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Trends in neonatal mortality in Brazil from 2007 to 2017

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Abstract *The objective of this study was to analyze the trends in neonatal mortality in Brazil from 2007 to 2017. This is an ecological time series study carried out with data from the Mortality Information System and the Information System on Live Births, analyzed through of Prais-Winsten regression. There was an average neonatal mortality rate of 9.46 deaths/1,000 live births in the analyzed period, with a reduction of 2.15% per year. There was a greater decline in early neonatal mortality compared to late neonatal mortality. There was an upward trend of neonatal deaths among preterm infants, newborns with extremely low birth weight, born by cesarean delivery, children of mothers over 30 years of age and of mothers with more than eight years of schooling. Regarding the causes of death, there was an increasing trend of deaths due to congenital malformations, infectious diseases, endocrine, nutritional and metabolic diseases and external causes. Still, there was an upward trend in preventable deaths by adequate care for women during pregnancy and for other causes that are not clearly preventable. Despite the general reduction in deaths, it is necessary to intensify public policies for adequate care for women during pregnancy to ensure improvement in the other indicators analyzed.*

Key words *Infant mortality, Neonatal mortality, Ecological studies, Time series studies*

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introduction

The infant mortality rate is a sensitive indicator to assess the quality of life, socioeconomic development, and access to health services of the population[1]. Over the years, on a global scale, infant deaths have decreased considerably, mainly as a result of the decrease in the post-neonatal component. Neonatal deaths, in turn, have had little significant reduction and represent a challenge for developing countries such as Brazil[2].

Regarding neonatal mortality, specifically from 1990 to 2019, developed countries such as Canada, the United States, the United Kingdom and Japan had rates of 3.4 deaths per 1,000 live births (lb), 3.6/1,000 lb, 2.6/1,000 lb and 0.9/1,000 lb, respectively. Meanwhile, in developing countries such as Brazil, Bolivia, Guatemala and Panama, the neonatal mortality rate (NMR) in the same year corresponded to 8.5/1,000 lb, 14.9/1,000 lb, 12.7/1,000 lb and 8.8 deaths/1,000 lb, respectively. In turn, Pakistan, a country in Asia, had a NMR of 43.0 deaths/1,000 lb and the Central African Republic, a country in Africa, had 41.8 deaths/1,000 lb[3].

Brazil registered a remarkable reduction in the neonatal mortality rate from 25.33/1,000 lb in 1990 to 8.5 deaths/1,000 lb in 2019[3]. However, if we compare neonatal deaths between Brazilian regions, there is a disparity between them, with the North and Northeast regions having high rates of neonatal mortality in relation to the South and Southeast regions[4].

Further, there are major differences between early and late NMRs. Researches show that deaths occurring in the early neonatal period (zero to six days of life) have higher records and a slight increase in some Brazilian states[5,6].

As for the causes of neonatal deaths, infection, premature delivery and birth asphyxia are the main causes of neonatal mortality in the world[7]. The *Nascer no Brasil* national survey conducted between 2011 and 2012 identified that neonatal deaths were mostly associated with prematurity, low birth weight, maternal risk factors, congenital malformations and perinatal asphyxia, which are strongly associated with the low quality of care provided during prenatal care and childbirth[8]. It can be said that neonatal mortality is determined by several factors, however many of its causes are considered preventable, and these are important instruments for monitoring and evaluating health services[1].

From this perspective, from 2000 onwards, political programs and strategies were instituted to improve the indicators of infant and neonatal mortality in the country, such as the Humanization Program in Prenatal and Birth (PHPN), the Baby-Friendly Hospital Initiative (IHAC), the National Pact for the Reduction of Maternal and Neonatal Mortality and, more recently, programs such as Stork net and QualiNeo, with a view to reducing maternal and neonatal mortality based on the qualification and humanization of care provided[9]. Specifically between 2004 and 2007, the Ministry of Health (MH) proposed the principles and guidelines of the National Policy for Comprehensive Care for Women's Health, with an emphasis on improving obstetric and neonatal care[10]. However, despite the implementation of the aforementioned policies, there is still little progress in reducing the neonatal mortality rate among Brazilian regions.

In this context, this study is justified by the need to analyze the trend of neonatal mortality in Brazil from 2007, considering that the results can give visibility to the problem in question and offer subsidies to health managers in decision-making for the implementation of actions and planning the application of resources in this area or even verifying whether these programs and policies contributed to the reduction of neonatal mortality. It is understood that time series studies make it possible to identify atypical patterns in the evolution of morbidity and mortality levels and in the structure of its causes, in addition to being useful for evaluating the impact produced by the implemented interventions[11].

Thus, this study aimed to analyze the trend of neonatal mortality in Brazil from 2007 to 2017.

Method

This is an ecological study with time series analysis, defined as a sequence of quantitative data relating to specific moments, and studied according to their distribution over time, serving to indicate the risks to which people are subject, to monitor the health of the population, predict the occurrence of events, provide support for causal explanations, assist in health planning and assess its impact[12].

The analyzed data correspond to neonatal deaths that occurred in Brazil in the years 2007 to 2017, registered in the Mortality Information System (MIS) and in the Information System on Live Births (SINASC), made available by the MH on the online platform of the Department of Informatics of the Unified Health System (DATASUS).

Neonatal mortality rates were analyzed according to period (early – 0 to 6 days; late – 7 to 27 days), sex (male, female), race/skin color (white, black, yellow, brown, and indigenous), state and region of residence, birth weight in grams [< 1,000 (extremely low weight), < 1,500 (very low weight), < 2,500 (low weight), ≥ 2,500 and <4,000 (adequate weight), and more than 4,000 (macrosomy)], gestational age (in weeks – preterm: < 37; term: 37-41; post-term: > 42), maternal age (in years: <20, 20-29, ≥30), type of delivery (vaginal and cesarean delivery), maternal education in full years of schooling (no education, > 8 years), causes of death, according to the ICD-10 chapter, and deaths from preventable causes.

For the analysis of the preventability of deaths, the Brazilian list of preventable causes of deaths by SUS interventions in children fewer than five years of age was used, which had its first version published in 2007, proposed by authors from different areas in order to monitor the impact of health actions on the risk of death for the population. Such analysis is of paramount importance for evaluating the effectiveness of health care services[13]. To analyze the causes of deaths, the International Statistical Classification of Diseases and Related Health Problems – 10th edition (ICD-10) was used.

To calculate the gross neonatal mortality rate, the number of deaths of residents from 0 to 27 completed days (MIS) was considered the numerator, and the total number of live births of resident mothers (SINASC), the denominator, multiplied by 1,000. In the calculation of early neonatal mortality, deaths of residents from 0 to 6 days and late deaths from 7 to 27 complete days were considered as numerator. Neonatal mortality rates were calculated by period and according to sex, race, region and states, and proportional mortality for the other variables[14].

To measure the rate of variation of the line that adjusts the points of the time series, the base 10 logarithmic transformation of the coefficients (Y) was performed, as it helps to reduce the heterogeneity of the variance of the residuals of the linear regression analysis. Furthermore, this transformation contributes to the determination of the trend. The Prais-Winsten procedure was used for generalized linear regression analysis, as it allows the estimation of regression coefficients with correction of first-order temporal autocorrelation. Through linear regression, it was possible to estimate the value of coefficient b1 applying the confidence interval of this coefficient, also, to calculate the trend or percentage change and the confidence interval of the measure, respectively.

The quantitative estimation of the trend was calculated by the following expression: APC = [-1 + 10^{b1}] * 100%, and by $_{95\%}$CI = [-1 + $10^{b1min.}$] * 00%; [-1 + 10^{b1max}] *100%. APC refers to the term Annual Percentage Change and CI to the Confidence Interval. When the rate was positive, the time series was considered to present an upward trend; when negative, a downward trend; and when there was no significant difference from zero, a stationary trend. The analysis was performed using the STATA 11.1 software.

This study was approved by the Ethics Committee of University Hospital Júlio Muller, under Opinion number 2,788.928 (CEP/HUJM).

Results

In Brazil, a total of 303,260 neonatal deaths were recorded in the period from 2007 to 2017, with a mean neonatal mortality rate of 9.46 deaths/1,000 lb. In turn, the mean early NMR was 7.20 deaths/1,000 lb, and the late NMR was 2.26 deaths/1,000 lb.

A downward trend was observed in neonatal mortality in the period (APC: 2.13; $_{95\%}$CI: -2.56; -1.69), and also in early (APC: -2.09; $_{95\%}$CI: -2.64; -1.54) and late (APC: 1.76; $_{95\%}$CI: -2.27; -1.06) neonatal mortality. Regarding sex, an average rate of 8.42 deaths/1,000 lb and 10.33 deaths/1,000 lb were seen among females and males in the analyzed period, with a downward trend in both sexes, with a APC of -1.69 ($_{95\%}$CI: -2.30; -1.09) and -2.26 ($_{95\%}$CI: -2.53; -1.99), respectively.

With regard to the race/color of the newborns, it was noted that the highest NMR was found in the indigenous race (13.97 deaths/1,000 lb), followed by the white (9.42 deaths/1,000 lb), brown (8.41 deaths/1,000 lb), black (7.24 deaths/1,000 lb), and yellow (5.34 deaths/1,000 lb) races. There was a downward trend in neonatal deaths in the black (APC: 15.23; $_{95\%}$CI: -23.13; -6.51), yellow (APC: 7.70; $_{95\%}$CI: -12.83; -2.26), and brown (APC: 1.98; $_{95\%}$CI: -3.43; -0.50) races. However, the trend proved to be stationary among white and indigenous neonates.

It can be seen in Table 1 that the Northern Region had the highest mean NMR in the country, with 11.02 deaths/1,000 lb. The lowest rates were seen in the South (7.81 deaths/1,000 lb) and Southeast (8.50 deaths/1,000 lb) regions. Among the states, the three highest rates were identified

in Amapá (14.24 deaths/1,000 lb), Bahia (12.59 deaths/1,000 lb) and Pará (11.83 deaths/1,000 lb). As for the trend, it was found that there was a decrease in all Brazilian regions and in most states, with the exception of Amazonas, Roraima, Maranhão, Sergipe and Goiás, which showed a stationary trend in the period.

Regarding maternal factors, there was a higher percentage of deaths among newborns born to mothers aged between 20 and 29 years (41.19%). However, it is noteworthy that there was an upward trend of neonatal deaths in children of mothers aged over 30 years in the period. As for maternal education, the highest percentage of neonatal deaths was found among mothers with more than eight years of schooling (47.68%), with an upward trend in the period investigated (Table 2).

Most neonatal deaths occurred among preterm newborns (63.89%), with an upward trend in the years analyzed. Although the highest percentage of deaths is among those born from vaginal births (50.75%), the trend was decreasing in this type of birth, while deaths of newborns

Table 1. Time series analysis of neonatal mortality rates (per 1,000 live births) according to regions and states. Brazil, 2007-2017.

Regions/states	Deaths in the period	Rate 2007	Rate 2017	Mean rate	APC[a]	$_{95\%}$CI[b]	Trend
North	37.997	12.15	10.43	11.02	-1.58	-2.36; -0.79	Downward
Acre	1.865	13.41	8.86	10.07	-2.64	-4.46; -0.79	Downward
Amapá	2.374	17.95	12.27	14.24	-4.21	-6.13; -2.25	Downward
Amazonas	8.617	10.24	10.68	10.17	-0.06	-0.69; 0.57	Stationary
Pará	18.559	12.65	11.07	11.83	-1.62	-2.73; -0.49	Downward
Rondônia	2.929	12.52	8.36	10.07	-3.40	-5.91; -082	Downward
Roraima	1.170	10.44	9.97	10.03	0.83	-3.19; 5.03	Stationary
Tocantins	2.483	10.88	8.42	9.11	-2.14	-3.76; -0.49	Downward
Northeast	101.908	12.66	10.10	10.97	-2.05	-2.57; -1.53	Downward
Alagoas	6.423	13.78	8.89	10.88	-3.57	-5.02; -2.10	Downward
Bahia	29.200	14.57	11.47	12.59	-1.85	-2.24; -1.46	Downward
Ceará	13.614	10.81	9.19	9.55	-2.18	-3.17; -1.17	Downward
Maranhão	14.386	11.15	11.21	10.98	-0.39	-0.89; 0.11	Stationary
Paraíba	6.582	13.14	9.55	10.22	-3.26	-4.59; -1.90	Downward
Pernambuco	15.674	12.08	8.67	10.14	-2.70	-3.76; -1.64	Downward
Piauí	6.651	14.41	10.36	12.20	-2.51	-3.08; -1.94	Downward
Rio Grande do Norte	5.048	10.75	8.50	9.60	-1.72	-2.64; -0.80	Downward
Sergipe	4.330	12.90	11.84	11.37	-1.09	-2.76; 0.61	Stationary
Midwest	23.575	9.99	8.32	9.29	-1.57	-1.88; -1.25	Downward
Distrito Federal	4.083	7.89	8.19	8.39	-0.10	-1.67; 1.49	Stationary
Goiás	9.577	9.61	8.47	9.41	-0.83	-2.38; 0.75	Stationary
Mato Grosso	5.568	10.81	8.59	9.73	-1.77	-2.13; -1.40	Downward
Mato Grosso do Sul	4.347	12.25	7.75	9.46	-4.57	-6.33; -2.79	Downward
Southeast	106.962	9.44	7.96	8.50	-1.69	-2.30; -1.07	Downward
Espírito Santo	4.911	9.43	7.70	8.36	-2.08	-3.29; -0.85	Downward
Minas Gerais	25.808	10.39	8.15	9.04	-2.86	-3.64; -2.07	Downward
São Paulo	54.087	8.82	7.68	8.07	-1.46	-1.95; -0.96	Downward
Rio de Janeiro	22.156	10.02	8.57	9.07	-1.60	-1.96; -1.24	Downward
South	32.818	8.70	7.28	7.81	-2.03	-2.49; -1.57	Downward
Paraná	13.947	9.09	7.49	8.23	-2.18	-2.65; -1.71	Downward
Rio Grande do Sul	11.524	8.30	6.97	7.55	-1.85	-2.66; -1.02	Downward
Santa Catarina	7.347	8.64	7.38	7.48	-2.02	-2.89; -1.15	Downward

[a] Annual percentage change; bconfidence interval of the APC.

Source: Authors.

born by cesarean delivery showed a growing trend, with an increase of 2.58% per year. In addition, there was a greater proportion of neonatal deaths among neonates with extremely low birth weight (34.13%), with an increase in the trend of 2.60% per year (Table 2).

It is noted in Table 3 that most causes of death refer to some conditions originating in the perinatal period (78.23%). However, regarding the trend, it is noteworthy that some chapters had an increase over the period, such as some infectious and parasitic diseases, endocrine, nutritional and metabolic diseases, external causes and congenital malformations, deformities and chromosomal abnormalities.

Regarding mortality from conditions originating in the perinatal period, most of the cases occurred due to maternal factors and complications of pregnancy, labor and childbirth (22.03%), which grew in the country during the years studied, as shown in Table 4. Still, other respiratory affections of the newborn also showed a growing trend in the years of study.

With regard to the preventability of deaths, there was a predominance of conditions that could be reduced by adequate care for women during pregnancy (35.91%), with an upward trend of 0.37% per year. In addition, there was an increase of 1.39% per year in deaths from other causes, not clearly preventable (Table 5).

Discussion

The results of this study point to a decreasing trend in neonatal mortality in the country. This

Table 2. Time series analysis of neonatal mortality according to maternal and neonatal factors. Brazil, 2007-2017.

Variables	Deaths in the period		2007	2017	APC[a]	$_{95\%}$CI[b]	Trend
	N	%	%	%			
Maternal age							
< 20 years	63.581	20.94	21.45	19.06	-0.92	-1.64; -0.19	Downward
20-29 years	124.902	41.19	39.51	41.16	0.05	-0.32; 0.41	Stationary
> 30 years	77.490	25.78	19.80	32.05	4.80	4.52; 5.09	Upward
Ignored	37.287	12.09	19.24	7.73	-8.10	-8.65; -7.54	Downward
Maternal education							
No schooling	12.951	4.20	6.11	2.84	-7.88	-9.28; -6.46	Downward
18 years	84.751	27.79	30.93	22.24	-3.19	-4.19; -2.17	Downward
> 8 years	143.212	47.68	33.74	59.70	5.36	4.70; 6.02	Upward
Ignored	62.346	20.33	29.23	15.22	-5.54	-6.26; -4.81	Downward
Gestational age							
Preterm	193.482	63.89	60.70	68.00	0.86	0.27; 1.44	Upward
Term	70.296	23.06	25.76	21.50	-2.06	-4.43; 0.38	Stationary
Post-term	2.470	0.80	1.02	0.57	-7.31	-9.98; -4.56	Downward
Ignored	37.012	12.24	12.52	9.92	-0.68	-8.10; 7.33	Stationary
Type of delivery							
Vaginal	154.179	50.75	52.69	49.41	-0.92	-1.35; -0.48	Downward
Cesarean	125.026	41.43	34.85	45.22	2.58	1.87; 3.30	Upward
Ignored	24.055	7.83	12.45	5.37	-6.69	-8.24; -5.13	Downward
Birth weight							
Extreme low weight	102.994	34.13	29.05	38.36	2.60	1.95; 3.26	Upward
Very low weight	42.424	13.98	14.40	14.01	-0.25	-0.96; 0.47	Stationary
Low weight	55.743	18.36	18.55	17.73	-0.62	-0.97; -027	Downward
Adequate	70.593	23.26	22.86	22.22	-0.43	-0.95; 0.09	Stationary
Macrosomy	4.785	1.57	1.66	1.52	-0.82	-1.60; -0.04	Downward
Ignored	26.721	8.70	13.48	6.17	-6.27	-7.35; -5.19	Downward

[a]Annual percentage change; [b]confidence interval of the APC.

Source: Authors.

Table 3. Time series analysis of the neonatal mortality rate according to the causes of death. Brazil, 2007-2017.

ICD-10 Chapter	Deaths in the period		2007	2017	APC[a]	95%CI[b]	Trend
	N	%	%	%			
I. Certain infectious and parasitic diseases	2.028	0.69	0.58	0.95	9.34	5.73; 13.08	Upward
II. Neoplasms	234	0.08	0.08	0.07	3.50	-6.64; 14.73	Stationary
III. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	126	0.04	0.03	0.04	2.52	-1.46; 6.66	Stationary
IV. Endocrine, nutritional and metabolic diseases	392	0.13	0.13	0.14	3.52	0.39; 6.74	Upward
V. Mental and behavioral disorders*	7	0.00	0.01	0.00	-	-	-
VI. Diseases of the nervous system	345	0.11	0.11	0.07	-6.66	-10.08; -3.10	Downward
VII. Diseases of the eye and adnexa	13	0.00	0.01	0.01	-3.49	-12.09; 5.95	Stationary
VIII. Diseases of the ear and mastoid process *	1	0.00	0.00	0.00	-	-	-
IX. Diseases of the circulatory system	472	0.15	0.24	0.10	9.13	-13.36; -4.70	Downward
X. Diseases of the respiratory system	1.323	0.43	0.55	0.30	-4.00	-6.27; -1.68	Downward
XI. Diseases of the digestive system	148	0.05	0.07	0.03	-6.66	-13.30; 0.48	Stationary
XII. Diseases of the skin and subcutaneous tissue	16	0.01	0.00	0.02	6.69	-6.06; 21.17	Stationary
XIII. Diseases of the musculoskeletal system and connective tissue*	11	0.00	0.00	0.00	-	-	-
XIV. Diseases of the genitourinary system	69	0.02	0.04	0.01	-13.75	-25.26; -0.46	Downward
XVI. Certain conditions originating in the perinatal period	237.462	78.23	80.23	76.71	-0.50	-0.67; -0.33	Downward
XVII. Congenital malformations, deformations and chromosomal abnormalities	55.650	18,44	18,89	20,37	2,61	2,25; 2,97	Crescente
	55.650	18.44	18.89	20.37	2.61	2.25; 2.97	Upward
XVIII. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	1.823	0,61	0,45	0,61	3,78	0,37; 7,31	Crescente
	3.140	1.01	1.58	0.57	-10.52	-13.07; -7.89	Downward
XX. External causes of morbidity and mortality	1.823	0.61	0.45	0.61	3.78	0.37; 7.31	Upward

[a]Annual percentage change; [b]confidence interval of the APC; *categories did not reach seven points for trend analysis.

Source: Authors.

result shows that ministerial policies and programs, such as the implementation of the stork network and the expansion of primary health care[1,2], were important for the modification of this curve, although there is still a long way to go before we reach ideal levels like those of developed countries, whose neonatal mortality rates are around 4/1,000 lb[15].

There are differences in the period of neonatal death, since the APC showed a greater decline in early mortality compared to late mortality. However, despite this downward trend at the national level, the early component is still three times higher than the mean rate of late neonatal mortality.

Corroborating these findings, other studies developed in the Brazilian context[4,8,16] suggest that the causes of neonatal deaths, especially in the first week of life, are associated with prenatal care and childbirth, with inadequate care for the newborn in the nursing room delivery and in the neonatal unit. This situation highlights the need

Table 4. Time series analysis of the neonatal mortality rate for some conditions originating in the perinatal period, according to the mortality list. Brazil, 2007-2017.

ICD-10 chapter and causes	Óbitos no período		2007	2017	APC[a]	95%CI[b]	Trend
	N	%	%	%			
I. Fetus and newborn affected by maternal factors and complications of pregnancy, labor and delivery	51.522	22,03	15,92	29,32	6,56	5,65; 7,47	Upward
II. Disorders related to the length of gestation and fetal growth	27.292	11,35	14,13	8,54	-5,41	-6,44; -0,45	Downward
III. Trauma occurred during birth	776	0,33	0,30	0,32	-0,61	-1,94; 0,73	Stationary
IV. Intrauterine hypoxia and birth asphyxia	20.738	8,67	10,00	7,57	-2,90	-3,14; -2,65	Downward
V. Respiratory distress of newborn	33.837	14,16	15,45	11,94	-2,76	-3,21; -2,31	Downward
VI. Congenital pneumonia	4.204	1,76	1,90	1,19	-4,27	-7,42; -1,01	Downward
VII. Other respiratory conditions of newborn	25.896	10,92	10,27	11,12	0,66	0,28; 1,04	Upward
VIII. Bacterial sepsis of newborn	34.242	14,38	15,37	13,70	-0,94	-1,42; -0,45	Downward
IX. Omphalitis of newborn with or without hemorrhage	423	0,18	0,22	0,18	-4,48	-6,87; -2,02	Downward
X. Hemorrhagic and hematological disorders of newborn	6.357	2,67	2,68	2,49	-0,42	-1,09; 0,26	Stationary
XI. Remainder of perinatal conditions	32.175	13,55	13,77	13,63	0,03	-0,24; 0,29	Stationary

[a]Annual percentage change; [b]Confidence Interval of the APC.

Source: Authors.

for greater attention and investments in perinatal care, with actions aimed at qualifying and strengthening maternal and child health services.

With regard to Brazilian regions and states, the mean rates of neonatal deaths showed disparities, with higher rates in the North (11.02/1,000 lb) and Northeast (10.97/1,000 lb), above the national average (9.46/1,000 lb). It is suggested that regional inequalities in the country, as evidenced in the North and Northeast axis, may be related to worse socioeconomic and health indicators[17]. Despite the current incentives and public policies aimed at less favored regions, these are still not enough to decentralize the concentration of investments and income in the states of the South and Southeast, maintaining the lowest income levels for the semi-arid Northeast and the countryside of the North and Center-West, which may explain the country's regional inequalities and the results of neonatal mortality presented in this research[18].

Although the Midwest region (9.29/1,000 lb) has a slightly lower neonatal mortality rate compared to the national one, the state of Mato Grosso (9.73/1,000 lb) is the only one in the region that exceeds the mean of deaths in the country. For this reason, it was included, together with nine other states of the federation, to compose the QualiNeo Strategy. This Strategy integrates several policies to reduce infant mortality, aiming to qualify newborn care practices aimed at reducing neonatal mortality and birth asphyxia rates in maternity hospitals in regions with higher mortality rates, which are currently concentrated in the North and Northeast regions[19]. At the same time, the underreporting of neonatal death records in the state may be suspected, due to technical inaccuracies in filling out the Death Certificates.

Of the neonatal variables analyzed in this research, preterm birth, extremely low birth weight and cesarean delivery showed an increasing trend over the years. Low birth weight is closely related to prematurity or intrauterine growth restriction, being strongly associated with neonatal death[20]. Such determinants are associated with low levels of socioeconomic development, maternal characteristics and maternal and child care[21]. Furthermore, preterm birth, in many cases, is associated with unnecessary cesarean delivery, as well as complications of delivery and birth[22]. In this sense, identifying risk factors and strengthening

Table 5. Time series analysis of the neonatal mortality rate according to preventable causes. Brazil, 2007-2017.

Causes preventable	Deaths in the period		2007	2017	APC[a]	$_{95\%}$CI[b]	Trend
	N	%	%	%			
I. By immunization actions	94	0.03	0.01	0.02	2.32	-11.09; 17.75	Stationary
II. By adequate care for women during pregnancy	108.832	35.91	35.04	36.58	0.37	0.03; 0.70	Upward
III. By adequate care for women during childbirth	42.869	14.10	15.04	13.80	-1.09	-1.59; -0.58	Downward
IV. By adequate care of newborn	73.115	24.07	25.27	22.73	-0.94	-1.17; -0.71	Downward
V. By adequate diagnosis and treatment actions	1.925	0.63	0.72	0.55	-2.22	-3.50; -0.92	Downward
VI. By health promotion actions linked to care actions	3.122	1.03	0.96	1.02	1.73	-1.34; 4.90	Stationary
VII. By ill-defined causes	68.228	2.24	2.44	1.98	-2.07	-3.53; -0.59	Downward
VIII. Too many causes (not clearly preventable)	66.475	21.98	20.52	23.31	1.39	1.18; 1.61	Upward

[a]Annual percentage change; [b]confidence interval of the APC.

Source: Authors.

quality prenatal care can be effective in preventing unfavorable outcomes.

Race/color alone cannot be considered a risk factor for neonatal mortality. However, due to the history of discrimination and exploitation, some races began to build an asymmetry in terms of socioeconomic conditions and access to health services, among other rights that remain until today[23], such as education, housing and income. For this reason, the color/race variable can become a decisive risk factor and social and health vulnerability[5].

The results of research showing worse health conditions in the black population in Brazil in recent years[23] led to the creation of several public policies in order to change this reality, among them the National Policy for Comprehensive Health of the Black Population. Another program that may have positively influenced income distribution and equity in access to health is the "Bolsa Família" (family grant), which acts in the transfer of resources, enabling the population's access to basic rights. These actions, in turn, appear to be effective, since, according to data presented in this study, there was a downward trend of 15.23% per year in neonatal mortality in black children. However, this reduction has not been observed among the indigenous population.

The stability of the neonatal mortality rate in indigenous peoples, amid a decreasing trend in the general population, allows us to suggest that there are specific risk factors for indigenous people that need to be investigated and/or that general actions to control mortality in this portion of the population have not been effective. You can also think about the difficulties in accessing primary health care services that many villages have and, consequently, the births and deaths of children without filling out the death certificate[22,24]. This fact makes necessary the elaboration and implementation of specific public policies for this population.

In addition to external factors, such as the care provided to pregnant women, individual factors also pose risks to neonatal mortality, such as age and maternal education. In the present study, deaths were higher among children of mothers aged between 20 and 29 years, with an increasing trend among those over 30 years of age, in addition to mothers with eight or more years of schooling.

An ecological survey on perinatal mortality in the state of Pernambuco, carried out from 2009 to 2011, showed a higher proportion of perinatal deaths in mothers aged 20 to 34 years old and with less than twelve years of schooling; only 27.5% of them had finished high school[25].

Women with a mean age for pregnancy, low socioeconomic status and few years of schooling, associated with unfavorable obstetric factors,

such as the short interval between births, multiple pregnancy, a history of stillbirth, in addition to ovarian aging, are more likely to develop hypertension arterial blood pressure and diabetes mellitus, potential risk factors for increased maternal and neonatal morbidity and mortality[21].

When the causes of neonatal deaths are observed according to ICD-10 chapters, conditions related to the perinatal period still remain as causes of mortality in the country, and most of them occurred due to maternal factors and complications of pregnancy, labor and childbirth, which grew up in the country during the period studied.

Perinatal mortality is closely linked to obstetric causes. Therefore, they are considered potentially preventable events, reflecting the quality of care provided in prenatal care and childbirth. Obstetric causes are mentioned in another study that showed that perinatal deaths were related to causes that could be reduced by adequate care for women during pregnancy and childbirth[26]. It can be considered that government and health services efforts in recent years are focused on reducing neonatal deaths, while investments in the prevention of fetal deaths have received less attention.

As for the trend of neonatal mortality by causes, some chapters had an increase over the period analyzed, such as some infectious diseases and congenital malformations. In developing countries, the incidence of neonatal infection is approximately 40 times higher, causing twice as many deaths compared to developed countries. A retrospective cohort study, carried out in 12 public hospitals in Nepal, showed that neonatal infection was associated with primiparous mothers, who did not receive prenatal care, with suspected infection during pregnancy, with cesarean births and among newborns who presented asphyxia at birth[27].

In countries with the highest infant mortality rates, half of neonatal deaths are caused by infections, while in countries with lower rates, prematurity and congenital malformations are the main causes of death[28,29].

Congenital malformations, deformities and chromosomal anomalies are the second leading cause of neonatal mortality in Brazil, a situation similar to that found in developed countries[30]. This factor may be associated with difficulties in early diagnosis, considering that most malformations and chromosomal anomalies occur for an unknown cause, which limits actions to prevent and reduce these deaths. In addition, this cause has been little studied and deepened in research, which is possibly due to the fact that it does not belong to the classification of preventable deaths, contributing to the lack of knowledge and advances on this variable[31].

It is known that quality prenatal care is extremely efficient in reducing maternal and child morbidity and mortality, as it helps in the early identification of pregnancy and labor risks, in addition to providing adequate referrals when necessary. A survey identified that, in 2014, about 40% of preventable infant and neonatal deaths that occurred in Brazil were related to inadequate prenatal care[32].

On the other hand, effective measures, such as adequate and quality prenatal care, development of actions to promote health and disease prevention, promotion of fetal development, reduction of possible complications in pregnancy, childbirth and postpartum, in addition to assistance in early identification of maternal and neonatal morbidities are essential goals for the preventability of deaths[20].

Despite the quantity of policies and programs aimed at reducing neonatal mortality, it is imperative to emphasize that such deaths are a reflection that go beyond health issues, involving social and economic inequities and equal access to quality health services, which it is a permanent challenge for governments and managers.

It is noteworthy that the findings of this study may have resulted from the improvement in the filling out of death certificates over the years in the country. In general, there is a downward trend in the information ignored in this study. As for the completeness of the information, although there are variables filled in excellently, that is, with fewer incomplete fields such as place of death, age of death and gender of the newborn, most of the information is still filled with quality classified as bad and very bad[33].

Therefore, the limitation found in the study was the quality of the information used, in view of the high numbers of ignored records found in the studied variables, such as maternal education, which corresponded to up to 20.33% of the findings, representing the highest underreporting observed among the variables selected in this research. The use of secondary and public domain data depends on the correct and complete filling of the information to be analyzed. Therefore, it is important to raise awareness and qualify the medical professionals responsible for filling out death declarations and death certificates.

Conclusion

It is concluded that, between 2007 and 2017, there was a decline in the neonatal mortality rate in Brazil, with early mortality being the one with the greatest reduction; however it still remains high when compared to late deaths. The increase of deaths in newborns born to women aged over 30 years and with more than 8 years of schooling is noteworthy, in addition to the growing trend among preterm newborns, newborns with extremely low birth weight, and those born by cesarean delivery. The growth of neonatal deaths caused by congenital malformations, infectious diseases, endocrine, nutritional and metabolic diseases and external causes is noteworthy, as well as of preventable deaths by adequate care for women.

In this research, it appears that, despite the general reduction in neonatal deaths, there is still a need to intensify effective government policies in health and in the economic area to improve the life of the individuals and society as a whole. Neonatal mortality rates are influenced by several factors, such as economic and cultural aspects, and not just a single specific cause. For this reason, improvements must occur in the health sphere, but also in other sectors, contributing in a comprehensive and equitable way to the reduction of neonatal deaths in Brazil, as determined by the principles of the Unified Health System.

Collaborations

The authors contributed to the construction of the manuscript as follows: FBS Bernardino; TM Gonçalves; TID Pereira in the design and planning of the study. FBS Bernardino and JS Xavier in contributing to the drafting. BHBM Freitas contributed to the analysis and interpretation of the results. MAM Gaíva carried out a critical review of the content and writing of the work, in addition to the approval of the final version sent.

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