



Trend of preventable neonatal mortality in the States of Brazil


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Abstract

Objectives: to describe the trend of preventable neonatal mortality due to interventions by the Unified Health System in Brazil from 2000 to 2018, according to groups of causes of death and maternal residence.

Methods: mixed ecological study with data from the Mortality Information System and Information System on Live Births. The analysis occurred based on the number and rates of avoidable neonatal mortality, polynomial regression models by least squares method and thematic maps.

Results: the avoidable neonatal mortality rate decreased from 10.98 in 2000 to 6.76 per 1,000 live births in 2018. Preventable causes prevailed due to adequate care for women during pregnancy, childbirth, fetus and newborn. Deaths from preventable causes from health promotion actions during pregnancy increased in Maranhão ($p=0.003$) and the Federal District ($p=0.001$) and remained stable in nine states. There was stability in the rates of mortality due to delivery in Maranhão, Piauí and Amazonas. The causes avoidable by actions with the newborn showed a decreasing trend, except for Roraima where there was stability.

Conclusions: there are inequalities in trends of avoidable neonatal mortality rates in the states second according to the group of causes and the need to improve access to and quality of maternal and child health care in these places

Key words Neonatal mortality, Trend, Mortality records, Spatial distribution



Introduction

Neonatal death is that which occurs from zero to 27 days of life and is considered an important indicator of public health in countries,^{1,2} with causes related to healthcare offered during pregnancy, childbirth and after birth.^{3,4}

Although it is the main component of infant mortality, neonatal deaths worldwide reduced from 37 deaths per 1,000 live births in 2000 to 18.0 per 1,000 live births in 2017.³ In Brazil, the neonatal mortality rate, which was 26 deaths per 1,000 live births in 1990, declined to 16.7 per 1,000 live births in 2015.⁵ The implementation of public policies aimed at improving maternal and child health care contributed to this decline in Brazil, including the National Program for the Humanization of Childbirth and Birth in 2000 and the Stork Network in 2011, aiming to achieve the goals established in the Millennium Development Goals (MDGs), defined by the United Nations (UN).⁶

The main risk factors for neonatal death are the absence or low quality of prenatal care, maternal health complications during pregnancy, low birth weight, asphyxia at birth and prematurity,⁷ which are injuries considered preventable by health service interventions.⁸ The eradication of preventable neonatal mortality is part of the UN Sustainable Development Goals (SDGs),⁹ and understanding the trend of mortality can help achieve this goal.¹⁰

The trend analyses of neonatal mortality coefficients are important for the evaluation of policies and projection of mortality, being useful tools for the planning of health actions.¹¹ A worldwide study on the trend of neonatal mortality in the period from 1990 to 2017 demonstrated the reduction of neonatal mortality rates, which declined from 30.6 deaths per thousand live births, in 1990, to 18.0 deaths per 1,000 live births in 2017. The study forecast the occurrence of 27.8 million neonatal deaths worldwide, from 2018 to 2030,¹⁰ if the trend level of reduction of coefficients in countries is maintained. Thus, the identification of the trend of avoidable neonatal mortality in different spaces and realities can optimize care practices, contribute to the rational use of resources and reorganize care networks to promote the reduction of health inequities.¹²

Providing scientific evidence for the evaluation of implemented policies and planning of measures aimed at reducing preventable neonatal mortality in the states of Brazil was the motivation of the study that aimed to analyze the trend of preventable neonatal mortality by interventions of the Unified Health System, according to groups of causes and

maternal state of residence, in the period from 2000 to 2018.

Methods

This is a mixed ecological study, with spatial and temporal approach, of preventable neonatal deaths that occurred in the states of Brazil, from 2000 to 2018. The period is justified by considering the year 2000, the date of publication of the "Millennium Declaration" of the UN, an important moment of the establishment of goals for the improvement of social and health indicators of nations.

Data from the Mortality Information System (SIM – Portuguese acronym) were used, which aims to systematize information from the Death Certificate throughout Brazil and the Information System on Live Births (SINASC – Portuguese acronym) that includes the records of the Declarations of Live Births in Brazil. SIM and SINASC files are available according to year and state of residence.

The records of deaths aged less than or equal to 27 days had their causes classified as preventable or non-preventable. The classification occurred by comparing the International Code of Diseases (ICD) of the *basic cause of death field (CAUSABAS)*, with the codes contained in the "*List of causes of preventable deaths by interventions of the Brazilian Unified Health System*".⁸

The preventable causes of the list are distributed in the following groups: 1) Reducible by immunoprevention actions; 2.1) Reducible by adequate care of women during pregnancy; 2.2) Reducible by adequate delivery care; 2.3) Reducible by adequate attention to the newborn; 3) Reducible by appropriate diagnostic and treatment actions; and 4) Reducible by appropriate health promotion actions. Poorly defined causes of death and other causes were excluded from the analysis.

The analysis of neonatal deaths according to a group of preventable causes⁸ and place of residence occurred through absolute and relative frequencies, year of occurrence, triennium (2000 to 2002; 2008 to 2010; 2016 to 2018) and neonatal mortality rates per 1,000 to 2002; 2008 to 2010; 2016 to 2018) and neonatal mortality rates per 1,000 live births. For the rates of the first (T1) and last (T3) trienniums, the percentage variation was calculated using the formula: $(T3-T1)/(T1) \times 100$.

For the analysis of the trend of the three main groups of preventable causes, polynomial regression was performed by minimum squares method, considering the calendar years as an independent variable

(X) and the avoidable neonatal mortality rate as dependent variable (Y). The linear regression models ($Y = \beta_0 + \beta_1 X$), second order ($Y = \beta_0 + \beta_1 X + \beta_2 X^2$) and third order ($Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3$) were tested. The residue analysis was used to evaluate the adequacy of the model, as well as the homoscedasticity of the variables by states and group of causes. A significant trend was considered one whose model presented $p < 0.05$. Through the equations, it was possible to identify the mean of the avoidable neonatal mortality rate in the period in the states (β_0), as well as the impact of the reduction or increase in the year desired to be estimated. The software used was SPSS Statistics, version 20.0.

The trend of neonatal mortality in each state was represented in thematic maps, based on the map of Brazil available on the website of the Brazilian Institute of Geography and Statistics (IBGE – Portuguese acronym). The maps were constructed with the open-source Geographic Information System (GIS) QGIS version 3.4.

The precepts contained in Resolution 510/2016 of the National Health Council were respected and because it is a research with secondary data, in the public domain, without the identification of neonates

or their families, this study was exempt of the use of the Informed Consent Form (TCLE – Portuguese acronym).

Results

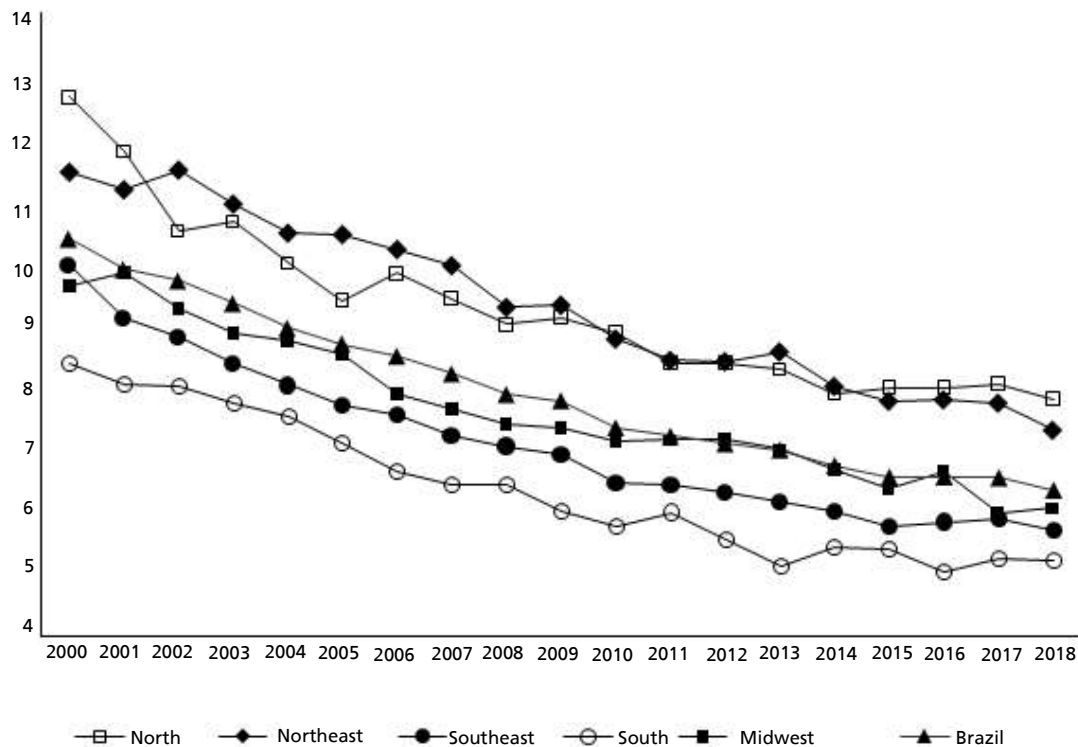
From 2000 to 2018, 56,442,235 records were identified in SINASC and 591,097 records of neonatal deaths in SIM, 76% of which were classified as preventable by interventions by the Unified Health System. The neonatal all-cause mortality rate decreased from 13.60 per 1,000 live births in 2000 to 8.54 in 2018. On the other hand, the avoidable neonatal mortality rate decreased from 10.98 per 1,000 live births in 2000 to 6.76 in 2018. The mean rate of avoidable deaths in the period was 8.38.

A reduction in avoidable neonatal mortality rates was observed in all regions of Brazil. The North and Northeast regions had the highest rates of avoidable neonatal mortality during the period, and the South region had the lowest (Figure 1).

There was a reduction in avoidable neonatal mortality rates in the states of Brazil, except for Roraima (North Region) and Maranhão (Northeast Region) which showed an increase of 12.64% and

Figure 1

Distribution of avoidable neonatal mortality rates, by region. Brazil, 2000 to 2018.



6.94%, respectively. The main reduction in the avoidable neonatal mortality rate (-54.41%) was identified in the state of Rondônia (North Region) (Table 1).

Preventable neonatal deaths occurred mainly due to causes related to adequate care for women during pregnancy (44.02%), adequate care for the fetus and newborn (34.96%) and adequate attention to women during childbirth (18.65%). The rate of neonatal mortality preventable by immunoprevention actions decreased by 89.14%, while the rate of adequate care for women during pregnancy decreased by 13.73% (Table 2).

The rate of neonatal mortality preventable by adequate attention to pregnancy showed a decreasing trend in 16 states, except for the growing trend iden-

tified in the states of Maranhão ($p=0.003$) and the Federal District ($p=0.001$). There was stability in the mortality rate due to these causes in nine states in the North, Northeast and Midwest regions (Table 3). It was observed in the maps that the rates of neonatal mortality preventable by adequate attention during delivery remained stable in the states of Maranhão, Piauí and Amazonas, and for the others it was shown a decreasing trend (Figure 2).

Discussion

From 2000 to 2018 there was a reduction in the avoidable neonatal mortality rate in Brazil and in most states. The neonatal all-cause mortality rate has followed the downward trend, but still has high coef-

Table 1

Preventable neonatal mortality rate (per thousand live births) according to state of residence for three years. Brazil, 2000 to 2018.

Region/ State	2000-2002	2008-2010	2016-2018	PV
North				
Rondônia	12.69	8.61	5.78	-54.41
Acre	10.99	7.76	6.45	-41.32
Amazonas	11.51	7.49	7.97	-30.71
Roraima	7.17	6.91	8.08	12.64
Para	11.67	9.83	8.56	-26.69
Amapá	15.13	13.59	9.88	-34.73
Tocantins	10.81	7.99	6.45	-40.31
Northeast				
Maranhão	7.60	8.97	8.12	6.94
Piauí	9.47	10.15	8.19	-13.47
Ceará	11.01	8.07	6.65	-39.65
Rio Grande do Norte	10.73	7.77	6.41	-40.20
Paraíba	11.23	8.41	6.57	-41.47
Pernambuco	12.14	8.73	6.73	-44.59
Alagoas	13.83	10.00	7.05	-49.03
Sergipe	16.69	9.09	9.41	-43.59
Bahia	11.85	10.11	8.80	-25.77
Southeast				
Minas Gerais	10.35	7.46	5.71	-44.83
Espírito Santo	9.13	6.53	5.49	-39.86
Rio de Janeiro	10.13	7.25	6.54	-35.42
São Paulo	8.47	6.36	5.57	-34.24
South				
Paraná	9.34	6.55	5.43	-41.86
Santa Catarina	7.33	5.49	4.75	-35.27
Rio Grande do Sul	7.32	5.88	5.17	-29.41
Midwest				
Mato Grosso do Sul	11.33	8.48	5.27	-53.47
Mato Grosso	11.70	7.90	6.30	-46.14
Goiás	8.55	6.84	6.74	-21.13
Distrito Federal	7.90	6.39	5.92	-25.11
Brazil	9.99	7.67	6.48	-35.10

PV = percentage variation in the mortality rate between the first and last three years.

Table 2

Preventable neonatal mortality rate by group of causes for three years. Brazil, 2000 to 2018.

Cause group	2000-2002			2008-2010			2016-2018			PV
	n	%	rate	n	%	rate	n	%	rate	
Care during pregnancy	34,622	36.93	3.69	30,829	46.32	3.55	27,783	49.12	3.18	-13.73
Care to the NB	39,223	41.83	4.18	21,533	32.35	2.48	17,262	30.52	1.98	-52.68
Attention to childbirth	17,347	18.50	1.85	12,824	19.27	1.48	10,314	18.24	1.18	-36.08
Health promotion	1,243	1.33	0.13	778	1.17	0.09	790	1.40	0.09	-31.67
Diagnosis / adequate treatment	1,229	1.31	0.13	571	0.86	0.07	401	0.71	0.05	-64.92
Immunization	99	0.11	0.01	27	0.04	0.003	10	0.02	0.001	-89.14

PV = percentage variation in the mortality rate between the first and last three years.

Figure 2

Neonatal mortality trend due to adequate care for women during pregnancy (A), adequate care during birth (B) and adequate care for the fetus and newborn (C). Brazil, 2000 to 2018.

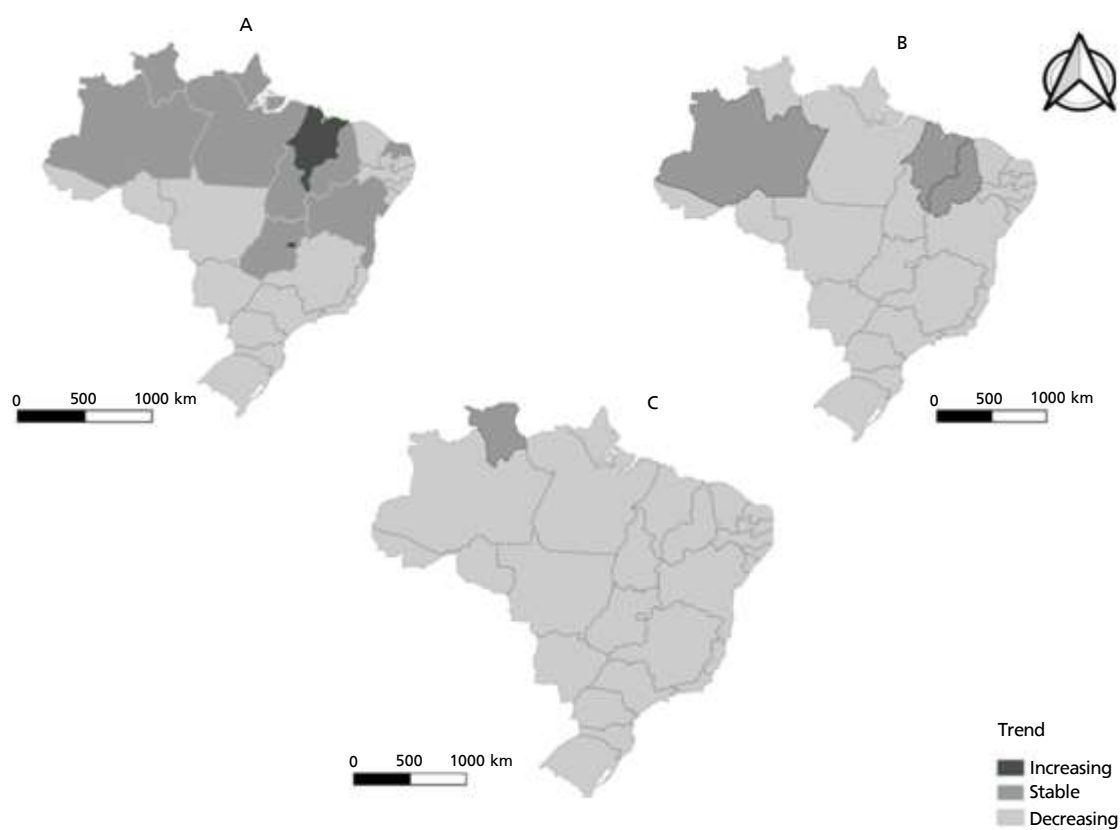


Table 3

Preventable neonatal mortality rate according to state for three years. Brazil, 2000-2018.

State	Attention to pregnancy			Attention to childbirth			Attention to newborn		
	model	r ²	p	model	r ²	p	model	r ²	p
Rondônia	y=3.291-0.142x	0.95	<0.001	y=1.713-0.102x	0.94	<0.001	y=3.408-0.176x	0.87	<0.001
Acre	y=2.848-0.042x	0.37	0.009	y=1.706-0.115x	0.77	<0.001	y=3.061-0.051x	0.41	0.006
Amazonas	y=3.088+0.012x	0.71	0.303	y=1.585-0.014x	0.18	0.088	y=3.121-0.165x	0.78	<0.001
Roraima	y=3.096-0.001x	0.01	0.931	y=1.224-0.046x	0.79	<0.001	y=1.745+0.020x	0.14	0.138
Para	y=3.685-0.006x	0.02	0.587	y=2.027-0.036x	0.82	<0.001	y=4.006-0.134x	0.90	<0.001
Amapá	y=3.984-0.018x	0.01	0.671	y=2.569-0.100x	0.86	<0.001	y=6.127-0.278x	0.91	<0.001
Tocantins	y=3.654-0.009x	0.14	0.657	y=1.797-0.087x	0.84	<0.001	y=2.308-0.180x	0.79	<0.001
Maranhão	y=3.146+0.077x	0.47	0.002	y=2.051+0.021x	0.22	0.055	y=2.960-0.057x	0.56	0.001
Piauí	y=4.661+0.058x	0.10	0.215	y=2.210+0.006x	0.02	0.585	y=2.627-0.175x	0.76	<0.001
Ceará	y=3.508-0.118x	0.87	<0.001	y=1.699-0.069x	0.84	<0.001	y=3.066-0.109x	0.84	0.001
Rio Grande do Norte	y=3.779-0.028x	0.13	0.142	y=1.583-0.097x	0.87	<0.001	y=2.813-0.108x	0.52	0.001
Paraíba	y=3.148-0.075x	0.78	<0.001	y=1.776-0.049x	0.50	0.002	y=3.627-0.177x	0.96	<0.001
Pernambuco	y=4.232-0.091x	0.77	<0.001	y=1.713-0.084x	0.98	<0.001	y=2.705-0.156x	0.79	<0.001
Alagoas	y=3.703-0.110x	0.86	<0.001	y=1.886-0.082x	0.88	<0.001	y=4.296-0.188x	0.88	<0.001
Sergipe	y=4.822-0.162x	0.73	<0.001	y=2.429-0.096x	0.86	<0.001	y=3.555-0.261x	0.61	<0.001
Bahia	y=4.379-0.049x	0.21	0.058	y=2.213-0.040x	0.79	<0.001	y=3.762-0.130x	0.73	<0.001
Minas Gerais	y=3.517-0.069x	0.86	<0.001	y=1.247-0.062x	0.94	<0.001	y=2.693-0.153x	0.91	<0.001
Espírito Santo	y=3.599-0.075x	0.78	<0.001	y=1.387-0.047x	0.81	<0.001	y=1.793-0.113x	0.79	<0.001
Rio de Janeiro	y=3.726-0.037x	0.77	<0.001	y=1.412-0.046x	0.95	<0.001	y=2.382-0.140x	0.80	<0.001
São Paulo	y=2.914-0.018x	0.40	0.006	y=1.018-0.019x	0.65	<0.001	y=2.423-0.120x	0.94	<0.001
Paraná	y=3.849-0.041x	0.89	<0.001	y=1.270-0.073x	0.94	<0.001	y=1.549-0.123x	0.85	<0.001
Santa Catarina	y=2.617-0.029x	0.55	0.001	y=1.005-0.039x	0.78	<0.001	y=2.075-0.095x	0.94	<0.001
Rio Grande do Sul	y=3.238-0.051x	0.66	<0.001	y=0.964-0.029x	0.93	<0.001	y=1.704-0.072x	0.87	<0.001
Mato Grosso do Sul	y=3.426-0.133x	0.91	<0.001	y=1.733-0.075x	0.80	<0.001	y=2.650-0.171x	0.88	<0.001
Mato Grosso	y=3.607-0.059x	0.70	<0.001	y=1.438-0.068x	0.96	<0.001	y=3.065-0.174x	0.74	<0.001
Goiás	y=3.475+0.016x	0.16	0.107	y=1.275-0.024x	0.53	0.001	y=2.673-0.105x	0.91	<0.001
Distrito Federal	y=3.762+0.057x	0.54	0.001	y=1.005-0.039x	0.68	<0.001	y=1.690-0.084x	0.90	<0.001

Model y = mortality rate (per thousand live births); x = year of the estimate - 2009; r² = coefficient of determination.

ficients compared to other countries.¹³⁻¹⁵

The reduction observed in the states, except for Roraima and Maranhão, was the result of changes in the economic, educational, environmental and health care spheres that occurred in recent decades in Brazil that affected the health of mothers and children. Through intersectoral policies, problems such as low schooling, poverty and poor basic sanitation conditions were faced.⁶ The implementation of social programs such as Family Grant, health promotion and universalization, such as the Family Health Strategy, and maternal and child health, such as the Stork Network, allowed access to income, education and expansion of health services of greater complexity.^{16,17} It is understood that these actions influenced the empowerment of women and society in relation to social and reproductive rights, contributed to the structuring of maternal and child health services and helped reduce social inequities in some places, improving neonatal mortality indicators due to preventable causes.

Investigations of deaths by committees to prevent infant and fetal mortality in states are considered as allies in the reduction process. Preventable death is a sentinel event and the committees emerged to give visibility, investigate and monitor these deaths, in addition to proposing interventions to cope with them.¹⁴

At the regional level, states have implemented local maternal and child health policies and the results in preventable neonatal mortality may have disparities, according to the social and economic development of each region. In Pernambuco, for example, there was the implementation of the Mother Owl Program in 2007, aimed at prenatal care, qualification of childbirth and care for the newborn. A study in this state demonstrated a decrease in preventable neonatal mortality, especially in the early neonatal phase, due to the expansion of the high-risk network proposed in the program.¹⁸ It is observed that preventable causes are concentrated in groups related to the care of the mother-child binomial and, in order to have an impact on the improvement of indicators, it is essential that managers and health professionals are imbued with technical and scientific knowledge for the management and comprehensive, humanized and resolute care in prenatal care, birth and first month of life, as recommended in the policies.

Preventable causes due to adequate care for women during pregnancy were frequent and showed the lowest reduction among groups (-13.73%). It was observed in the maps the increase in neonatal mortality rates due to these causes in the state of

Maranhão and the Federal District, and stability in the states of Amazonas, Roraima, Pará, Amapá, Tocantins, Piauí, Rio Grande do Norte, Bahia and Goiás. Stability shows a warning sign for managers and health professionals since the downward trend was expected due to the implementation of policies and programs.

Pregnant women need support from health professionals because they present physiological and psychological conditions that influence fetal development and neonatal life. However, social and individual inequalities define access and quality of prenatal care, such as pregnancy in adolescence, residence in small municipalities in the interior and with a low Human Development Index.¹⁹ Pregnancy planning and women's satisfaction when discovering prenatal care also imply in prenatal quality indicators.²⁰ Intersectoral public policies aimed at adolescents and improving women's social conditions may be considered insufficient to reduce avoidable neonatal mortality in the states of Brazil.

In this context, the importance of prenatal consultation for pregnant women in vulnerable situations with qualified professionals is emphasized. The number of prenatal consultations for each Brazilian pregnant woman was considered satisfactory,⁶ but the amount is not sufficient to reduce health inequities.²¹⁻²² The common models of care that deal only with the biological aspects of the pregnant woman have not been sufficient to cover maternal and fetal needs in all their fullness. There are economic, family, education and housing difficulties that imply higher risk pregnancies and neonatal mortality, and it is necessary to structure comprehensive policies, the responsibility of managers and training of professionals to improve social and health indicators of women and families that affect preventable death.

The prenatal case management model has been shown to be a positive strategy for maternal and neonatal health. It deals with a model of care that uses active action of the professional, differentiated management for cases of greater complexity, aid in the dynamics between different services and health professionals, optimizing the integrality of care.²³

Preventable deaths from causes related to childbirth were responsible for another significant portion of neonatal deaths (18.65%). It was demonstrated in the maps that there was no growing trend for this group of causes, but Maranhão, Piauí and Amazonas presented stability. After pregnancy, qualified care for delivery becomes fundamental for the prevention of neonatal mortality and is associated with adequate infrastructure, availability of materials and profes-

sional training, which when absent or insufficient result in weaknesses in the labor care network such as delay in care, institutional violence and unfavorable neonatal outcomes.²⁴⁻²⁷

A literature review pointed out several problems faced by professionals who deliver in low- and middle-income countries, such as lack of training, low salaries, lack of equipment, extended working hours, inadequate spaces, low amounts of supplies and medicines, and even lack of electricity and water supply.²⁸ Places that need qualified care the most, due to structural and social problems, have difficulties that worsen the work process and influence neonatal mortality.

Regarding avoidable mortality rates due to adequate care with the newborn, a decreasing trend was observed in the states, except for Roraima, which presented stability. The rates of deaths due to care in this group reduced by 52.68% in Brazil considering the first and last three years of the study. This result was expected due to the expansion of beds in neonatal intensive care units and scientific advances in some regions, which influence the supply of new care technologies,²⁹ mainly for the prevention of death in the first 24 hours of life.^{2,15}

Rates of neonatal mortality preventable by immunoprevention, diagnosis, timely treatment and health promotion actions were less frequent and reduced during the study period. National programs promoting breastfeeding, immunization and expansion of the Family Health Strategy, considered world references, have contributed to improve the indicators for these causes.⁶

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The limitation of the study refers to the ecological fallacy of making inferences at the individual level based on aggregated population data. However, the study analyzed preventable neonatal mortality in Brazil through data from the information systems of the Ministry of Health that assist in the analysis of the health situation of Brazilian population, planning and evaluation of health programs and policies.³⁰ Studies that include evaluation of the quality of maternal and neonatal care in each state and difficulties of professionals in relation to prenatal, childbirth and care interventions with the newborn are necessary to develop strategies to prevent preventable deaths.

Authors' contribution

Prezotto KH and Fernandes CAM elaborated the initial project, which was reviewed by Oliveira RR and Pelloso SM. Prezotto KH was responsible for the statistical collection and analysis of the data. Prezotto KH and Fernandes CAM participated in the preliminary version of the article, which was reviewed by Oliveira RR and Pelloso SM. All authors read and approved the final version of the manuscript.

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