

# Ecological study of under-5 mortality trends in Goiás, 2000–2018

*Estudo ecológico das tendências de mortalidade em menores de 5 anos em Goiás, 2000–2018*

George Oliveira Silva<sup>1</sup> , Lucimeire Fermino Lemos<sup>1</sup> , Natália Del Angelo Aredes<sup>1</sup> 

## ABSTRACT

**Objective:** To identify the mortality rate in children under 5 years old and describe its evolution in the state of Goiás in regard to the component of age, sociodemographic variables, and preventability. **Methodology:** This is an ecological time series study using generalized linear regression via the Prais-Winsten method for trend analysis. **Results:** The correlation between mortality rates and the coverage of the *Estratégia de Saúde da Família* (Family Health Strategy) was verified by the Pearson correlation coefficient. The state of Goiás showed a decreasing trend in the mortality rate in children under 5 years old, with an annual percentage change of -1.6% (95%CI -1.8%– -0.9%) and a negative correlation with Family Health Strategy coverage ( $r=-0.193$ ;  $p=0.023$ ). **Conclusion:** The rates for preventability and subgroups of preventable causes were decreasing, except for deaths that can be prevented with adequate care for women during pregnancy. Deaths from preventable causes prevailed, suggesting the need for improvements in maternal and childcare.

**Descriptors:** Infant Mortality; Vital Statistics; Health Status Indicators; Primary Health Care; Time Series Studies.

## RESUMO

**Objetivo:** Identificar a taxa de mortalidade em crianças menores de 5 anos e descrever sua evolução no estado de Goiás quanto ao componente etário, variáveis sociodemográficas e evitabilidade. **Métodos:** Trata-se de um estudo ecológico de séries temporais utilizando regressão linear generalizada pelo método de *Prais-Winsten* para a análise de tendência. **Resultados:** A correlação das taxas de mortalidade com a cobertura da Estratégia Saúde da Família foi verificada pelo coeficiente de correlação de Pearson. O estado de Goiás apresentou tendência decrescente na taxa de mortalidade em crianças menores de 5 anos, com variação percentual anual de -1,6% (IC95% -1,8%– -0,9%) e correlação negativa com a cobertura da Estratégia Saúde da Família ( $r=-0,193$ ;  $p=0,023$ ). **Conclusão:** As séries das taxas por evitabilidade e subgrupos de causas evitáveis foram decrescentes, com exceção dos óbitos reduzíveis por adequada atenção à mulher na gestação. Prevaleram óbitos por causas evitáveis, sugerindo necessidade de melhorias na assistência materno-infantil.

**Descritores:** Mortalidade Infantil; Estatísticas Vitais; Indicadores Básicos de Saúde; Atenção Primária à Saúde; Estudos de Séries Temporais.

<sup>1</sup>Universidade Federal de Goiás (UFG) – Goiânia (GO), Brazil. E-mails: [georgeoliveira.z9@gmail.com](mailto:georgeoliveira.z9@gmail.com), [lucimeire\\_lemos@ufg.br](mailto:lucimeire_lemos@ufg.br), [naredes@ufg.br](mailto:naredes@ufg.br)

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## INTRODUCTION

Infant mortality is an important indicator of the level of health, degree of socioeconomic development, and living conditions of a given population<sup>(1)</sup>. Reducing infant mortality is one of the Millennium Development Goals and a political goal of the United Nations Children's Fund (UNICEF) in all countries<sup>(2)</sup>.

Among the causes of death for this age group, those whose causes are preventable or reducible, and can be prevented, in whole or in part, by actions of accessible and effective health services are of concern<sup>(1)</sup>.

The preventable death variable refers to the efficiency of care provided by the health system, which may indicate the need for improvement in Primary Health Care (PHC) actions<sup>(3)</sup>. Mortality from preventable causes is expected to be lower in places where there is effective care, and a greater offer and access of health services<sup>(4)</sup>.

This context requires the reorganization of health units to serve the population in a broader and preventive way – such as monitoring child growth and development, and other actions provided for by the *Política Nacional de Atenção Integral à Saúde da Criança* (National Policy for Comprehensive Child Health Care) (PNAISC)<sup>(5)</sup> – and act vigorously in the early identification of injuries in the face of spontaneous demand, especially for prevalent diseases in childhood, with accurate treatment and longitudinal monitoring at this level of care of the *Sistema Único de Saúde* (Unified Health System) (SUS).

Notably, mortality rates have shown considerable reduction over the years, but still include a significant number of preventable deaths<sup>(3,4)</sup>. A recent study<sup>(3)</sup> points out that the North, Northeast, and Central-West regions have the highest mortality rates (16.3, 13.9 and 11.9/1,000 LB, respectively), while the Southeast and South regions have the lowest (9.5 and 7.9/1,000 LB, respectively). However, the Central-West region had the lowest average annual percentage of reduction in the mortality rate (3.5%), suggesting inequality in relation to other regions.

Therefore, understanding infant mortality at a regional and local level, its main causes, and analyzing the coverage of PHC can provide information for decision-making in the formulation of public policies or operational strategies that promote better effectiveness of the care network. Thus, the objectives of the study were to identify the mortality rate in children under 5 years of age (U5MR) and describe its evolution in the state of Goiás in regard to the component of age, sociodemographic variables, and preventability.

## METHODOLOGY

### Type and place of study

This is an ecological time series study of infant deaths in children under 5 years old registered in the *Sistema de*

*Informações sobre Mortalidade* (Mortality Information System) (SIM) of the state of Goiás, from 2000 to 2018. Time series are established as a way of organizing quantitative information in a given period<sup>(6)</sup> and are fundamental for the assessment of morbidity and mortality trends, especially when it comes to infant deaths due to preventable causes<sup>(7)</sup>.

The state of Goiás is the 12<sup>th</sup> most populous state in the country, with approximately 7,018,354 inhabitants, a per capita income of R\$ 1,323.00 and a human development index (HDI) of 0.735<sup>(8)</sup>. The state has 246 municipalities grouped into five macro-regions (North, Northeast, Central-North, Central-West, and Southwest) and 18 health regions: Central; Central-South; Entorno Norte; Entorno Sul; Estrada de Ferro; Northeast I; Northeast II; North; West I; West II; Pirineus; Rio Vermelho; São Patrício I; São Patrício II; Serra da Mesa; Southwest I; Southwest II; South.

### Data sources and variables

This study included deaths in children under 5 years old, infant and neonatal deaths registered in the *Sistema de Informações sobre Mortalidade* (Mortality Information System) (SIM) with the cause of death according to the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10). Furthermore, sociodemographic data regarding sex and race/color were collected in the SIM.

To calculate the mortality rates, data on the number of live births in the respective years were consulted in the *Sistema de Informações sobre Nascidos Vivos* (Live Births Information System) (SINASC). In addition, data on the percentage of coverage of the *Estratégia de Saúde da Família* (Family Health Strategy) (ESF) in the state of Goiás between 2007 and 2018 were collected in the *e-Gestor Atenção Básica* information system, with data collection being carried out in April 2020.

To identify the causes of deaths, the List of preventable causes of deaths by interventions of the Brazilian Unified Health System<sup>(7)</sup> was used, classified according to cause and ICD-10 code in:

- Preventable causes
  - Reducible by immunoprevention actions (A17, A19, A33, A37, G00.0, P35.0, P35.3);
  - Reducible by adequate care for women during pregnancy and childbirth and for the newborn (A50, B20 to B24, P00, P01, P03, P04, P05, P07, P55.0, P55.1, P55.8 to P57.9, P08, P10 to P15, P20, P21, P24, P23, P25 to P28, P35 to P39.9, except P35.0 and P35.3, P50 to P54, P58, P59, P70 to P74, P60, P61, P75 to P78, P80 to P83, P22, P90 to P96);
  - Reducible by appropriate diagnostic and treatment actions (G00.1 to G03, J00 to J06, J12 to J18, J20 to J22, J38.4, J40 to J47, except J43 and J44, J68 to J69, D50 to D53, A30 to A32, A38 to A41, A46, A49,

E03.0, E03.1, E10 to E14, E70.0, E73.0, E86, G40, G41, Q90, N39.0, I00 to I09);

- Reducible by appropriate health promotion actions, linked to appropriate health care actions (A00 to A09, A20 to A28, A90 to A99, B50 to B64, B99, E40 to E64, V01 to V99, X40 to X44, X45 to X49, W00 to W19, X00 to X09, W65 to W74, W75 to W84, W85 to W99, X85 to Y09, Y10 to Y34, W20 to W49, Y83 to Y84, Y40 to Y59);
- Ill-defined causes of death (R00 to R99, except R95);
- Other causes (not clearly avoidable).

## Statistical analysis

Data were tabulated in the TabWin 4.1.5 program according to the list of preventable causes of death. Statistical analysis was performed using the Stata program, version 16.0. The descriptive analysis of the cases was presented in the form of absolute and relative frequencies. Initially, mortality rates in children under 5 years of age in Goiás were calculated in the selected period according to location, age group, sex, race/color, preventability, and underlying cause. To include all deaths in the analysis, proportional distribution of deaths with unknown sex or race/color was performed. Thus, proportionally modified rates for these variables were obtained<sup>(9)</sup>.

Considering that, in the period covered by the study, the State of Goiás presented SINASC coverage above 90%, the use of the direct method for calculating rates was used. Rates were calculated using the ratio between the number of deaths in children in this age group and the number of live births (LB) in that year, multiplied by 1,000. Mortality rates in children under 5 years (U5MR), infant (IMR), and neonatal (NMR) were stratified. As for the age groups, they were stratified into early neonatal (0 to 6 days), late neonatal (7 to 27 days), and post-neonatal (28 to 364 days). All rates were logged.

The difference in means between the rates was verified by Student's t-test. For the analysis of the time series, generalized linear regression was used, using the Prais-Winsten method with robust variance<sup>(6)</sup>, in which stationary ( $p > 0.05$ ), decreasing ( $p < 0.05$  and negative regression coefficient) or ascendant ( $p < 0.05$  and positive regression coefficient) trends were obtained. Rates were considered as dependent variable "Y" and year as independent variable "X". The mean annual percentage change (APC) was obtained by the regression coefficient and standard error, using the formulas:

$$APC = [-1 + 10^{\beta}] * 100$$

$$CI95\% = [-1 + 10^{\beta \pm t * SE}] * 100$$

Where  $\beta$  is the regression coefficient, SE is the standard error and t is the tabulated value of the Student's t-test,

equivalent to 18 degrees of freedom. Pearson's correlation was used between mortality rates by health region and the ESF coverage rate, considering 2007 onwards, the year the program was implemented in the state of Goiás. Values of  $p < 0.05$  were considered significant.

As it is a public domain database, there was no need to submit the project to the Research Ethics Committee. However, the regulations of Resolution N°. 466/2012 of the National Health Council were respected.

## RESULTS

### Descriptive analysis of cases

Between 2000 and 2018, 29,010 deaths of children under 5 years were registered in the state of Goiás. As for the health region, higher frequencies were observed in the Central (25.8%; 7,503), Central South (14.1%; 4,103), Entorno Sul (13.2%; 3,847) and Pirineus (7.7%; 2,243) regions. The most frequent age group in infant deaths in the period was the early neonatal group (45%; 13,076), followed by the post-neonatal (25.1%; 7,290) and late neonatal (15.1%; 4,396) groups. Deaths in male children (55.9%; 16,237) and in white (54.1%; 15,707) and brown (43.6%; 12,647) children predominated. Regarding the group of causes, 63.5% (18,439) were due to preventable causes, 33.5% (9,723) were not clearly preventable and 2.9% (848) were poorly defined.

Of the preventable deaths, 72.9% (13,448) were reducible with adequate care for women during pregnancy and childbirth and for the newborn, 13.3% (2,466) reducible by appropriate actions of diagnosis and treatment, 13.4% (2,474) reducible by adequate health promotion actions, linked to adequate health care actions, and 0.27% (51) reducible by immunoprevention actions.

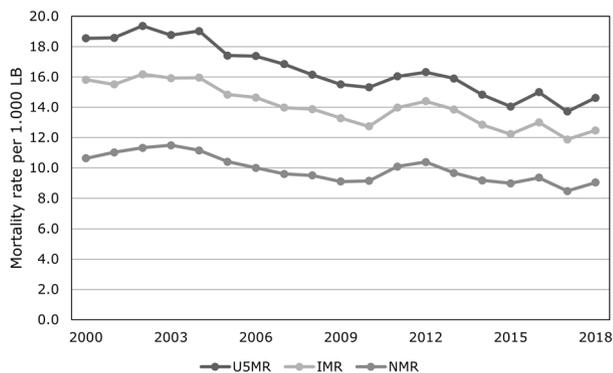
Newborn respiratory distress (9.6%; 2,788); infections specific to the perinatal period (9.5%; 2,760), such as unspecified bacterial sepsis of the newborn (6.9%; 2008) and unspecified neonatal period infection (1.8%; 525); respiratory and cardiovascular disorders specific to the perinatal period (6.7%; 1,958), such as newborn respiratory failure (2.7%; 801), unspecified congenital pneumonia (1.3%; 395), unspecified pulmonary hemorrhage originated in the perinatal period (0.9%; 271) and primary atelectasis of the newborn (0.7%; 209); and pneumonia (3.9%; 1,151) were among the main causes according to the ICD-10.

The occurrence of deaths caused by intestinal infectious diseases is noteworthy. Despite the low rate and the advances in recent decades, deaths of presumed infectious origin still occur in the state (1.7%; 511) and the main causes are diarrhea and gastroenteritis.

## Time trends

### Mortality rate by health region

The state of Goiás showed a decreasing trend in the main mortality indicators for children under 5 years old between 2000 and 2018 (Figure 1), with decreases in U5MR being identified [APC=-1.6% (95%CI -1.8%– -0.9%)], with a reduction from 18.5/1,000 LB to 14.6/1,000 LB,



U5MR: Under-5 mortality rate; IMR: Infant mortality rate; NMR: Neonatal mortality rate.

**Figure 1.** Trend of mortality indicators in children <5 years old (per 1,000 live births). Goiás, Brazil, 2000-2018.

representing a decrease of 21.1%; in the IMR [APC=-1.5% (95%CI -1.6%– -0.7%)], with a reduction from 10.6/1,000 LB to 9/1,000 LB, representing a decrease of 21.1% ; and in NMR [APC=-1.2% (95%CI -1.3%– -0.1%)], with a reduction from 10.6/1,000 LB to 9/1,000 LB, representing a 15% drop.

Entorno Norte, Pireneus, Rio Vermelho, and Southwest I health regions had a high U5MR in 2000, while in 2018, the regions Serra da Mesa and São Patrício II had the highest rates. Half of the regions showed a decreasing trend ( $p<0.05$ ) and the others showed stationary trends ( $p>0.05$ ) (Table 1).

Parallel to the decreasing trend of mortality indicators in children under 5, between 2007 and 2018, the coverage of the ESF in the state increased from 56.9% to 66.6% (Figure 2).

During this period, negative correlations between the U5MR and the coverage of the ESF in the state of Goiás ( $r=-0.193$ ;  $p=0.023$ ) and in the Central-South ( $r=-0.185$ ;  $p=0.03$ ), Entorno Norte ( $r=-0.181$ ;  $p=0.034$ ), Entorno Sul ( $r=-0.63$ ;  $p<0.001$ ), West I ( $r=-0.247$ ;  $p=0.004$ ) and Rio Vermelho ( $r=-0.179$ ;  $p=0.036$ ) health regions were verified through the Pearson correlation coefficient. No significant correlations were found between IMR and NMR with ESF coverage.

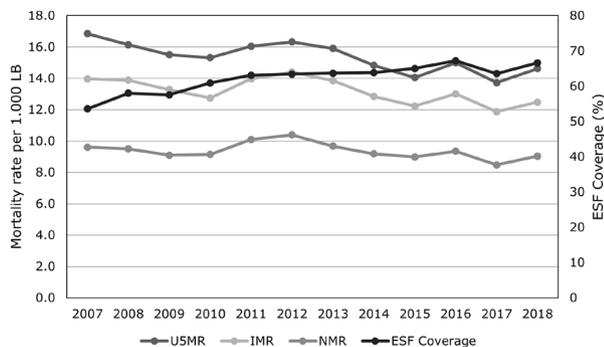
**Table 1.** Trend in the mortality rate in children <5 years (per 1,000 live births) according to health region. Goiás, Brazil, 2000–2018.

Region	2000		2018		p	APC (%)	95%CI	Trend
	n	Rate	n	Rate				
Central	458	18.37	361	13.13	<0.001	-1.83	-2.10– -1.56	↓
Central-South	217	17.93	198	14.58	0.001	-1.64	-1.80– -0.31	↓
Entorno Norte	90	20.40	58	14.37	0.001	-1.83	-1.99– -0.40	↓
Entorno Sul	241	18.96	205	16.03	0.002	-1.92	-2.13– -0.04	↓
Estrada de Ferro	61	18.84	59	14.20	0.073	-1.12	-1.84– -0.66	-
Northeast I	8	9.42	13	18.84	0.681	0.51	-1.81– -3.52	-
Northeast II	32	18.78	16	11.34	0.606	-0.46	-2.16– -1.65	-
North	41	16.26	19	10.36	0.122	-2.34	-4.24– -1.79	-
West I	35	18.78	18	13.14	0.088	-1.87	-3.09– -1.25	-
West II	22	15.17	17	11.32	0.296	-0.83	-2.02– -1.25	-
Pireneus	177	23.73	106	13.59	0.001	-2.16	-2.38– -0.21	↓
Rio Vermelho	64	20.04	32	11.10	<0.001	-2.75	-2.93– -0.85	↓
São Patrício I	27	10.68	34	16.44	0.663	-0.64	-3.30– -2.78	-
São Patrício II	34	14.48	51	21.44	0.42	-0.99	-3.04– -2.00	-
Serra da Mesa	36	18.11	31	20.18	0.043	-2.28	-1.88– -2.49	↓
Southwest I	107	21.04	109	16.88	<0.001	-1.73	-1.85– -0.67	↓
Southwest II	34	11.40	55	15.59	0.787	-0.21	-1.78– -1.64	-
South	58	17.25	63	18.79	0.027	-1.21	-1.72– -0.40	↓

APC: Annual percentage change; 95%CI: 95% confidence interval; ↑: Increase; ↓: Reduction; -: Stability.

## Mortality rate according to age group and sociodemographic variables

The trend in mortality rates based on age group and sociodemographic variables was decreasing, with rates being higher for males [ $t(36)=5.270$ ;  $p<0.001$ ]. The rate for the variables East Asian and indigenous race/color was stationary ( $p>0.05$ ), while the rate for white children was ascending ( $p<0.05$ ), and decreasing for black and brown children ( $p<0.05$ ) (Table 2).



U5MR: Under-5 mortality rate; IMR: Infant mortality rate; NMR: Neonatal mortality rate; ESF: *Estratégia de Saúde da Família* (Family Health Strategy).

**Figure 2.** Trend of mortality indicators in children <5 years (per 1,000 live births) compared to the coverage of the Family Health Strategy. Goiás, Brazil, 2007–2018.

## Mortality rate according to avoidability

The time series of rates for preventability and avoidable causes subgroups were mostly decreasing, except for deaths reducible by adequate care for women during pregnancy, which showed an upward trend ( $p<0.05$ ) (Table 3). Among these, fetal/neonatal deaths caused by maternal affections ( $p<0.05$ ) were noteworthy, such as maternal hypertensive disorders, maternal renal and urinary tract diseases, and maternal parasitic infections; and pregnancy complications ( $p<0.05$ ), such as premature rupture of membranes, multiple pregnancies, and incompetence of the cervix.

## DISCUSSION

The U5MR in the state of Goiás showed a significant reduction trend in the period analyzed ( $APC=-1.6$ ), with an average rate of 16.5/1,000 LB. This is lower than the rate in Latin America and the Caribbean (18/1,000 LB), according to the United Nations Organization (UNO) report<sup>(10)</sup>, and similar to the global trends for developing countries forecast in the year 2015 (19.1/1,000 LB)<sup>(11)</sup>.

Despite the downward trend and the results below national and global estimates, efforts are needed so that the U5MR keeps decreasing in line with the proposals of the Committing to Child Survival: A Promise Renewed<sup>(2)</sup> and with the projections for 2030 in a favorable scenario<sup>(11)</sup>, especially considering that most deaths are preventable. It is noteworthy that the rates identified in this study were lower than global projections for the next ten years, considering

**Table 2.** Trend in mortality rate in children <5 years (per 1,000 live births) according to age group and sociodemographic variables. Goiás, Brazil, 2000–2018.

Variables	2000		2018		p	APC (%)	95%CI	Trend
	n	Rate	n	Rate				
Age								
0 to 6 days	756	7.98	659	6.67	<0.001	-1.30	-1.43– -0.39	↓
7 to 27 days	252	2.66	235	2.38	0.004	-1.14	-1.28–0.17	↓
28 to 364 days	491	5.18	340	3.44	<0.001	-2.10	-2.19– -1.35	↓
Sex								
Male	1,022	20.97	822	16.27	<0.001	-1.98	-2.08– -1.20	↓
Female	736	15.99	624	12.91	<0.001	-1.37	-1.49– -0.54	↓
Race/color								
White	1,144	18.96	669	24.72	0.008	1.98	1.70–4.49	↑
Black	50	27.61	27	5.65	<0.001	-9.93	-10.25– -2.86	↓
East Asian	7	8.01	2	2.04	0.347	-2.30	-6.07–3.92	-
Brown	552	17.6	743	11.29	<0.001	-3.79	-3.93– -2.25	↓
Indigenous	4	11.22	5	40.47	0.902	-0.77	-12.56–13.4	-

APC: Annual percentage change; 95%CI: 95% confidence interval; ↑: Increase; ↓: Reduction; -: Stability.

**Table 3.** Trend in mortality rate in children <5 years (per 1,000 live births) according to the list of preventable causes of death. Goiás, Brazil, 2000–2018.

List of preventable cause of death	2000		2018		p	APC (%)	95%CI	Trend
	n	Rate	n	Rate				
1. Preventable death	1,172	12.37	862	8,72	<0.001	-2.46	-2.59– -1.38	↓
1.1 Immunoprevention actions	5	0.05	3	0.03	0.093	-5.35	-8.51–3.83	-
1.2 Adequate care for women during pregnancy and childbirth and for the newborn	791	8.35	631	6.38	<0.001	-1.83	-1.96– -0.51	↓
1.2.1 Care for women during pregnancy	84	0.89	194	1.96	<0.001	6.05	5.67–9.06	↑
Maternal conditions affecting the fetus or newborn	11	0.12	69	0.70	<0.001	15.16	14.07–21.71	↑
Maternal complications of pregnancy that affect the fetus or newborn	22	0.23	44	0.45	0.001	7.13	6.27–13.68	↑
Short-term pregnancy and low birth weight	37	0.39	66	0.67	0.929	0.23	-4.97–6.04	-
1.2.2 Care for women during childbirth	107	1.13	83	0.84	0.005	-2.52	-2.81–0.49	↓
Intrauterine hypoxia and birth asphyxia	57	0.60	35	0.35	<0.001	-5.01	-5.25– -2.23	↓
Neonatal aspiration	39	0.41	37	0.37	0.286	-1.44	-3.39–2.08	-
1.2.3 Care for the newborn	600	6.33	354	3.58	<0.001	-3.95	-4.06– -2.76	↓
Perinatal period-specific respiratory and cardiovascular disorders	201	2.12	71	0.72	<0.001	-6.24	-6.53– -2.44	↓
Perinatal period-specific Infections	151	1.59	123	1.24	0.004	-2.07	-2.34–0.30	↓
Newborn respiratory distress	189	1.99	77	0.78	<0.001	-6.35	-6.63– -2.68	↓
1.3 Appropriate diagnosis and treatment actions	206	2.17	110	1.11	<0.001	-4.59	-4.83– -1.97	↓
Pneumonia	67	0.87	47	0.48	<0.001	-4.74	-5.04– -0.85	↓
Other bacterial diseases	45	0.62	20	0.20	<0.001	-6.89	-7.07– -4.56	↓
1.4 Appropriate health promotion actions	170	1.79	118	1.19	0.002	-3.51	-3.83–0.08	↓
Intestinal infectious diseases	37	0.57	16	0.16	<0.001	-7.55	-7.91– -1.25	↓
Transport accidents	31	0.35	24	0.24	<0.001	-3.39	-3.55– -1.57	↓
2. Ill-defined causes	77	0.81	22	0.22	<0.001	-7.79	-7.97– -5.38	↓
3. Other causes (not clearly preventable)	509	5.37	562	5.68	0.116	0.21	0.04–0.59	-

APC: Annual percentage change; 95%CI: 95% confidence interval; ↑: Increase; ↓: Reduction; -: Stability.

the adoption of measures to reduce mortality due to preventable causes<sup>(11)</sup>.

Half of the health regions in the state of Goiás showed a significant downward trend and the remainder showed stability in the U5MR. Except for the São Patrício I and II and West II regions, all regions that showed stationary trends are peripheral, relatively far from the capital and the majority of municipalities with medium or high HDI<sup>(8)</sup>. Among the regions with stationary trends, Estrada de Ferro, with 18 municipalities and 286,433 inhabitants,

and Southwest II, with 10 municipalities and 215,282 inhabitants<sup>(8)</sup>, between 2007 and 2018, had an average ESF coverage of less than 80%, suggesting the fragility of the program in these regions.

The increase in ESF coverage since its implementation was associated with a reduction in TMM5 in the state of Goiás. However, only the Central South, Entorno Norte, Entorno Sul, West I, and Rio Vermelho health regions contributed to this reduction, suggesting that the greater coverage in the period analyzed resulted in lower rates.

Considering that there was no downward trend in mortality during the study period in half of the health regions, there is a need for progressive investments in the ESF, since studies show that the greater its coverage, the lower the mortality rates<sup>(4,12)</sup>, although this does not correspond to the findings in this study for IMR and NMR. We believe that it is through the strengthening of the network at this level of SUS care that better indicators will be achieved for the entire Brazilian population, especially for children.

Decreasing trends were also observed according to the age component for IMR, NMR, and the strata of early neonatal, late neonatal and post-neonatal mortality, corroborating national and global estimates<sup>(10,11)</sup>. Similar to other studies<sup>(13,14)</sup>, deaths in children under one year of age, especially early newborns, contributed to higher mortality rates in the period, reinforcing that this age group should be a priority in the formulation of public policies.

In line with the Millennium Development Goals<sup>(1)</sup>, which aims to end preventable deaths of newborns and children under 5 by 2030, Brazil has had considerable success in reducing infant mortality rates, with a reduction of 47.1/1,000 LB in 1990 to 20/1,000 LB in 2007 (APC=-5.1%). In the same period, the Northeast region had the highest APC (-5.9%) while the Central-West region had the lowest (-4.1%)<sup>(15)</sup>.

In this case, Goiás has contributed to achieving the national goal regarding U5MR and neonatal mortality, however, the challenge of eliminating preventable deaths among children still persists and requires more studies and strategies to strengthen prevention, early detection, and treatment, including the different levels of SUS care, in particular ESF.

In a study carried out with national data<sup>(16)</sup>, the state of Goiás presented a reduction in the IMR from 23.3/1,000 LB in 1998 to 16.9/1,000 NV in 2007 and an APC of -0.6%. Suggesting changes in this scenario, the IMR in this study showed a reduction from 15.8/1,000 LB in 2000 to 12.4/1,000 LB in 2018 (APC=-1.51%).

Regarding mortality rates by age group, the early neonatal, late neonatal and post-neonatal components showed a decreasing trend with an APC of -1.30%, -1.14% and -2.10%, respectively. These results are similar to studies carried out in Guarulhos (in the state of São Paulo) between 1996 and 2011<sup>(17)</sup>, and Rio Branco (in the state of Acre) between 1999 and 2015<sup>(14)</sup>. However, despite the results of the present study showing trends of reduction in mortality rates, APCs are still low when compared to other studies.

The trends in U5MR by sex were decreasing, while for males they were higher ( $p < 0.001$ ). The risk of developing respiratory problems, due to slower and later pulmonary maturation in boys, may explain the probability of a higher occurrence of deaths in the neonatal period in males<sup>(18)</sup>.

Trends for race/color were mostly decreasing. However, for East Asian and indigenous children they were stationary, while for white children they were ascendant. Such results may reflect the proper adoption of parameters for the care of the most vulnerable groups in health, providing equitable care<sup>(19)</sup>. However, it is essential to emphasize that these results may be associated with the proper completion of data in the SIM in the most recent years of the time series compared to the initial years.

Considering that early neonatal deaths of brown children represented 1/3 of the total for this age group, the need to reinforce actions within the scope of the *Política Nacional de Saúde Integral da População Negra* (National Policy for Comprehensive Health of the Black Population) is evident<sup>(20)</sup>. Precarious socioeconomic, environmental and sanitary conditions have been important determinants of low accessibility to the SUS, a factor associated with infant mortality<sup>(13)</sup>. Expanding access to quality care is critical to reducing these inequities and mortality<sup>(20)</sup>.

According to preventability, there was a reduction in deaths from preventable causes from 12.3/1,000 LB in 2000 to 8.7/1,000 LB in 2018 (APC=-2.6%). Nationally, between 2000 and 2013, there was an annual percentage reduction of 5.1%, with a reduction in the rate from 22.8/1,000 LB to 11.3/1,000 LB<sup>(3)</sup>, pointing to preventable deaths as the main group of causes.

Deaths reducible by adequate care for women during pregnancy and childbirth and for the newborn showed a decreasing trend. However, when stratified, there was an upward trend in deaths reducible by adequate care for women during pregnancy, corroborated by the increase in mortality from maternal conditions affecting the fetus or newborn and maternal complications of pregnancy.

These results follow the national trend and highlight the need to improve the quality of prenatal care and management of pregnant women<sup>(3)</sup>, actions carried out in the context of the ESF, as well as postpartum care for women and newborns<sup>(4)</sup>.

The reduction among the other preventability indicators may be associated with assertive actions in tertiary care<sup>(21)</sup> and the expansion of primary health care (PHC), especially for deaths that can be reduced by health promotion actions, as it allows greater access for the population to health services<sup>(12)</sup>. However, deaths reducible by adequate care for the newborn deserve attention as they represent the highest frequency of deaths among the subgroups of preventable causes.

The high reduction in deaths caused by pneumonia (APC=-4.74%), which globally represents 12.8% of deaths in children under 5 years of age and 2.7% of neonatal deaths, is highlighted<sup>(1)</sup>. These results corroborate the goals of the Integrated Global Action Plan, which aim to reduce mortality in children under 5 from pneumonia to up to 3/1,000 LB through protective actions, related to the establishment of good

health practices from birth, such as exclusive breastfeeding up to six months of age, adequate complementary food and vitamin A supplementation; preventive, related to actions to prevent illness, such as immunization and basic sanitation; and of proper treatment<sup>(22)</sup>.

Likewise, there was a significant reduction in mortality from intestinal infectious diseases such as diarrhea (APC=-7.55%), which globally represent 8.6% of deaths in children under 5 years old<sup>(1)</sup>. These results suggest effective actions over the years in the prevention of the disease such as immunoprevention, adequate supply of water and basic sanitation, and effective clinical management<sup>(1)</sup>.

The reduction in deaths caused by transport accidents may be associated with the implementation of traffic laws, inspection actions and improvement of transport routes. However, the large number of cases, compatible with the relevant statistics of mortality from external causes in children, reveals the need for prevention strategies in the occurrence of these injuries, such as encouraging the use of equipment such as a seat belt and appropriate chair for each age group<sup>(23)</sup>.

Still, it is salutary that health professionals are qualified for early identification of the disease, performing clinical management before complications and the need for hospitalization, avoiding an increase in the statistics of hospitalizations of children for causes sensitive to primary care. In this sense, it is necessary to strengthen the attributes of PHC (first contact access, longitudinal treatment, comprehensiveness, and coordination), as well as the interdisciplinarity of professionals working in child health<sup>(24)</sup>.

At this level of care, actions such as monitoring child growth and development at PNAISC<sup>(5)</sup> strengthen disease prevention and early detection of diseases in the target population. The scope of the medical appointment includes the analysis of the growth pattern, the periodic assessment of motor and cognitive development, and the interaction with the environment and people, updating the immunization program, guidelines on healthy eating and breastfeeding, prevention of hypovitaminosis A and anemia, anamnesis and the complete physical examination of the child.

Deaths reducible by immunoprevention actions were a minority. Despite showing a stationary trend, these results demonstrate success in the vaccination coverage of the national immunization program and the need to encourage the population to consistently seek PHC for child vaccination, despite the drop in the national coverage rate in this population in recent years<sup>(25)</sup>.

Limitations must be considered for this study. First, it should be noted that the reliability of these data depends on the complete and accurate filling in of information systems, which have become more reliable over the years. Because this study considers data between 2000 and 2018, information referring to the initial years may be less accurate than the most

current information due to possible underreporting caused by the transfer of information to computerized systems.

Limitations regarding the random variations of the crude rates derived from small numbers should also be considered, since their high instability to measure mortality when cases are rare, and the population is small implies unreliable results. Thus, the variables Northeast I health region and East Asian and indigenous race/color must be treated with attention.

Despite this, it is believed that the risk of bias in trend analyses is minimal, and the study contributes to the planning of health strategies in the state of Goiás, as well as in the country, based on a better understanding of a part of the Central-West.

## CONCLUSION

The trends of U5MR, IMR, and NMR in the state of Goiás between 2000 and 2018 were decreasing, following the national and international scenarios. The early neonatal age component, male sex, and deaths from preventable causes contributed to the highest mortality rates. Fifty percent of the health regions showed a tendency to reduce the U5MR, while the rest showed stability in the rate. Negative correlations were observed between the U5MR and the coverage of the ESF in the state, demonstrating that the expansion of care in the context of PHC reduces the under-five infant mortality rate.

The analysis of preventable deaths in the state of Goiás suggests the need for greater public investments in the ESF and in the strengthening of maternal care and childcare, such as actions to promote health, adequate prenatal care, and childbirth assistance.

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