

## Temporal trends and projections of caesarean sections in Brazil, its administrative macro-regions, and federative units

Rômulo Cesar Rezzo Pires (<https://orcid.org/0000-0003-0967-3351>)<sup>1</sup>  
Victor Nogueira da Cruz Silveira (<https://orcid.org/0000-0002-5271-7412>)<sup>1</sup>  
Maria do Carmo Leal (<https://orcid.org/0000-0002-3047-515X>)<sup>2</sup>  
Zeni Carvalho Lamy (<https://orcid.org/0000-0002-9332-0542>)<sup>3</sup>  
Antônio Augusto Moura da Silva (<https://orcid.org/0000-0003-4968-5138>)<sup>3</sup>

**Abstract** *Trend studies on the model of birth in Brazil show a scenario of successive linear increases in cesarean rates. However, they ignore possible changes in the temporal evolution of this delivery modality. Thus, this study aimed to evaluate possible inflection points in cesarean rates in Brazil, its macro-regions, and federated units, as well as to estimate projections for 2030. A time series with information on cesarean sections from 1994 to 2019 from the SUS Department of Informatics was used. Autoregressive integrated moving average and joinpoint regression models were used to obtain cesarean rate projections and trends, respectively. Cesarean rates showed a significant upward trend over the 26 study years at all levels of aggregation. On the other hand, when considering the formation of segments, a stabilization trend was observed both in the country and in the South and Midwest regions, starting in 2012. Rates tended to increase in North and Northeast and significantly decrease in Southeast. Projections show that in 2030, 57.4% of births in Brazil will be cesarean, with rates higher than 70% in Southeast and South regions.*

**Key words** *Cesarean section, Temporal distribution, Forecasts, Epidemiology*

<sup>1</sup> Programa de Pós-Graduação em Saúde Coletiva, Universidade Federal do Maranhão (UFMA). R. Barão de Itapary 155, Centro. 65020-070 São Luís MA Brasil. [romulo.pires@yahoo.com.br](mailto:romulo.pires@yahoo.com.br)

<sup>2</sup> Escola Nacional de Saúde Pública Sergio Arouca, Fundação Oswaldo Cruz. Rio de Janeiro RJ Brasil.

<sup>3</sup> Departamento de Saúde Pública, UFMA. São Luís MA Brasil.

## Introduction

Cesarean section is a life-saving procedure in specific obstetric circumstances and clinically recommended to prevent maternal and neonatal mortality. However, when performed without medical indications, it may be associated with negative short- and long-term outcomes for both mother and child<sup>1,2</sup>.

Maternal and fetal morbidity and mortality are higher after cesarean sections compared to vaginal delivery<sup>3-5</sup>. However, cesarean section is the most common major surgery in many countries. Its frequency increased in the last 30 years and currently exceeds by far the maximum percentage of 10% to 15% recommended by the World Health Organization (WHO) in a systematic review<sup>6-8</sup>.

The average overall cesarean rate is 21.1%, ranging from 5% in sub-Saharan Africa to 42.8% in Latin America/the Caribbean. Despite the high rates in many countries, cesarean section showed upward trends in all continents and sub-regions of the globe from 1990 to 2014<sup>7</sup>, 2000 to 2015<sup>9</sup>, and 1990 to 2018<sup>8</sup>. Its increase in the last three decades was higher in East and Western Asia and North Africa (44.9%, 34.7%, and 31.5%, respectively). In total, 38 million cesarean sections are estimated for 2030, which corresponds to 28.5% of women worldwide undergoing this delivery modality<sup>8</sup>.

Brazil has the second highest cesarean rate in the world (55.7% in 2018), followed by the Dominican Republic (58.1% in 2018)<sup>8</sup>. Studies presented significant linear upward cesarean rate trends in Brazil from 1994 to 2009<sup>10</sup>, 2000 to 2011<sup>11,12</sup>, 2001 to 2015<sup>13</sup>, and 2014 to 2017<sup>14</sup>. However, Belarmino *et al.*<sup>15</sup> showed stable cesarean rates at the national and macro-regional levels and a slight decrease in Southeastern Brazil from 2010 to 2017, suggesting the possible existence of inflection points in the historical series of deliveries in Brazil.

Cesarean section is a multifactorial phenomenon positively related to better socioeconomic conditions and/or access to health services<sup>11-13</sup>. Data from the National Health Survey<sup>16</sup> conducted from 1990 to 2013 with 16,175 women showed that cesarean sections are more prevalent in Midwest, Southeast, and South regions of the country and among women with higher schooling levels, health insurance, and who were older in the first pregnancy, suggesting the existence of inequalities regarding this delivery modality<sup>16,17</sup>.

For decades, the Brazilian Ministry of Health has been developing public policies aimed at women's health care, such as the Integral Attention to Women's Health Program<sup>18</sup>. The Human-

ization of Prenatal And Birth Program<sup>19</sup> and the National Policy for Integral Attention to Women's Health<sup>20</sup> were important milestones for changing practices related to delivery in Brazil and resulted in the *Rede Cegonha* (Stork Network) program<sup>21</sup>, which aimed to change the model of delivery and birth, encouraging good practices based on scientific evidence, and had reducing unnecessary cesarean sections as one of its goals. The *Parto Adequado* (Adequate Delivery) program (2015) for supplementary health and the *Parto Cuidadoso* (Careful Delivery) program (2018) for the SUS also stand out, aiming to monitor online cesarean deliveries in Brazil, as well as the Apice-On, an improvement and innovation project focused on obstetric and neonatal care and teaching<sup>21</sup>.

Due to its territorial extension and heterogeneity regarding socioeconomic and cultural conditions, adherence to public policies, and access to health services, both the occurrence and evolution of cesarean sections in Brazil may have heterogeneous patterns between the different levels of aggregation in time. Thus, this study aimed to analyze the temporal evolution of cesarean rates in Brazil, its macro-regions, and federative units (FUs), considering possible trend changes over a long period (1994-2019), as well as to estimate the projections of this delivery modality for 2030.

## Methods

This was an ecological time-series study on cesarean trends in Brazil. The Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) was used to build the database, analyze, and present the results of the study<sup>22</sup>.

Data on cesarean sections from 1994 to 2019 were collected from the Information System on Live Births (SINASC), which was made available by the Brazilian Ministry of Health in <http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sinasc/cnv/nvuf.def>.

Brazil, its five geographical macro-regions, and 27 federative units were the aggregation levels considered. Cesarean rate (%) was the response variable, obtained by the quotient between the number of cesarean births and the total number of live births in the same year, multiplied by 100. The calendar year was the regressive variable.

For trend analysis, a joinpoint regression model was used to assess the occurrence of possible points of significant changes in the trend. During the modeling strategy, the possibility of

adding one or more inflection points to the model was tested. The number of inflections used in the analysis resulted from models defined later to allow the best representation of the trend, with the lowest number of inflection points. Moreover, the slope of the line segment or annual percent change (APC) was estimated with a 95% confidence interval, as well as the variation of the entire period by the average annual percent change (AAPC). The AAPC was estimated as a weighted geometric mean of the APC with weights equal to the length of each line segment during the pre-specified fixed interval. In upward trends, the APC/AAPC and the 95%CI lower limits were higher than zero (positive). In downward trends, the APC/AAPC and the 95%CI upper limits were lower than zero (negative)<sup>23</sup>. Rates with the APC/AAPC equal to zero and/or 95%CI containing zero were considered stationary. Significance tests were performed using the Monte Carlo permutation technique with 4,999 permutations<sup>24</sup>. For each trend found, 95%CI and a 5% significance level were used. Temporal analyses were performed in the Joinpoint Regression Program<sup>25</sup>, and the number of points required for the adjustment of each segment was automatically selected by the standard software configuration.

Cesarean rate projections for 2030 were estimated by autoregressive integrated moving average (ARIMA) models adjusted for the three levels of aggregation adopted. Initially, the assumptions of stationarity and seasonality of data were evaluated. Stationarity was analyzed by autocorrelation function plots and the Dickey-Fuller test increased with a 5% significance level. If the time series was not stationary, a differentiation test was performed. Seasonality was evaluated using a time series and a partial autocorrelation function plot.

In the selection of ARIMA models for each subsample, the lowest values of the second-order Akaike information criterion (AICc) and the Bayesian information criterion (BIC) were considered. Analyses were performed in the R Studio program<sup>26</sup> using the forecast, tseries, and xts packages.

The behavior of cesarean rates from 2020 to 2030 was analyzed using the AAPC, in accordance with Boerma *et al.*<sup>9</sup>.

The study did not require approval by a Research Ethics Committee, since the aggregated secondary data analyzed were of public domain, with unrestricted access.

## Results

### Caesarean rate variations

From 1994 to 2019, 77,064,234 deliveries occurred in Brazil, of which 35,792,103 were cesarean births (46.4%). We found the lowest cesarean rate in the first year of the series (32%) and the highest in 2014 (56.9%). Cesarean rates varied widely among the macro-regions of the country. The Midwest region had the highest rates (minimum and maximum), ranging from 42.7% (1999) to 63% (2018), followed by South (40.5% in 1999 and 62.7% in 2013), Southeast (31.3% in 1994 and 61.3% in 2013), Northeast (23.3% in 1994 and 52.4% in 2019), and North (26.9% in 1994 and 47.7% in 2019) regions. Among FUs, we found the highest cesarean rates in Goiás (67.43% in 2014), Rondônia (66.9% in 2015), and Espírito Santo (66.8% in 2013). On the other hand, we found the lowest rates in Amapá (10.7%), Sergipe (11.5%), and Ceará (18.3%) in the first year of the series.

### Caesarean rate trends

The annual average cesarean rate in Brazil significantly increased by 2.1%, considering the complete series. During this period, we observed four temporal behaviors by segmented modeling: a rapid growth until 1996 (APC=11.4%), followed by a slight decrease until 2000 (APC=-3%), a consequent growth until 2012 (APC=3.6%), and stabilization until the end of the series (APC=0) (Table 1).

Despite the different temporal behaviors, all macro-regions showed a significant increase in cesarean rates in the entire study period. After segmented modeling, North, Northeast, and Midwest regions showed significantly higher percentage increases from 2001 to 2012, followed by smaller increases until the end of the series. In other macro-regions, increases were higher from 1994 to 1996, followed by a significant decrease until 1999 and a subsequent increase until 2012. After this year, rates stabilized in South and Midwest regions and significantly decreased in the South. The highest average percentage increases occurred in Northeast (AAPC=3.2%) and North (AAPC=2.3%) regions, with average growth proportions above the national variation, considering the entire study period (Table 1).

The number of segments formed for FUs ranged from two (n=3 FUs) to five (n=3 FUs), with a mode equal to four segments (n=9 FUs).

The trends in these segments did not have a defined pattern and despite this heterogeneity, all FUs, except for Mato Grosso, showed a significant upward trend in annual mean cesarean rates from 1994 to 2019. During this period, the largest average annual percentage increases occurred in Amapá (5%), Ceará (4.7%), and Sergipe (4.5%). On the other hand, Mato Grosso do Sul (0.5%), Rio de Janeiro (0.9%), and Goiás (1.1%) had the lowest increases (Table 2 and Figure 1).

In general, FUs in Northern and Northeastern Brazil had the lowest rates at the beginning of the historical series and showed higher upward trends in the 2000s. On the other hand, FUs in other macro-regions, such as Santa Catarina, Paraná, Rio de Janeiro, and Espírito Santo, had high rates at the beginning of the series and from 2012 to 2019, underwent a process of decelera-

tion that promoted stabilization or even downward trends (Table 2 and Figure 1).

### Analysis of cesarean rate projections

The analysis of projections showed that in 2030, the percentage of cesarean births in Brazil will be 57.4%, with a higher concentration in Southeast and South regions and rates 13% higher than the national estimate (Table 3). FUs in North (Rondônia, Amazonas, and Roraima) and Northeast regions (Rio Grande do Norte, Ceará, and Alagoas) had both the highest projected cesarean rates and the lowest estimates (Table 3 and Figure 1).

When considering the evolution of the projected cesarean rates from 2020 to 2030, the AAPC was positive for Brazil (0.1% per year)

**Table 1.** Cesarean rate trends (%) in Brazil and macro-regions (1994-2019).

Macro-region	Cesarean rate (%)			Segments	APC (95%CI)	AAPC (95%CI)
	1994 <sup>a</sup>	2006 <sup>a</sup>	2019 <sup>a</sup>			
Brazil	32.0	45.0	56.3	1994-1996	11.4* (8.6 to 14.2)	2.1* (1.8 to 2.4)
				1996-2000	-03.0* (-4.3 to -1.8)	
				2000-2012	03.6* (3.5 to 3.8)	
				2012-2019	0.04 (-0.3 to 0.4)	
North	26.8	33.8	47.7	1994-1996	4.5 (-0.1 to 9.3)	2.3* (1.8 to 2.7)
				1996-2001	-2.0* (-3.4 to -0.6)	
				2001-2012	4.9* (4.5 to 5.3)	
				2012-2019	0.7* (0.1 to 1.3)	
Northeast	23.3	34.6	52.4	1994-1996	3.1 (-0.7 to 7.0)	3.2* (2.6 to 3.9)
				1996-1999	-0.7 (-4.3 to 3.0)	
				1999-2002	3.6 (-0.1 to 7.5)	
				2002-2012	6.2* (5.8 to 6.5)	
				2012-2019	0.7* (0.2 to 1.2)	
Southeast	31.3	53.1	58.5	1994-1996	24.5* (21.6 to 27.6)	2.2* (1.9 to 2.5)
				1996-1999	-5.0* (-7.3 to -2.7)	
				1999-2012	2.4* (2.3 to 2.6)	
				2012-2019	-0.7* (-1.0 to -0.4)	
South	40.6	51.3	61.3	1994-1996	4.2* (1.4 to 7.0)	1.6* (1.2 to 2.0)
				1996-1999	-2.7* (-5.3 to 0.0)	
				1999-2012	3.3* (3.1 to 3.5)	
				2012-2019	-0.3 (-0.6 to 0.1)	
Midwest	48.65	50.6	62.5	1994-1996	2.7* (0.4 to 5.2)	1.0* (0.6 to 1.5)
				1996-1999	-5.6* (-7.7 to -3.4)	
				1999-2002	1.1 (-1.2 to 3.5)	
				2002-2012	3.3* (3.1 to 3.5)	
				2012-2019	0.3 (0.0 to 0.6)	

<sup>a</sup> Information System on Live Births (SINASC); APC: annual percent change; AAPC: average annual percent change; \*p<0.05; 95%CI: 95% confidence interval.

and its macro-regions (below 2%), except for the Midwest region (-0.1%). FUs in Northern and Northeastern Brazil had a positive AAPC, ranging from 0.4% to 3%, except for Amazonas and Alagoas (0% and -0.6%, respectively). On the other hand, FUs in the other macro-regions had AAPC values below and/or close to zero, except for Rio Grande do Sul (1.7%) (Table 3).

## Discussion

From 1994 to 2019, cesarean rates were very high compared to the parameters recommended by the WHO<sup>1</sup> and showed a general upward trend in all levels of aggregation adopted. Moreover, both the highest rates of the historical series and the highest projected rates belonged to Midwest,

**Table 2.** Cesarean rate trends (%) in Brazilian federative units (1994-2019).

FU	Cesarean rate (%)			Segments	APC (95%CI)	AAPC (95%CI)
	1994 <sup>a</sup>	2006 <sup>a</sup>	2019 <sup>a</sup>			
RO	38.2	55.3	66.7	1994 to 1998	0.8 (-0.7 to 2.4)	2.2* (1.9 to 2.6)
				1998 to 2010	4.1* (3.8 to 4.5)	
				2010 to 2019	0.4 (0.0 to 0.9)	
AC	22.8	28.8	44.4	1994 to 1996	-7.0 (-18.0 to 5.4)	2.7* (1.7 to 3.7)
				1996 to 2019	3.6* (3.3 to 3.9)	
AM	28.7	32.0	39.4	1994 to 2002	-2.9* (-3.9 to -2.0)	1.0* (0.5 to 1.1)
				2002 to 2008	7.6* (5.5 to 9.7)	
				2008 to 2019	0.5 (-0.1 to 1.1)	
RR	18.8	25.1	34.6	1994 to 1997	8.2* (0.3 to 16.8)	2.7* (0.7 to 4.8)
				1997 to 2005	-0.6 (-2.6 to 1.4)	
				2005 to 2008	14.8 (-1.4 to 33.6)	
				2008 to 2019	0.6 (-0.4 to 1.7)	
PA	24.7	32.8	50.3	1994 to 1996	11.7* (7.3 to 16.3)	2.8* (2.2 to 3.3)
				1996 to 2000	-4.5* (-6.4 to -2.6)	
				2000 to 2006	3.7* (2.7 to 4.6)	
				2006 to 2012	6.9* (5.9 to 7.8)	
				2012 to 2019	0.4 (-0.2 to 0.9)	
AP	10.7	24.3	36.6	1994 to 1997	9.9* (4.9 to 15.2)	5.0* (3.5 to 6.4)
				1997 to 2000	1.7 (-7.3 to 11.6)	
				2000 to 2004	11.3* (6.3 to 16.6)	
				2004 to 2014	4.3* (3.5 to 5.2)	
				2014 to 2019	0.4 (-1.7 to 2.5)	
TO	28.2	35.8	56.9	1994 to 1997	2.9 (-0.7 to 6.7)	2.8* (2.0 to 3.5)
				1997 to 2001	-3.0 (-6.4 to 0.5)	
				2001 to 2014	4.9* (4.5 to 5.4)	
				2014 to 2019	1.8* (0.2 to 3.4)	
MA	24.3	28.0	49.9	1994 to 2002	-1.6* (-2.5 to -0.8)	2.7* (2.3 to 3.2)
				2002 to 2013	5.7* (5.0 to 6.3)	
				2013 to 2019	3.4* (2.0 to 4.8)	
PI	33.3	38.9	57.7	1994 to 2001	-1.2* (-2.4 to 0.0)	2.4* (1.9 to 3.0)
				2001 to 2011	5.5* (4.6 to 6.4)	
				2011 to 2019	1.9* (0.9 to 2.9)	
CE	18.3	37.4	58.4	1994 to 1996	15.9* (10.6 to 21.6)	4.7* (4.0 to 5.4)
				1996 to 1999	0.6 (-4.1 to 5.5)	
				1999 to 2013	6.1* (5.8 to 6.3)	
				2013 to 2019	0.1 (-0.7 to 0.9)	
RN	24.2	39.1	62.3	1994 to 2002	2.1* (1.4 to 2.8)	3.8* (3.5 to 4.2)
				2002 to 2012	7.1* (6.5 to 7.7)	
				2012 to 2019	1.2* (0.4 to 2.0)	

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**Table 2.** Cesarean rate trends (%) in Brazilian federative units (1994-2019).

FU	Cesarean rate (%)			Segments	APC (95%CI)	AAPC (95%CI)
	1994 <sup>a</sup>	2006 <sup>a</sup>	2019 <sup>a</sup>			
PB	40.3	42.5	60.6	1994 to 2001	-3.9* (-5.3 to -2.5)	1.4* (0.8 to 2.1)
				2001 to 2011	5.7* (4.7 to 6.7)	
				2011 to 2019	1.1 (-0.1 to 2.3)	
PE	26.3	38.9	51.0	1994 to 2002	1.9* (1.3 to 2.4)	2.7* (1.9 to 3.5)
				2002 to 2010	6.3* (5.6 to 7.0)	
				2010 to 2014	2.1 (-0.4 to 4.7)	
				2014 to 2017	-3.3 (-0.8 to 1.7)	
				2017 to 2019	2.3 (-2.7 to 7.6)	
AL	19.3	36.2	52.4	1994 to 2000	1.9* (0.5 to 3.3)	4.1* (3.6 to 4.5)
				2000 to 2011	8.9* (8.2 to 9.6)	
				2011 to 2019	-0.8 (-1.6 to 0.1)	
SE	11.5	28.4	44.6	1994 to 2013	5.7* (4.9 to 6.5)	4.5* (3.4 to 5.7)
				2013 to 2019	0.8 (-3.4 to 5.2)	
BA	20.7	30.2	46.0	1994 to 1999	-1.6* (-3.2 to 0.0)	3.0* (2.6 to 3.5)
				1999 to 2012	6.1* (5.7 to 6.6)	
				2012 to 2019	0.7 (-0.2 to 1.7)	
MG	41.5	47.9	58.1	1994 to 1996	6.3* (3.8 to 8.9)	1.3* (1.0 to 1.3)
				1996 to 2000	-4.4* (-5.5 to -3.2)	
				2000 to 2012	3.2* (3.0 to 3.3)	
				2012 to 2019	0.1 (-0.2 to 0.4)	
ES	42.5	50.8	60.0	1994 to 1996	3.4 (-0.8 to 7.81)	1.4* (0.8 to 2.0)
				1996 to 1999	-2.2 (-6.2 to 1.9)	
				1999 to 2004	1.8* (0.4 to 3.1)	
				2004 to 2012	4.8* (4.3 to 5.4)	
				2012 to 2019	-1.7* (-2.2 to -1.1)	
RJ	44.7	54.5	57.7	1994 to 1996	3.9* (0.8 to 7.1)	0.9* (0.6 to 1.3)
				1996 to 2002	0.1 (-0.6 to 0.8)	
				2002 to 2012	2.6* (2.3 to 2.8)	
				2012 to 2019	-1.4* (-1.8 to -1.0)	
SP	24.4	55.1	58.8	1994 to 1996	32.3* (17.4 to 49.1)	3.2* (2.3 to 4.2)
				1996 to 2019	1.0* (0.7 to 1.3)	
PR	43.6	51.8	62.3	1994 to 1996	5.4* (2.7 to 8.2)	1.4* (1.0 to 1.7)
				1996 to 1999	-4.5* (-6.9 to -2.0)	
				1999 to 2013	2.9* (2.8 to 3.1)	
				2013 to 2019	-0.5* (-1.0 to -0.1)	

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Southeast, and South regions. On the other hand, Northeast and North regions of the country and their FUs showed the highest significant average increases in the historical series. Considering the occurrence of segments, cesarean rates in Brazil and its macro-regions significantly decreased from 1996 to 2001, but increased until 2012. After this period, North and Northeast regions showed a significant upward trend and the other macro-regions, stability (Midwest) or decrease (South and Southeast), corroborating the hypothesis of heterogeneity of temporal patterns.

### Caesarean rate variations

In 2019, cesarean rates in Brazil were above the global estimate (21.1%; n=154 countries) and higher compared with countries with the highest rates in the world, such as Cyprus (55.3%), Egypt (51.8%), and Turkey (50.8%). Even countries without high cesarean rates showed upward trends from 1990 to 2018, which represents a worldwide public health problem<sup>8</sup>.

Nationally, Midwestern, Southern, and Southeastern Brazil remain with the highest

**Table 2.** Cesarean rate trends (%) in Brazilian federative units (1994-2019).

FU	Cesarean rate (%)			Segments	APC (95%CI)	AAPC (95%CI)
	1994 <sup>a</sup>	2006 <sup>a</sup>	2019 <sup>a</sup>			
SC	39.5	51.6	57.4	1994 to 1996	3.1 (-0.4 to 6.8)	1.4* (0.9 to 2.0)
				1996 to 1999	-2.1 (-5.4 to 1.4)	
				1999 to 2005	3.9* (3.1 to 4.7)	
				2005 to 2012	2.9* (2.3 to 3.5)	
				2012 to 2019	-1.0* (-1.4 to -0.5)	
RS	38.0	50.5	63.1	1994 to 1996	3.4* (0.5 to 6.3)	2.0* (1.6 to 2.4)
				1996 to 1999	-1.1 (-3.8 to 1.7)	
				1999 to 2012	3.6* (3.4 to 3.7)	
				2012 to 2019	0.1 (-0.2 to 0.5)	
MS	54.7	51.1	62.2	1994 to 1996	2.8 (-1.4 to 7.2)	0.5* (0.0 to 1.0)
				1996 to 2000	-8.0* (-9.9 to -6.1)	
				2000 to 2012	3.2* (2.9 to 3.5)	
				2012 to 2019	0.4 (-0.1 to 1.0)	
MT	54.8	50.3	60.9	1994 to 1997	-1.3* (-3.1 to 0.7)	0.4 (-0.1 to 0.9)
				1997 to 2000	-6.4* (-9.9 to -2.8)	
				2000 to 2013	2.5* (2.3 to 2.8)	
				2013 to 2019	0.2 (-0.4 to 0.9)	
GO	51.3	51.8	67.0	1994 to 1996	1.6 (-1.3 to 4.6)	1.1* (0.7 to 1.6)
				1996 to 1999	-5.3* (-8.0 to -2.5)	
				1999 to 2003	0.8 (-0.7 to 2.2)	
				2003 to 2012	4.2* (3.9 to 4.6)	
				2012 to 2019	0.1 (-0.3 to 0.5)	
DF	33.2	48.1	54.5	1994 to 1999	2.3* (1.0 to 3.5)	2.0* (1.7 to 2.4)
				1999 to 2007	3.9* (3.1 to 4.6)	
				2007 to 2019	0.7* (0.4 to 1.0)	

<sup>a</sup>Information System on Live Births (SINASC); FU: federative; APC: annual percent change; AAPC: average annual percent change; RO: Rondônia AC: Acre; AM: Amazonas; RR: Roraima; PA: Pará; AP: Amapá; TO: Tocantins; MA: Maranhão; PI: Piauí; CE: Ceará; RN: Rio Grande do Norte; PB: Paraíba; PE: Pernambuco; AL: Alagoas; SE: Sergipe; BA: Bahia; MG: Minas Gerais; ES: Espírito Santo; RJ: Rio de Janeiro; SP: São Paulo; PR: Paraná; SC: Santa Catarina; RS: Rio Grande do Sul; MS: Mato Grosso do Sul; MT: Mato Grosso; GO: Goiás; DF: Distrito Federal. \*p<0.05. 95%CI: 95% confidence interval.

Source: Authors.

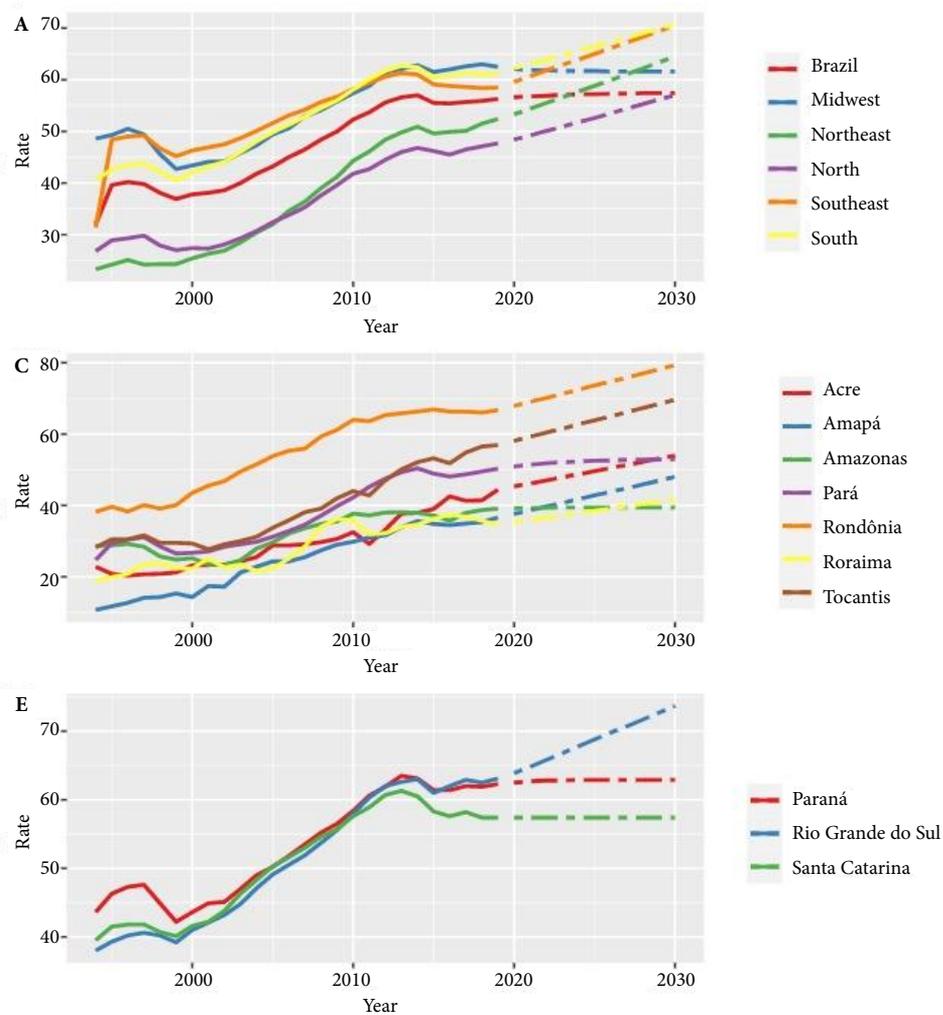
cesarean rates, corroborating the results of the National Health Survey from 1990 to 2013<sup>16</sup>. FUs have a pattern of spatial dependence in the distribution of the prevalence of cesarean delivery, with clusters in Southeastern, Southern, and Midwestern Brazil with a high prevalence of cesarean delivery and correlated to higher human development indexes<sup>17</sup>.

### Caesarean rate trends

Since the beginning of the monitoring of births in Brazil, cesarean rates have gradually increased by about 30% in the early 1980s, 40% in the early 1990s, 50% in 2009, and 55.7% in

2017<sup>8,27</sup>. Nationally based studies have shown a linear upward cesarean rate trend<sup>10-14</sup>. However, this study showed the formation of inflection points from 1994 to 2019 by segmented regression for the aggregates studied. This model is an efficient and flexible statistical method, capable of establishing inflection points and a cesarean rate trend pattern per aggregation unit in different periods. The behavior of the response variable can be analyzed in different periods of the explanatory variable (time) or separately, relating the trends to the cultural, socioeconomic, and political specificities of each FU.

Brazil and its macro-regions, especially the Southeast, showed successive increases in cesar-

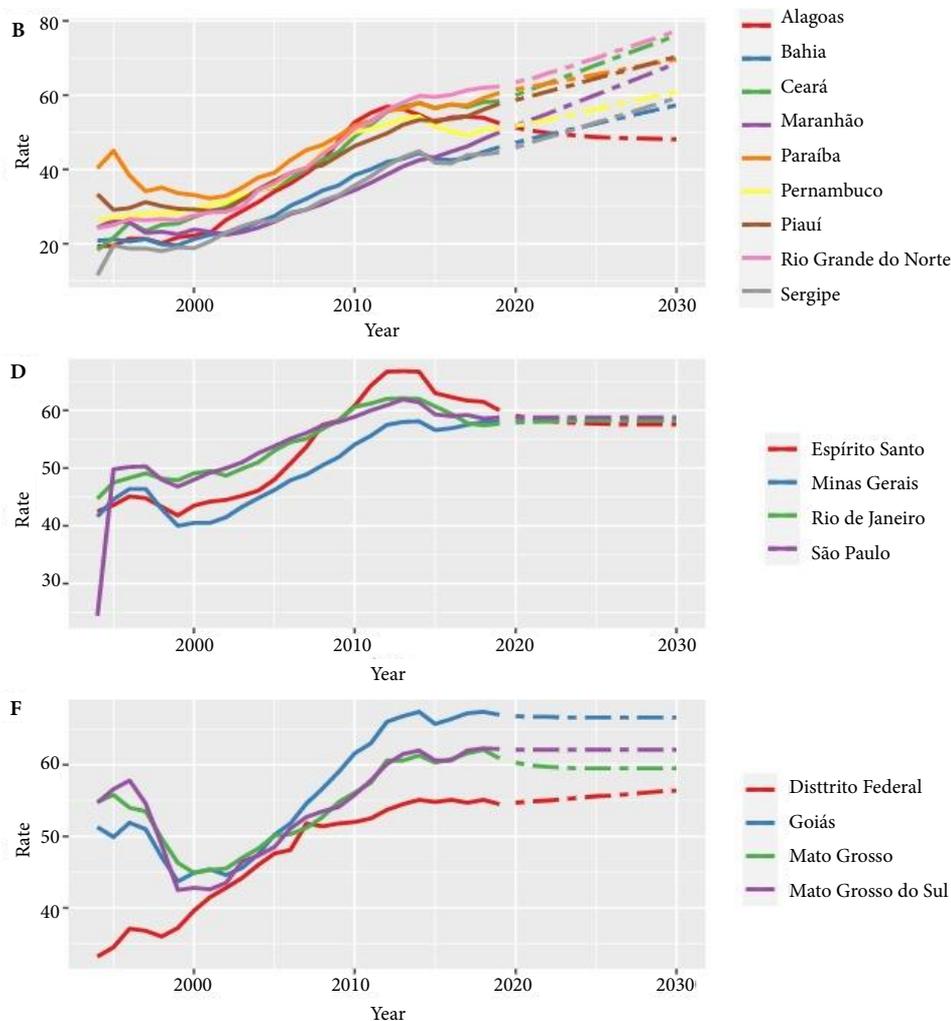


it continues

**Figure 1.** Trends (1994-2019) and projections (2020-2030) of cesarean rates in macro-regions and federative units of Brazil. Continuous lines are trend estimates and dotted lines represent projections. (A) Macro-regions; (B) Northeast; (C) North; (D) Southeast; (E) South; and (F) Midwest.

cesarean rates in the first three years of the historical series (1994-1996). This period follows the implementation of SINASC and the progressive increase in the coverage of this system, which was created in 1990 and until 1998, was already operating in all municipalities of the country<sup>28</sup>. During this period, the hegemonic process of hospitalization and medicalization of the delivery process, which since the 1950s has contributed to the removal of the control of women in giving birth, was improved.

The decrease from 1996 to 1999/2000 may be due to the agreement between the Brazilian Ministry of Health and Health Departments that established a maximum limit for cesarean sections in the SUS, restricting the transfer of resources to this limit. Moreover, the Ministry of Health increased by 160% the amount of compensation for vaginal delivery and established the payment for labor analgesia. Ordinance 2,816/1998 stipulated limits for the payment of caesarean sections to hospitals: 40% for the second half of



**Figure 1.** Trends (1994-2019) and projections (2020-2030) of cesarean rates in macro-regions and federative units of Brazil. Continuous lines are trend estimates and dotted lines represent projections. (A) Macro-regions; (B) Northeast; (C) North; (D) Southeast; (E) South; and (F) Midwest.

Source: Authors.

1998, expecting a semiannual gradual reduction until reaching 30% in 2000, contributing to a reduction in rates within the SUS and outsourced services<sup>29</sup>. During this period, cesarean rates significantly decreased by 3% in Brazil and its macro-regions, except for the Northeast.

From 1999 to 2002, cesarean rates significantly increased in Brazil and its macro-regions, coinciding with the replacement of Ordinance 2,816/1998 by 466/2000, which implemented the National Pact for the Reduction of Cesarean

Rates. This document provided for a reduction in the proportion of cesarean sections of 25% by 2008, sharing the responsibility for monitoring hospitals with state administrations<sup>30</sup>. However, only few FUs met its targets and some of them had not meet any target until 2007. Thus, besides the decentralization of actions to the state level, the great contribution of the private sector in the increase in cesarean sections during this period possibly negatively affected cesarean rates in Brazil.

On the other hand, we can interpret the stabilization trend from 2012 to 2019 in South and Midwest regions, as well as the decrease in Southeast, due to the policies implemented in the public sector and supplementary health since 2011, such as the *Rede Cegonha* program, which includes strategies based on the principles of hu-

manization and proposes the paradigm of a new model of delivery care, from birth and health of children, ensuring the reduction of maternal and neonatal mortality. Moreover, we highlight the *Diretrizes de Atenção à Gestante: a operação cesariana* (Guidelines for Care for Pregnant Women: cesarean section)<sup>31</sup> and the *Parto Cuidadoso*

**Table 3.** Projections of cesarean rates (%) in Brazil, its macro-regions, and federative units (2020, 2025, and 2030) and characteristics of the selected models.

Aggregation unit	Projections <sup>a</sup> (95%CI)						AAPC (%)	Model used	$\sigma^2$
	2020		2025		2030				
Brazil	56.6	(53.3-59.8)	57.2	(36.8-77.7)	57.4	(22.5-92.3)	+ 0.1	1.1.0	2.8
Macro-region									
North	48.4	(46.7-50.2)	52.6	(44.7-60.6)	57.0	(45.1-68.9)	+ 1.7	1.1.0	0.8
Northeast	53.3	(51.6-55.1)	58.8	(50.9-66.7)	64.5	(52.7-76.2)	+ 1.9	1.1.0	0.8
Southeast	59.6	(52.8-66.4)	65.0	(48.3-81.8)	70.5	(47.8-93.1)	+ 1.7	0.1.0	12.2
South	62.2	(60.3-64.0)	66.4	(59.1-73.8)	70.7	(60.5-80.9)	+ 1.3	0.1.1	0.9
Midwest	62.1	(59.7-64.6)	61.7	(49.7-73.6)	61.6	(43.3-79.9)	- 0.1	1.1.0	1.6
FU									
RO	67.9	(65.3-70.4)	73.6	(67.4-79.8)	79.3	(70.9-87.7)	+ 1.6	0.1.0	1.7
AC	45.3	(41.7-48.8)	49.6	(40.9-58.3)	53.9	(42.1-65.7)	+ 1.7	0.1.0	3.3
AM	39.2	(36.7-41.8)	39.3	(29.5-49.3)	39.4	(25.1-53.6)	0.0	1.1.0	1.7
RR	35.3	(31.3-39.3)	38.5	(28.6-48.3)	41.6	(28.3-54.9)	+ 1.7	0.1.0	4.2
PA	50.9	(48.3-53.5)	52.5	(35.8-69.2)	53.0	(24.0-82.0)	+ 0.4	1.1.0	1.8
AP	37.6	(35.4-39.8)	42.8	(37.4-48.2)	48.0	(40.6-55.3)	+ 2.5	0.1.0	1.3
TO	58.1	(54.9-61.2)	63.8	(56.0-71.6)	69.6	(59.0-80.1)	+ 1.8	0.1.0	2.6
MA	51.7	(49.5-53.8)	60.1	(49.7-70.6)	68.6	(47.3-90.0)	+ 2.8	0.2.1	1.2
PI	58.6	(56.2-61.0)	64.5	(46.8-82.1)	70.4	(46.9-93.9)	+ 1.8	0.2.2	1.5
CE	60.0	(56.9-63.1)	68.1	(60.5-75.6)	76.3	(65.8-86.3)	+ 2.4	0.1.0	2.5
RN	63.5	(61.4-65.7)	69.9	(59.9-77.4)	77.4	(62.0-92.8)	+ 2.0	2.1.1	1.2
PB	61.4	(56.6-66.3)	65.5	(53.8-77.3)	69.6	(53.7-85.5)	+ 1.2	0.1.0	6.0
PE	51.7	(49.2-54.2)	56.2	(45.9-66.4)	60.9	(46.0-75.9)	+ 1.7	1.1.0	1.6
AL	51.3	(48.3-54.3)	48.8	(30.5-67.0)	48.1	(17.5-78.8)	- 0.6	1.1.0	2.3
SE	45.9	(42.1-49.9)	52.6	(43.1-62.1)	59.2	(46.3-72.0)	+ 2.5	0.1.0	3.9
BA	47.2	(45.1-49.3)	52.3	(44.4-60.2)	57.3	(46.0-68.7)	+ 1.9	1.1.0	1.2
MG	58.2	(55.8-60.6)	58.3	(45.3-71.4)	58.3	(37.6-79.1)	0.0	1.1.0	1.5
ES	59.1	(56.2-62.0)	57.7	(43.2-72.2)	57.6	(35.1-80.0)	- 0.3	1.1.0	2.2
RJ	57.9	(56.0-59.8)	58.3	(47.8-68.7)	58.3	(41.7-75.0)	0.0	1.1.0	1.0
SP	61.2	(52.2-70.2)	62.0	(53.0-71.0)	58.8	(30.0-77.6)	- 0.4	0.1.0	27.0
PR	62.5	(60.0-65.0)	62.9	(50.4-75.4)	62.9	(43.7-82.2)	0.0	1.1.0	1.6
SC	57.4	(55.5-59.3)	57.4	(46.2-68.6)	57.4	(39.1-75.8)	0.0	1.1.0	1.0
RS	63.9	(62.0-65.8)	68.8	(61.4-76.1)	73.7	(63.2-84.3)	+ 1.7	1.1.0	1.0
MS	62.1	(58.6-65.7)	62.1	(48.6-75.7)	62.1	(43.3-81.0)	0.0	0.1.1	3.3
MT	60.3	(57.7-62.9)	59.5	(47.5-71.5)	59.5	(41.5-77.4)	- 0.1	1.1.0	1.8
GO	66.8	(63.6-70.0)	66.6	(52.7-80.5)	66.6	(46.0-87.2)	0.0	1.1.0	2.6
DF	54.7	(52.5-56.9)	55.6	(47.2-63.9)	56.4	(41.0-71.9)	+ 0.3	0.2.1	1.3

FU: federative unit. RO: Rondônia AC: Acre; AM: Amazonas; RR: Roraima; PA: Pará; AP: Amapá; TO: Tocantins; MA: Maranhão; PI: Piauí; CE: Ceará; RN: Rio Grande do Norte; PB: Paraíba; PE: Pernambuco; AL: Alagoas; SE: Sergipe; BA: Bahia; MG: Minas Gerais; ES: Espírito Santo; RJ: Rio de Janeiro; SP: São Paulo; PR: Paraná; SC: Santa Catarina; RS: Rio Grande do Sul; MS: Mato Grosso do Sul; MT: Mato Grosso; GO: Goiás; DF: Distrito Federal. AAPC: average annual percent change.  $\sigma^2$ : test variance. 95%CI: 95% confidence interval. <sup>a</sup>Estimated from the historical series from 1994 to 2019.

Source: Authors.

initiative of the Ministry of Health, which is an online system to monitor the amount of cesarean sections performed in SUS<sup>32</sup>.

In the field of supplementary health, the *Parto Adequado* program (2016) of the National Health Agency (ANS) presents important results among the participating hospitals. Cesarean rates in health plan operators decreased from 84.5% in 2013 and to 82.7% in 2020 (-1.8%). Moreover, from 2017 to 2019, the percentage of vaginal deliveries increased from 33% to 37% in the participating hospitals. Neonatal ICU admissions decreased by 18%, from 40 per 1,000 live births to 33 per 1,000 live births, and about 20,000 unnecessary cesarean sections were avoided<sup>33</sup>.

Thus, actions and policies aimed at the humanization of childbirth cause their effects in a discrete but cumulative way and are only part of the causal chain involved in the trend of the type of delivery, besides social, economic, cultural, and demographic factors.

Regarding differences in regional trends, the richest macro-regions of Brazil presented significant increases at the beginning of the series and since 2012, cesarean rates stabilized or decreased. According to scientific evidence, Brazilian women with a higher socioeconomic status, living in FUs with higher gross domestic product (GDP) and human development index (HDI), undergo more normal delivery. On the other hand, women with a lower socioeconomic status, living in poorer FUs, still undergo more cesarean section, which is sometimes seen as a consumer good. This evidence is found in FUs in Southeastern Brazil, which had the highest GDP in the country in 2017 and where the variables higher maternal schooling level and higher prenatal coverage were associated with a reduction in cesarean rates<sup>15</sup>.

The result of a review of studies conducted in Southeastern and Southern Brazil on models of delivery care is also important when considering regional differences. Results showed that the use of new delivery care practices in line with the guidelines of the Ministry of Health, such as delivery care performed by multidisciplinary teams, including obstetric nurses, using complementary integrative humanized therapies in the pregnancy period, delivery in normal delivery centers, encouraging the participation of companions, offering non-pharmacological measures for pain relief, and care for prepartum, childbirth, and postpartum in a single environment, have contributed to the reduction of unnecessary cesarean sections<sup>34</sup>.

All FUs had cesarean rates higher than 30% since 2012. This value has been considered the upper limit of the adjusted reference rate for the Brazilian population, according to the C-Model tool, developed by the WHO<sup>31</sup>. Therefore, many of these sections were unnecessary and would not be related to improvements in maternal and neonatal mortality at the population level<sup>1</sup>.

Differences in trends in FUs may show the length of the different time periods used, as well as differences in the modeling strategies adopted. In general, the strategy adopted in the aforementioned studies uses *a priori* one time interval and finds estimates to interpret the trend for this period. In this study, we considered the entire period with available information on the delivery modality and obtained from the modeling by inflection points cesarean rate trends segmented later. Thus, this study presents more detailed trends and trend changes over an extended period. Moreover, the processes of demographic and epidemiological transition and the implementation and effectiveness of health policies in each FU should be considered<sup>35</sup>.

Except for Mato Grosso, FUs showed a significant increase in cesarean rates in the complete series, but different trend patterns in the segments formed by different inflection points. We observed two temporal patterns: FUs that had the lowest cesarean rates at the beginning of the series and showed a rapid increase from the 2000s and FUs that had high rates at the beginning of the series and underwent a process of deceleration that promoted stabilization or even downward trends since 2012. This finding shows the different moments of FUs in relation to obstetric transition<sup>36</sup>, which has the secular tendency to move from a pattern of high maternal mortality to low maternal mortality, from the predominance of direct obstetric causes of maternal mortality to an increasing proportion of indirect causes associated with chronic-degenerative diseases, the aging of mothers, and the modification of the natural history of pregnancy and delivery to a pattern of institutionalization of care, increased rates of obstetric intervention, and eventual over-medicalization.

These differences present the phenomenon of the “two-stage growth” of the cesarean epidemic in Brazil. This phenomenon already affects other countries, such as China, where cesarean rates increased rapidly in large and supercities in the 1990s and early 2000s, but decreased in the last ten years, while cesarean rates in rural areas steadily increased<sup>37</sup>. Thus, cesarean sections

should be conducted in a sustainable way, considering each epidemiological, technological, and social factor, the context of implementation of public policies, and the respective scenarios projected for the upcoming decades.

### Analysis of caesarean rate projections

After 2019, caesarean rates in Brazil will increase slightly (0.1% per year), remaining at a high level until 2030 and representing more than half of deliveries in the country. This slow growth corroborates Belarmino *et al.*<sup>15</sup>, who hypothesized that Brazil reached a plateau in the prevalence of caesarean section (60%) and projected reduced rates from 2017. Despite signs of stabilization, in 2030, the caesarean rate in Brazil is expected to be 2.7 times higher than the global average<sup>8</sup> and Southeast and South regions, as well as the states of Rondônia, Ceará, Rio Grande do Norte, Piauí, and Rio Grande do Sul, will have caesarean rates higher than 70%. Thus, the persistence of high caesarean rates in Brazil requires the adoption of effective and more articulated policies, capable of reducing the number of caesarean sections, combined with movements to raise awareness of women about the advantages of vaginal delivery based on scientific evidence, while still considering their autonomy to choose the delivery modality.

Macro-regions with the best socioeconomic indicators will have higher caesarean rates in 2030; however, considering only 2020 and 2030, most FUs in macro-regions with the highest caesarean rates (Southeast and South regions) will have stable or reduced rates (except for Rio Grande do Sul) in the average annual percent change, whereas in FUs in North and Northeast regions, the projections show percentage increase (except for Amazonas and Alagoas). Moreover, in Midwest, all FUs presented a negative average annual percent change, except for the Federal District. The pattern of temporal distribution found supports the hypothesis of a two-speed epidemic within Brazil, in which aggregation units with a high caesarean rate at the beginning of the series would tend to stabilize or decrease from 2012.

The methodology used for prediction considers past caesarean rates as the greatest predictors for future projections, thus, the detailed analysis of trends in the historical series helps understand the different behaviors expected for 2020

to 2030. Alagoas, for example, already showed signs of decrease since 2012, with successively decreasing rates, which directly affects the projections for 2030. On the other hand, Amazonas shows signs of stabilization since 2010 and the projections confirmed this trend. The projected rate for Rondônia in 2030 is the largest in Brazil. This FU is part of the group with very high rates at the beginning of the series and in 2019, it had the second highest rate in the country (66.7%). We already expected these projections, especially considering that from 2020 to 2030, its annual percentage change is positive (1.6%), one of the largest in Brazil. Moreover, 2020 and preliminary 2021 data already show this increase. However, most extreme projections at the end of the series may present a higher degree of inaccuracy.

### Strengths and limitations

This study analyzed an extensive series of information on caesarean sections and identified general and later segmented trends (from inflection points). We used data to project rates for Brazil in 2030 by autoregressive integrated moving average models. These models are able to detect trend changes in the historical series and predict the behavior of the response variable. General estimates and at broader aggregation levels can hide differences and inequalities within a country and, thus, the use of hierarchically lower levels of aggregation produces more specific information for each context of implementation of caesarean monitoring actions. The trend estimates obtained in this study are robust, but conditioned to the coverage of SINASC in FUs, which was wide, homogeneous, and higher than 90%, except for Maranhão (84.3%) and Bahia (88.5%)<sup>28</sup>. On the other hand, these estimates come from secondary data, which have limited information on, for example, the source of funding and the clinical indication of the surgery. The inclusion of only live births was another limiting factor. In the case of projections, we did not consider the possible effects of the COVID-19 pandemic<sup>8</sup> on both caesarean sections in Brazil and draft laws already approved in São Paulo (2019), Pará (2020), and Paraná (2020) or being discussed in the Chamber of Deputies and Senate since 2021, which guarantee to pregnant women the right to choose for caesarean section in the SUS and would negatively affect the advances made so far.

### **Final considerations**

We observed high cesarean rates and varied time patterns of increase, stabilization, or decrease in the aggregation units analyzed. Brazil had a trend of stabilization since 2012; however, projections show high values for some regions and FUs until 2030. Inflection points show the heterogeneity of the phenomenon in time and contribute to a better historical understanding. The use of models with inflection points, along with projection methods, is effective to identify priority interven-

tion units in time, supporting decision making, the implementation of strategies of the sectors involved, and a more incisive action regarding the excessive and/or unnecessary performance of cesarean sections. Thus, the humanization of childbirth would assume a priority role in the current agenda of health actions in Brazil by strengthening and improving the existing and others specific initiatives for each context, reducing the number of cesarean sections and, consequently, maternal and perinatal mortality, to achieve the target of the Sustainable Development Goals for 2030.

## Collaborations

RCR Pires: design, data interpretation, article writing, critical review and approval of the version to be published. VNC Silveira: data analysis and interpretation, critical review and approval of the version to be published. MC Leal: critical review and approval of the version to be published. ZC Lamy: critical review and approval of the version to be published. AAM Silva: design, data interpretation, article writing, critical review and approval of the version to be published.

## References

1. World Health Organization (WHO). Human Reproduction Programme, 10 April 2015. WHO Statement on caesarean section rates. *Reprod Health Matters* 2015; 23(45):149-150.
2. World Health Organization (WHO). *WHO Recommendations Non-clinical Interventions to Reduce Unnecessary Caesarean, Sections*. Geneva: WHO; 2018.
3. Sandall J, Tribe RM, Avery L, Mola G, Visser GH, Homer CS, Gibbons D, Kelly NM, Kennedy HP, Kildanto H, Taylor P, Temmerman M. Short-term and long-term effects of caesarean section on the health of women and children. *Lancet* 2018; 392(10155):1349-1357.
4. Zhang T, Sidorchuk A, Sevilla-Cermeño L, Vilaplana-Pérez A, Chang Z, Larsson H, Mataix-Cols D, Fernández de la Cruz L. Association of Cesarean Delivery with Risk of Neurodevelopmental and Psychiatric Disorders in the Offspring: A Systematic Review and Meta-analysis. *JAMA Netw Open* 2019; 2(8):e1910236.
5. Blake JA, Gardner M, Najman J, Scott JG. The association of birth by caesarean section and cognitive outcomes in offspring: a systematic review. *Soc Psychiatry Psychiatr Epidemiol* 2021; 56(4):533-545.
6. Betran AP, Torloni MR, Zhang J, Ye J, Mikolajczyk R, Deneux-Tharaux C, Oladapo OT, Souza JP, Tunçalp Ö, Vogel JP, Gülmezoglu AM. What is the optimal rate of caesarean section at population level? A systematic review of ecologic studies. *Reprod Health* 2015; 12:57.
7. Betrán AP, Ye J, Moller AB, Zhang J, Gülmezoglu AM, Torloni MR. The Increasing Trend in Caesarean Section Rates: Global, Regional and National Estimates: 1990-2014. *PLoS One* 2016; 11(2):e0148343.
8. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. *BMJ Glob Health* 2021; 6(6):e005671.
9. Boerma T, Ronsmans C, Melesse DY, Barros AJD, Barros FC, Juan L, Moller AB, Say L, Hosseinpoor AR, Yi M, Rabello Neto DL, Temmerman M. Global epidemiology of use of and disparities in caesarean sections. *Lancet* 2018; 394(10192):23-24.
10. Hofelmann DA. Tendência temporal de partos cesáreos no Brasil e suas regiões: 1994 a 2009. *Epidemiol Serv Saude* 2012; 21(4):561-568.
11. Barros FC, Matijasevich A, Maranhão AG, Escalante JJ, Rabello Neto DL, Fernandes RM, Vilella ME, Matos AC, Albuquerque C, Léon RG, Victora CG. Cesarean sections in Brazil: will they ever stop increasing? *Rev Panam Salud Publica* 2015; 38(3):217-225.
12. Rattner D, Moura EC. Nascimentos no Brasil: associação do tipo de parto com variáveis temporais e sociodemográficas. *Rev Bras Saúde Matern Infant* 2016; 16(1):39-47.
13. Kluthcovsky ACGC, Amari VCS, Esperidião CR, Ciriaco EM, Freitas NB, Vernizi BT. Trends and factors associated with cesarean sections in Brazil and its States between 2001 and 2015. *Mundo Saude* 2019; 43(4):1044-1063.

14. Rudey EL, Leal MDC, Rego G. Cesarean section rates in Brazil: Trend analysis using the Robson classification system. *Medicine (Baltimore)* 2020; 99(17):e19880.
15. Belarmino V, Dumith SC, Gonçalves CV. Cut down on the prevalence of cesarean sections in Brazil: a time-series from 2000 to 2017. *SciELO Preprints* [no prelo 2021]. Doi: <https://doi.org/10.1590/SciELOPreprints.1827>.
16. Eufrásio LS, Souza DE, Fônsêca AMC, Viana ESR. Brazilian regional differences and factors associated with the prevalence of cesarean sections. *PTM Fisioter Mov* 2018; 31:e003108.
17. Belarmino V, Carlotto K, Maduell MCP, Gonçalves CV. Spatial distribution of cesarean sections in Brazil from 2000 to 2019. *RSD* 2022; 11(4):e43211427657.
18. Nagahama EEI, Santiago SM. A institucionalização médica do parto no Brasil. *Cien Saude Colet* 2005; 10(3):651-657.
19. Brasil. Portaria nº 569, de 1º de junho de 2000. Institui o Programa de Humanização do Pré-natal e Nascimento, no Âmbito do Sistema Único de Saúde. *Diário Oficial da União*; 2000.
20. Brasil. Ministério da Saúde (MS). Secretaria de Atenção à Saúde. Política Nacional de Atenção Integral à Saúde da Mulher: princípios e diretrizes. Brasília: MS; 2004.
21. Leal MCC. Parto e nascimento no Brasil: um cenário em processo de mudança. *Cad Saude Publica* 2018; 34(5):e00063818.
22. Stevens GA, Alkema L, Black RE, Boerma JT, Collins GS, Ezzati M, Grove JT, Hogan DR, Hogan MC, Horton R, Lawn JE, Marušić A, Mathers CD, Murray CJ, Rudan I, Salomon JA, Simpson PJ, Vos T, Welch V; The GATHER Working Group. Guidelines for Accurate and Transparent Health Estimates Reporting: the GATHER statement. *Lancet* 2016; 388(10062):e19-e23.
23. Rea F, Pagan E, Compagnoni MM, Cantarutti A, Pugni P, Bagnardi V, Corrao G. Joinpoint regression analysis with time-on-study as time-scale. Application to three Italian population-based cohort studies. *Epidemiol Biostat Public Health* 2017; 14(3):e12616-1.
24. Kim HJ, Fay MP, Feuer EJ, Midthune DN. Permutation tests for joinpoint regression with applications to cancer rates. *Stat Med.* 2000; 19(3):335-351.
25. Joinpoint Regression Program. Version 4.9.0.1. *Statistical Methodology and Applications Branch* [computer program]. Bethesda: National Cancer Institute; 2021 [cited 2021 jun 15]. Available from: <https://surveillance.cancer.gov/joinpoint/>.
26. R Core Team 2021. Version 4.2.1. *R: A Language and Environment for Statistical Computing* [computer program]. Vienna: The R Foundation; 2021.
27. Ramires de Jesus G, Ramires de Jesus N, Peixoto-Filho FM, Lobato G. Cesarean rates in Brazil: what is involved? *BJOG* 2015; 122(5):606-609.
28. Mello Jorge MHP, Gotlieb SLD, Soboll MLMS, Almeida MF, Latorre MRDO. Avaliação do Sistema de Informação sobre Nascidos Vivos e o uso de seus dados em epidemiologia e estatísticas de saúde. *Rev Saude Publica* 1993; 27(Supl.):1-46.
29. Picheth SF, Crubellate JM, Verdu FC. A transnacionalização do parto normal no Brasil: um estudo das últimas cinco décadas. *Hist Cien Saude Manguinhos* 2018; 25(4):1063-1082.
30. Rattner D. Humanização na atenção a nascimentos e partos: ponderações sobre políticas públicas. *Interface (Botucatu)* 2009; 13(Supl. 1):759-768.
31. Brasil. Ministério da Saúde (MS). Secretaria de Ciência, Tecnologia e Insumos Estratégicos. *Diretrizes de Atenção à Gestante: a operação cesariana*. Brasília: MS; 2016.
32. Magalhães MM, Melo CPG, Menezes Filho N, Komatsu BK. Os determinantes da realização de cesárias no Brasil. *Policy Paper* 2019; 41:1-28.
33. Instituto de Estudos de Saúde Suplementar (IESS). *O Parto Adequado: evidências científicas e os seus desdobramentos no Brasil e no Mundo*. São Paulo: ISS; 2022.
34. Pereira RM, Fonseca GO, Pereira ACC, Gonçalves GA, Mafra RA. Novas práticas de atenção ao parto e os desafios para a humanização da assistência nas regiões sul e sudeste do Brasil. *Cien Saude Colet* 2018; 23(11):3517-3524.
35. Batista Filho M, Santos CC. Cirurgias cesáreas: a evolução temporal, tendência epidêmica, propostas e recomendações da OMS, dúvidas e desafios atuais. *Rev Bras Saude Mater Infant* 2018; 18(4):851-854.
36. Souza JP, Tunçalp Ö, Vogel JP, Bohren M, Widmer M, Oladapo OT, Say L, Gülmezoglu AM, Temmerman M. Obstetric transition: the pathway towards ending preventable maternal deaths. *BJOG* 2014; 121 (Supl. 1):1-4.
37. Li HT, Luo S, Trasande L, Hellerstein S, Kang C, Li JX, Zhang Y, Liu JM, Blustein J. Geographic Variations and Temporal Trends in Cesarean Delivery Rates in China, 2008-2014. *JAMA* 2017; 317(1):69-76.

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Chief editors: Maria Cecília de Souza Minayo, Romeu Gomes

