	1.00	1.00
Medium (0.600–0.699)	1.09 (1.05–1.13)	1.07 (1.02–1.12)	1.09 (1.05–1.13)
High/Very high (≥0.700)	1.07 (1.03–1.10)	1.07 (1.02–1.12)	1.06 (1.02–1.10)

Outcome: cesarean section in antepartum fetal deaths at term (≥37 weeks), Brazil, 2014–2023. All models adjusted for maternal age, education, plurality, hospital type, macro-region, and municipal HDI, except S2 (plurality excluded; all observations were singletons). Reference categories: aPR=1.00.
aPR= adjusted prevalence ratio; CI confidence interval; HDI= Human Development Index.
S0= Main multivariable model (2014–2023); S1= Restricted to 2019–2023; S2= Singleton pregnancies only, plurality excluded from model.
[a] Variable excluded from model (constant within stratum).

Sensitivity analysis — adjusted prevalence ratios (aPR; 95% CI) stratified by macro-region.

Variables	North (n=6,022)	Northeast (n=16,233)	Central-West (n=2,828)	Southeast (n=12,944)	South (n=4,212)
Maternal age (years)					
20–29(ref.)	1.00	1.00	1.00	1.00	1.00
<20	0.87 (0.80–0.95)	0.84 (0.79–0.89)	0.78 (0.69–0.89)	0.76 (0.70–0.82)	0.84 (0.75–0.93)
30–39	1.08 (1.01–1.14)	1.07 (1.03–1.11)	1.12 (1.05–1.20)	1.15 (1.11–1.20)	1.00 (0.94–1.06)
≥40	1.01 (0.90–1.14)	0.95 (0.88–1.03)	0.95 (0.82–1.10)	1.14 (1.07–1.22)	1.06 (0.96–1.17)
Maternal education (years)					
8–11 (ref.)	1.00	1.00	1.00	1.00	1.00
≤7	0.90 (0.85–0.96)	0.91 (0.87–0.94)	0.90 (0.82–0.97)	1.02 (0.97–1.06)	0.92 (0.86–0.99)
≥12	1.16 (1.07–1.26)	1.20 (1.13–1.26)	1.03 (0.95–1.12)	1.14 (1.09–1.20)	1.26 (1.18–1.34)
Plurality					
Singleton (ref.)	1.00	1.00	1.00	1.00	1.00
Multiple	1.66 (1.51–1.83)	1.52 (1.42–1.64)	1.43 (1.27–1.61)	1.63 (1.54–1.74)	1.60 (1.47–1.73)
Hospital type					
Public (ref.)	1.00	1.00	1.00	1.00	1.00
Philanthropic	1.11 (1.01–1.21)	1.16 (1.11–1.21)	1.05 (0.97–1.14)	1.40 (1.34–1.46)	1.27 (1.18–1.37)
Private	1.51 (1.40–1.63)	1.46 (1.39–1.54)	1.49 (1.39–1.61)	1.59 (1.51–1.67)	1.25 (1.14–1.38)
Municipal HDI					
Low/Very low (ref.)	1.00	1.00	1.00	1.00	1.00
Medium	1.02 (0.96–1.10)	1.11 (1.06–1.15)	1.39 (0.96–2.02)	1.15 (0.96–1.38)	0.91 (0.53–1.57)
High/Very high	0.99 (0.92–1.06)	1.10 (1.04–1.15)	1.35 (0.93–1.95)	1.18 (0.99–1.41)	0.83 (0.48–1.43)

Outcome: cesarean section in antepartum fetal deaths at term (≥37 weeks), Brazil, 2014–2023. Each column is an independent model restricted to that macro-region, adjusted for maternal age, education, plurality, hospital type, and municipal HDI; macro-region excluded (constant within stratum).
aPR= adjusted prevalence ratio; CI= confidence interval; HDI= Human Development Index.
Wide confidence intervals for HDI in Central-West, South, and Southeast reflect low municipal HDI variability within those regions.

Supplementary Table 2

Mode of delivery in antepartum fetal deaths (FD) by gestational age group and in term live births, Brazil, 2014–2023.

Year	Vaginal delivery (n)	Cesarean section (n)	Total (n)	Cesarean rate (%)
FD 22–27 weeks				
2014	4,475	760	5,235	14.5%
2015	5,277	859	6,136	14.0%
2016	5,077	726	5,803	12.5%
2017	5,353	787	6,140	12.8%
2018	5,318	819	6,137	13.3%
2019	5,376	801	6,177	13.0%
2020	4,960	712	5,672	12.6%
2021	5,249	810	6,059	13.4%
2022	5,158	798	5,956	13.4%
2023	5,208	786	5,994	13.1%
FD 28–31 weeks				
2014	3,526	1,374	4,900	28.0%
2015	3,543	1,376	4,919	28.0%
2016	3,282	1,219	4,501	27.1%
2017	3,324	1,240	4,564	27.2%
2018	3,328	1,322	4,650	28.4%
2019	3,102	1,264	4,366	29.0%
2020	3,102	1,293	4,395	29.4%
2021	3,185	1,420	4,605	30.8%
2022	2,845	1,299	4,144	31.3%
2023	2,741	1,300	4,041	32.2%
FD 32–36 weeks				
2014	4,275	2,865	7,140	40.1%
2015	4,748	2,836	7,584	37.4%
2016	4,129	2,834	6,963	40.7%
2017	4,350	2,739	7,089	38.6%
2018	4,212	2,885	7,097	40.7%
2019	3,893	2,780	6,673	41.7%
2020	3,972	2,902	6,874	42.2%
2021	3,916	2,927	6,843	42.8%
2022	3,478	2,839	6,317	44.9%
2023	3,126	2,810	5,936	47.3%
FD ≥37 weeks				
2014	3,694	2,886	6,580	43.9%
2015	3,911	3,039	6,950	43.7%
2016	3,470	2,825	6,295	44.9%
2017	3,509	2,782	6,291	44.2%
2018	3,461	2,870	6,331	45.3%
2019	3,158	2,735	5,893	46.4%
2020	3,068	2,672	5,740	46.6%
2021	2,918	2,568	5,486	46.8%
2022	2,552	2,398	4,950	48.4%
2023	2,139	2,272	4,411	51.5%
Term live births				
2014	1,088,730	1,471,478	2,560,208	57.47%
2015	1,155,870	1,456,809	2,612,679	55.76%
2016	1,101,406	1,380,764	2,482,170	55.63%
2017	1,127,564	1,424,020	2,551,584	55.81%
2018	1,134,070	1,442,885	2,576,955	55.99%
2019	1,092,377	1,403,332	2,495,709	56.23%
2020	1,023,098	1,361,925	2,385,023	57.10%
2021	1,012,048	1,327,718	2,339,766	56.75%
2022	941,117	1,293,797	2,234,914	57.89%
2023	899,568	1,313,851	2,213,419	59.36%

Source: *Sistema de Informações sobre Mortalidade–Declaração de Óbito Fetal* (SIM–DOFET; Mortality Information System–Fetal Death Certificate) and *Sistema de Informações sobre Nascidos Vivos* (SINASC; Live Birth Information System), Brazilian Ministry of Health.
LB = live births; FD = fetal deaths. Term live births include all births at ≥37 weeks of gestational age.