

All-cause mortality rates for indigenous in the states of Brazil and their (non) correlation with socioeconomic and health indicators in the years 2000 and 2010

Arthur Arantes da Cunha¹  Rodolfo Antonio Corona¹  Giovana Carvalho Alves¹ 
Maira Tiyomi Sacata Tongu Nazima¹  Emerson Augusto Castilho-Martins¹ 

¹ Universidade Federal do Amapá – UNIFAP. Macapá/AP, Brasil.
E-mail: emersonmartins@unifap.br

Abstract

In 2010, the indigenous population represented 0.2% of the Brazilian population and was mostly located in the Legal Amazon region. In Brazil, there are laws to protect the indigenous population, in addition to a National Health Care Policy for Indigenous Peoples. However, a large part of the indigenous population is considered under social and sanitary vulnerability, which are more pronounced in certain regions of the country. Therefore, this study aimed to calculate and evaluate the all-cause mortality rate in the Brazilian indigenous population and investigate correlations with socioeconomic and health indicators. This is an ecological study based on official data (2000 and 2010). The number of deaths were extracted from the Mortality Information System. Indigenous population data were extracted from Demographic Censuses of the Brazilian Institute of Geography and Statistics. The all-cause mortality rate were calculated by states and correlated, through Pearson's correlation test, with socioeconomic and health indicators extracted from the Atlas Brazil platform. In Brazil, an increase in the overall indigenous mortality rate was observed of 15.0% between 2000 and 2010. Among the regions, the Midwest had the highest rates in 2000 and 2010 (4.54 and 5.56 deaths/1,000 indigenous people, respectively). In 2000, the state with the highest all-cause mortality rate was Piauí (9.76/1,000) and in 2010 it was Mato Grosso do Sul (6.54/1,000). All-cause mortality rate did not present a significant correlation (p -value ≤ 0.05) with the analyzed indicators. The findings of this study indicated that the all-cause mortality rate in Brazil increased unevenly, according to regions/states, and without any correlation with the socioeconomic and health indicators analyzed.

Keywords: Health of Indigenous Populations. Vulnerable Populations. Ethnic Origin and Health. Epidemiology. Development Indicators.

INTRODUCTION

Between the 16th and 21st centuries, Brazil's indigenous population suffered a great decrease. Before the beginning of the colonization of Brazil, the indigenous population was estimated between 2 and 4 million individuals, belonging to more than 1,000 ethnic groups¹. In 2010, according to the most recent Census of the Brazilian Institute of Geography and Statistics (IBGE), the Brazilian indigenous population was

approximately 820,000 individuals (0.2% of the Brazilian population). Most of this population was located in the nine states (federative units = FU) of the Brazilian Legal Amazon region, and about 61.0% lived in rural areas/indigenous lands².

Although the colonization process has also reduced the number of indigenous ethnic groups in Brazil, there is still a huge sociocultural diversity. According to the

DOI: 10.15343/0104-7809.2022465145261

2010 IBGE Census, there are 305 indigenous ethnic groups in the country, which speak 274 different languages. In addition to language, the great cultural diversity of these peoples encompasses their secular traditions, their social and political organizations, their form of habitation, their dances and costumes, and their ways of relating to the environment and non-indigenous society^{1,2}.

In order to promote, protect, and recover the health of this population, since 1999, there has been a national subsystem of indigenous health care, composed of Special Indigenous Health Districts. These districts form a network of health services in indigenous lands, which follows the principles of the Unified Health System and works in line with the National Health Care Policy of Indigenous Peoples. However, the healthcare situation of the indigenous population in Brazil remains critical, with relevant state and regional disparities in access to health and socio-economical aspects³⁻⁶.

Amid the disorderly expansions of local economies, which in many cases occur illegally, indigenous peoples face situations of social tension, widespread vulnerability, and constant violence. This context, present in several regions of Brazil and especially those with lower socioeconomic development, can be understood as a constant threat to the integrity of these peoples, in order to affect aspects of great importance such as sociocultural organization and health condition, also having, as a possible reflection, the increase in general morbidity and mortality

from infections, foreign diseases, and chronic diseases, such as diabetes, obesity, and cardiovascular diseases⁴⁻⁹.

In Brazil, socioeconomic and health conditions vary greatly according to the region and the state analyzed⁶. In this context, the Brazilian Legal Amazon region, geographically removed from the main economic axis of the country, has many localities in which populations have precarious living conditions, which is due, in part, to Brazil's historical process of unequal development and the inefficiency of government public policies^{5,7,8}.

In addition, there is a constant advance in forest deforestation and a progressive expansion of the agricultural frontier in the Legal Amazon region and other FUs, such as Mato Grosso do Sul. The constant advance in deforestation and a progressive expansion of the agricultural frontier generates several violent conflicts over land and wealth. These factors contribute to the increase in the vulnerability of the indigenous population^{5,7,8}, which in recent decades has had mortality rates higher than those of the non-indigenous population^{10,11}, besides presenting an increasing trend in mortality rates¹².

Given this scenario and considering the scarcity of national studies that investigate the relationship between the all-cause mortality rate and local/regional development, the present study aimed to calculate and evaluate the all-cause mortality rate in the Brazilian indigenous population in each FU and to investigate correlations of all-cause mortality rate with socioeconomic and health indicators in the years 2000 and 2010.

METHODS

Study design, data sources, and calculation method

This is an observational, retrospective study of a descriptive ecological design,

based on official secondary open access public data, referring to the Brazilian indigenous population in the years 2000 and 2010. Commonly, ecological studies

aim to describe the frequency of a given event of interest and investigate possible relationships with socioeconomic, geographic, demographic, and other factors, when noting the limitations inherent in establishing an ecological correlation. In these studies, observation units are aggregate groups of individuals, such as populations of countries or states^{13,14}. In many cases, secondary data are used, which may make it impossible, due to the unavailability/lack of data, to provide an adequate adjustment of the rates studied by important characteristics of the populations analyzed, such as gender and age group¹⁵. However, it is noteworthy that crude rates have great epidemiological relevance and are used in comparative analysis studies of crude mortality rates in which it was not possible to perform any standardization^{16,17}.

In the present study, the number of deaths was extracted, according to each state and the Brazilian region, from the all-cause mortality rate section (1996-2015) of the Mortality Information System (MIS) of the Informatics Department within the Unified Health System¹⁸ of the Ministry of Health.

$$\text{All-cause mortality rate} = \frac{\text{Number of new deaths in 2000} \times 1,000}{\text{Indigenous population in the respective year (2000 or 2010)}}$$

The socioeconomic and health indicators of the 27 Brazilian states, referring to the years 2000 and 2010, correlated with the all-cause mortality rate of the states, were extracted from the Atlas Brasil platform⁶. In the present study, the following indicators were used: Municipal Human Development Index (MHDI); Municipal Human Development Index Income dimension (MHDI-R); Municipal Human Development Index Longevity dimension (MHDI-L); Municipal Human Development Index Education dimension (MHDI-E); Gini index; per capita income in Reais; and

The variables 'year of death' (2000 and 2010) and 'color/race' (indigenous) were selected. Only the deaths of individuals declared indigenous were included. Thus, cases reported as 'ignored' for 'color /race' were excluded from the analysis. It is noteworthy that the all-cause mortality rate section of the MIS provides quantitative deaths related to the sum of deaths caused by 'all causes'.

In the next stage, data from the indigenous population were extracted, referring to the years 2000 and 2010 by state and the Brazilian region, from the Demographic Censuses of 2000 and 2010², conducted by IBGE. Thus, it is notable that the choice of the years studied was due to the availability of open access public data about the indigenous population contingents, by IBGE, and the absolute numbers of stratified deaths "race/color", by the Ministry of Health.

After obtaining population data and the number of deaths of indigenous peoples, all-cause mortality rate were calculated. The calculations were systematically made per state (n=27), per region, and per year (2000 and 2010), based upon 1,000 indigenous peoples. The following calculation formula was used:

percentage of poor people⁶. These indicators were chosen due to the associations described in previous studies, including mortality/health situation^{19,20}.

Data analysis

The data were analyzed using the statistical software Statistical Package for the Social Sciences® version 20.0. Data distribution was analyzed using Quantil-Quantil Plot and tested by Kolmogorov-Smirnov adherence test, the most appropriate test for the sample size of the present study (n=27) according to Torman et

al.²¹. The hypothesis of normal distribution was accepted, according to the Kolmogorov-Smirnov test, for all variables of the present study, including socioeconomic and health indicators.

Furthermore, the test used in the correlation analyses was Pearson's parametric correlation test (bivariate), in which the correlation direction (positive or negative) and the intensity of Pearson's coefficient (r) were observed in the correlations of the all-cause mortality rate calculated with socioeconomic and health indicators. Regarding the intensity of the correlation, the interpretation values of the r described by Levin

et al. were used²². R ranges from +1.00 to -1.00. Values in the range from +/-1.00 to +/-0.60 represent a strong correlation between the variables, between +/-0.59 and +/-0.30 indicate moderate correlation, between +/-0.29 and +/-0.10 indicate weak correlation, and between +/-0.09 to 0.00 indicate no correlation. The level of significance adopted was $p\text{-value} \leq 0.0522$.

Ethical aspects

Because exclusive use of open access secondary data, which does not allow individual identification, the present study did not need to be evaluated by a Research Ethics Committee.

RESULTS

A total of 2,285 indigenous deaths were recorded in 2000 in Brazil. In 2010, 2,927 deaths were recorded. This increase in the absolute number of deaths resulted in a percentage change rate of 28.1% between 2000 and 2010. Regarding the all-cause mortality rate, an increase was also identified in the period (+15.0%), from 3.11 deaths/1,000 indigenous people in 2000 to 3.58 deaths/1,000 indigenous people in 2010 (Table 1).

Among the Brazilian regions, the North region was the one with the highest percentage of deaths recorded, both in 2000 ($n=625$; 27%) and in 2010 ($n=1,158$; 40%). The South and Southeast regions showed, in the period studied, a reduction in the indigenous population of 11.6% and 39.2%, respectively (Table 1). The Midwest region had the highest all-cause mortality rate in both 2000 (4.54 deaths/1,000 indigenous peoples) and in 2010 (5.56 deaths/1,000 indigenous people), an increase of 22.3%. The absolute number of deaths recorded and the respective populations in 2000 and 2010, by region, are shown in Table 1.

In 2000, the state with the highest all-cause mortality rate was Piauí, with a rate of 9.76 deaths per 1,000 indigenous peoples. In 2010, the state with the highest indigenous mortality rate was Mato Grosso do Sul, with a rate of 6.54 deaths per 1,000 indigenous people. The state with the highest percentage increase between 2000 and 2010 was Rondonia, whose rate increased from 0.66 deaths/1,000 indigenous to 4.41 deaths/1,000 indigenous people. The other mortality and variation rates, by state, are shown in Table 2.

Table 3 shows that the all-cause mortality rate of the indigenous population did not present a significant correlation with any of the socioeconomic and health indicators studied. In addition, the r value was between +/-0.09 to 0.00 in the MHDI, MHDI-L, MHDI-E, and per capita income indicators in 2000 as well as in the MHDI, MHDI-R, MHDI-L, and percentage of poor people indicators in 2010, which showed no correlation. The indicators, referring to the years 2000 and 2010, used in the correlation tests are presented in Table 4.

Table 1 – All-cause mortality rate ($\times 1,000$), absolute number of deaths and indigenous population in Brazilian regions and Brazil, 2000 and 2010.

Region/Brazil	Number of deaths (%)		Indigenous population (%)		All-cause mortality rate (%)		
	Year 2000	Year 2010	Year 2000	Year 2010	Year 2000	Year 2010	Variation* 2000-2010
North	625 (27)	1,158 (40)	213,443 (29)	305,873 (37)	2.93	3.79	29.3%
Northeast	520 (23)	488 (17)	170,388 (23)	208,691 (26)	3.05	2.34	-23.4%
Southeast	513 (22)	318 (11)	161,188 (22)	97,960 (12)	3.18	3.25	2.0%
South	153 (7)	238 (8)	84,747 (12)	74,945 (9)	1.81	3.18	75.9%
Midwest	474 (21)	725 (25)	104,359 (14)	130,494 (16)	4.54	5.56	22.3%
Brazil	2,285 (100)	2,927 (100)	734,127 (100)	817,963 (100)	3.11	3.58	15.0%

*Percentage rate of variation in the all-cause mortality rate between 2000 and 2010.

Source: Brazilian Institute of Geography and Statistics (IBGE) and Mortality Information System (MIS).

Table 2 – All-cause mortality rate ($\times 1,000$) in the 27 Brazilian federative units (states) and percentage rates of variation, 2000 and 2010.

Region/Federal Unit (State)	All-cause mortality rate		
	Year 2000	Year 2010	Variation* 2000-2010
North Region			
Rondonia	0.66	4.41	573.2%
Acre	2.12	4.71	121.9%
Amazonas	2.05	3.69	79.7%
Roraima	7.86	3.45	-56.2%
Para	2.65	4.20	58.1%
Amapa	1.01	2.83	181.9%
Tocantins	3.97	3.88	-2.2%
Northeast Region			
Maranhao	3.12	3.63	16.3%
Piaui	9.76	5.10	-47.8%
Ceara	4.67	1.50	-67.9%
Rio Grande do Norte	2.21	2.31	4.6%
Paraiba	2.87	1.83	-36.5%
Pernambuco	3.95	2.59	-34.5%
Alagoas	2.20	3.24	47.0%
Sergipe	1.34	2.87	114.5%
Bahia	2.32	1.33	-42.6%
Southeast Region			
Minas Gerais	1.93	4.08	111.6%
Espirito Santo	0.94	2.51	166.7%
Rio de Janeiro	1.09	4.40	305.8%
Sao Paulo	5.77	2.34	-59.4%
South Region			
Parana	2.41	3.78	56.7%
Santa Catarina	1.10	1.99	81.3%
Rio Grande do Sul	1.58	3.27	107.8%
Midwest Region			
Mato Grosso do Sul	6.64	6.54	-1.6%
Mato Grosso	1.92	4.47	132.9%
Goiias	2.27	5.39	137.7%
Distrito Federal	3.91	1.63	-58.3%

*Percentage rate of variation in the overall indigenous mortality rate between 2000 and 2010. Source: Brazilian Institute of Geography and Statistics (IBGE) and Mortality Information System (MIS).

Table 3 – Pearson's correlation coefficient (r) values for the all-cause mortality rate in the indigenous population in the Brazilian states ($n=27$) and their respective socioeconomic and health indicators in the years 2000 and 2010.

Indicator	Year 2000		Year 2010	
	All-cause mortality rate (n=27)	p-value	All-cause mortality rate (n=27)	p-value
MHDI	-0.080	0.692	-0.081	0.687
MHDI-R	-0.137	0.496	-0.034	0.867
MHDI-L	-0.089	0.660	-0.033	0.869
MHDI-E	-0.045	0.823	-0.142	0.480
Gini Index	0.175	0.381	-0.159	0.428
Income per capita	-0.071	0.725	-0.094	0.643
% poor people	0.171	0.394	-0.088	0.662

MHDI: Municipal Human Development Index; MHDI-R: Municipal Human Development Index Income dimension; MHDI-L: Municipal Human Development Index Longevity dimension; MHDI-E: Municipal Human Development Index Education dimension.

Table 4 – Socioeconomic and health indicators of the Brazilian regions and federal units, 2000 and 2010.

Region/ State	MHDI		MHDI Income		MHDI Longevity		MHDI Education		Gini Index		Minimum Wage*		% in poverty	
	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010
North Region	0.527	0.667	0.613	0.670	0.717	0.796	0.333	0.557	--	--	--	--	--	--
Rondonia	0.537	0.690	0.654	0.712	0.688	0.800	0.345	0.577	0.600	0.560	467.2	852.3	29.8	14.8
Acre	0.517	0.663	0.612	0.671	0.694	0.777	0.325	0.559	0.640	0.630	360.6	522.2	44.0	29.5
Amazonas	0.515	0.674	0.608	0.677	0.692	0.805	0.324	0.561	0.670	0.650	351.6	539.8	48.5	30.8
Roraima	0.598	0.707	0.652	0.695	0.717	0.809	0.457	0.628	0.610	0.630	462.2	605.6	33.6	26.7
Para	0.518	0.646	0.601	0.646	0.725	0.789	0.319	0.528	0.650	0.620	335.8	446.8	46.9	32.3
Amapa	0.577	0.708	0.638	0.694	0.711	0.813	0.424	0.629	0.620	0.600	424.6	599.0	38.1	24.1
Tocantins	0.525	0.699	0.605	0.690	0.688	0.793	0.348	0.624	0.650	0.600	344.4	586.6	45.2	22.2
Northeast Region	0.516	0.663	0.588	0.656	0.685	0.782	0.342	0.569	--	--	--	--	--	--
Maranhao	0.476	0.639	0.531	0.612	0.649	0.757	0.312	0.562	0.650	0.620	218.3	360.3	62.8	39.5
Piaui	0.484	0.646	0.556	0.635	0.676	0.777	0.301	0.547	0.650	0.610	254.8	416.9	57.3	34.1
Ceara	0.541	0.682	0.588	0.651	0.713	0.793	0.377	0.615	0.670	0.610	310.2	460.6	51.8	30.3
Rio Grande do Norte	0.552	0.684	0.608	0.678	0.700	0.792	0.396	0.597	0.640	0.600	351.0	545.4	44.9	23.8
Paraiba	0.506	0.658	0.582	0.656	0.672	0.783	0.331	0.555	0.630	0.610	299.1	474.9	49.6	28.9
Pernambuco	0.544	0.673	0.615	0.673	0.705	0.789	0.372	0.574	0.660	0.620	367.3	525.6	45.3	27.2
Alagoas	0.471	0.631	0.574	0.641	0.647	0.755	0.282	0.520	0.680	0.630	285.3	432.6	56.8	34.3
Sergipe	0.518	0.665	0.596	0.672	0.678	0.781	0.343	0.560	0.650	0.620	326.7	523.5	48.8	27.9
Bahia	0.512	0.660	0.594	0.663	0.680	0.783	0.332	0.555	0.660	0.620	322.0	496.7	49.7	28.7
Southeast Region	0.676	0.766	0.735	0.773	0.778	0.845	0.541	0.688	--	--	--	--	--	--
Minas Gerais	0.624	0.731	0.680	0.730	0.759	0.838	0.470	0.638	0.610	0.560	548.9	749.7	24.6	11.0
Espirito Santo	0.640	0.740	0.687	0.743	0.777	0.835	0.491	0.653	0.600	0.560	574.2	815.4	22.8	9.5
Rio de Janeiro	0.664	0.761	0.745	0.782	0.740	0.835	0.530	0.675	0.600	0.590	826.0	1.039.3	13.7	7.2
São Paulo	0.702	0.783	0.756	0.789	0.786	0.845	0.581	0.719	0.580	0.560	882.4	1.084.5	9.7	4.7

to be continued...

... continuation table 4

Region/ State	MHDl		MHDl Income		MHDl Longevity		MHDl Education		Gini Index		Minimun Wage*		% in poverty	
	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010
South Region	0.660	0.754	0.711	0.764	0.792	0.848	0.510	0.662	--	--	--	--	--	--
Parana	0.650	0.749	0.704	0.757	0.747	0.830	0.522	0.668	0.600	0.530	638.3	890.9	18.9	6.5
Santa Catarina	0.674	0.774	0.717	0.773	0.812	0.860	0.526	0.697	0.560	0.490	693.8	983.9	12.8	3.7
Rio Grande do Sul	0.664	0.805	0.720	0.867	0.804	0.857	0.505	0.702	0.580	0.600	708.1	1.758.3	15.6	3.8
Midwest Region	0.639	0.757	0.720	0.776	0.777	0.839	0.467	0.665	--	--	--	--	--	--
Mato Grosso do Sul	0.613	0.729	0.687	0.740	0.752	0.833	0.445	0.629	0.620	0.560	576.3	799.3	22.8	9.9
Mato Gosso	0.601	0.725	0.689	0.732	0.740	0.821	0.426	0.635	0.620	0.550	582.6	762.5	22.0	10.5
Goias	0.615	0.735	0.686	0.742	0.773	0.827	0.439	0.646	0.600	0.550	571.5	811.0	21.0	7.6
Distrito Federal	0.725	0.824	0.805	0.863	0.814	0.873	0.582	0.742	0.630	0.630	1.199.4	1.715.1	12.3	4.9

MHDl: Municipal Human Development Index; *Per capita income in Brazilian reais. The federal minimum wage in 2010 was R\$ 510.00 and in 2000 ranged from R\$ 136.00 on 01/01/2000 to R\$ 151.00 in 12/31/2000. Source: Atlas of Human Development of Brazil.

DISCUSSION

In Brazil, indigenous peoples have their own subsystem of indigenous healthcare management and promotion based on a network of Special Indigenous Health Districts³. However, this population, historically, has difficulty in accessing healthcare, a fact demonstrated by previous studies that identified higher mortality and lower access to healthcare services of the indigenous population when compared to non-indigenous people in Brazil¹⁰⁻¹², a scenario that is repeated in other countries such as Canada, New Zealand and Australia²³⁻²⁵. Therefore, the present study identified a percentage increase in the absolute number of indigenous deaths, between 2000 and 2010, of 28.1%.

It is possible that this increase is a reflection of a real growth in the absolute number of deaths that occurred, together with the improvement of notification services. It is noteworthy that only in 1991 did the IBGE Censuses begin to generate data on the indigenous 'race/color' category¹⁰, which represents an invaluable loss of retrospective information for the preparation of historical series

studies year by year. Moreover, the highest absolute number of deaths recorded in the North region reflects the fact that this region concentrates most of the national indigenous population and is in the deforestation arc of the Brazilian Amazon^{26,27}. The ecological study of Lima *et al.*¹² also identified a higher percentage of notifications in this region (39%).

The all-cause Brazilian mortality rate showed an increasing percentage change of 15.0% between 2000 and 2010, which is close to that found by Lima *et al.*¹² in the same period. This growth makes it relevant to highlight national aspects that may have influenced, in part, the increase in indigenous mortality, such as the progressive process of the dissolution of indigenous culture⁷. In this process, marked by factors such as the expansion of illegal/violent exploitation of agriculture and mining in indigenous lands, the natives are potentially forced to leave their lands and move to urban centers^{7,8}. This type of violence against indigenous peoples, in their own lands/villages, can be measured by analyzing the murders of native leaders in

conflicts with those interested in the exploitation of land⁸, in a clear scenario of violations of the Indigenous Statute²⁸, the National Policy of Health Care of Indigenous Peoples⁴, and the Federal Constitution of Brazil of 1988, which guard the rights of indigenous peoples to protection, health, and land. The damage done to indigenous peoples is not limited to direct violence, for illegal exploration ventures also cause damage to environmental health, as they contaminate rivers and destroy local fauna and flora, as well as enable the transmission of human diseases for which indigenous peoples may have low immunity⁵.

This context, due to violence/lack of protection, the increasing proximity of villages to cities and the search for possible better living conditions, accentuates the indigenous population displacement to the urban environment, with consequently changing environments and cultures^{8,29,30}. These changes increase exposure to factors related to death from external causes, such as: access to firearms, poverty and homelessness, alcoholism, drug use, depression, traffic accidents, violence, and others^{23,30-33}. Furthermore, environmental factors and lifestyle habits that also cause deaths from cancer, chronic diseases, sexually transmitted infections, and other causes^{12,23,34,35}. It is also important to highlight that a meta-analysis study pointed out that several studies identified lower indigenous mortality in urban areas compared to the rural area. However, this same meta-analysis highlights that none of the studies analyzed concluded that indigenous mortality in urban areas is lower than in rural areas. They also point out that the underreporting of indigenous deaths in urban areas is much higher than in rural areas and that the maintenance of indigenous lifestyles and traditional diets can favor the health of the most isolated peoples²³.

Four of the five Brazilian regions showed an increase in the mortality rate between

2000 and 2010, especially in the South (+75.9%) and Southeast (+2.0%), which were the only two regions that presented, in the period, a reduction in the indigenous population contingent, of 11.6% and 39.2% respectively². The increase in mortality and the reduction of the population may be related to each other and to sociocultural, historical, and economic aspects of these regions and the peoples who have inhabited them. Therefore, it is necessary to consider that these are the two most developed regions of the country⁶, with higher percentages of the white population and relevant degree of discrimination, invisibility, and urban marginalization of social minorities, such as indigenous peoples. This makes it possible that, with the greater indigenous migration to cities and consequently greater exposure to prejudice and racism, there will be a phenomenon of denial of indigenous cultural identity, which can result in a smaller number of self-declared indigenous peoples^{29,36,37}.

The Midwest region had the highest mortality rates in both 2000 and 2010. In this region, the State of Mato Grosso do Sul is located, which had the highest mortality rate in 2010 (6.54 deaths/1,000 indigenous peoples). This state is, historically, a place for the expansion of sugarcane plantations and violent conflicts of farmers against indigenous peoples^{8,29}. Therefore, Paula⁸ points out that over the course of only 5 years, a total of 7 indigenous leaders were killed in land disputes in Mato Grosso do Sul. Moreover, the advance of crops on indigenous lands is a process that violently removes the autonomy of the indigenous production, enabling them to submit to work in a regime analogous to that of slavery. In this context, it is emphasized that between 2004 and 2011 about 2,600 indigenous people were freed from this type of working condition in Mato Grosso do Sul⁸.

The State of Rondônia, which in the present study demonstrated the highest rate of positive percentage variation between 2000

and 2010, is located in one of the most affected areas of the deforestation arc of the Brazilian Amazon, and the state has one of the largest proportions of accumulated deforestation in the first decade of the 21st century^{26,27}. These scenarios, especially these two states (Mato Grosso do Sul and Rondonia), favor the emergence of violent conflicts with "producers", the loss of indigenous lands, the process of urbanization of indigenous peoples, and the dissolution of traditional culture, among other devices that expose indigenous peoples to higher risks of death and poor health conditions^{7,8,23,29,36}.

Another relevant result of the present study is the high all-cause mortality rate identified in 2000 in Piauí (9.76/1,000), the highest identified in this study. Among the possible justifications for this result is the underestimation of the indigenous population in Piauí. In the 1991 and 2000 Censuses, the indigenous population of Piauí was the smallest among the states. In 2010, the population was estimated at 2,944 individuals², a very different amount from that disclosed by the State Department of Health of Piauí in 2016, which was approximately 6,000 individuals³⁸. Moreover, only in 2020, through state law no. 7.389 of August 27, 2020, the first indigenous land was demarcated in the state of Piauí. This delay in the recognition of the indigenous presence in the state and in the allocation of the land represents a great damage in the context of social protection and access to healthcare.

The present study did not identify even a significant correlation between the all-cause mortality rate and the socioeconomic and health indicators of Brazilian states in either one of the years studied. In addition, in 8 of the 14 correlation tests performed, the *r* value indicated no correlation between indicator and mortality. Therefore, it is possible that indicators, such as MHD, MHD-L, MHD-R, and Gini Index, are limited in presenting socioeconomic and health outlooks of indi-

genous peoples, due to the low proportion of these peoples in the Brazilian population (0.2%)^{2,39} and their peculiarities and specificities regarding living conditions, access to healthcare, and economic and educational criteria³⁹.

However, when it comes to the general population, these initiators presented statistically significant correlations, in previous Brazilian studies, with mortality in traffic accidents, homicides, suicides, cardiovascular causes, and preventable causes^{19,20}. This reinforces the hypothesis that these indicators are effective to expose and represent the socioeconomic and health scenario of the general population, but they are limited when it comes to indigenous people. Thus, it is understood that, even when living in states with good indicators, the indigenous population may not fully enjoy the socioeconomic and health benefits.

This information suggests the need to create specific indexes for indigenous peoples, to better target public policies on health, income, and education. Furthermore, the use of the Multidimensional Poverty Index (MPI), which has been published annually (since 2010) by the United Nations Development Programme and the Oxford Poverty and Human Development Initiative, is an alternative for future studies. The MPI aims to complement the traditional measures of monetary poverty, investigating the incidence and intensities of ten poverty indicators, such as nutritional status, infant mortality, basic sanitation, housing, school attendance of children, and others. Although not currently available to indigenous populations of each Brazilian state, the MPI allows for comparisons between countries and sub-national regions according to ethnic groups. In the 2021 report on ethnic disparities, the MPI demonstrated that indigenous peoples are among the poorest and most vulnerable in Latin America⁴⁰.

The present study has important limita-

tions. Among them is the underreporting of indigenous deaths, which generates an underestimation of all-cause mortality rate. This underreporting has different degrees, which vary according to the state and the region of the country. These factors are related to the capacity and quality of notification services, which can be affected by the invisibility of the indigenous population, which is possibly more pro-

nounced in the urban environment. Moreover, although it is presumed that a certain homogeneity of the age groups of indigenous populations of the states that concentrate the largest indigenous population contingents in Brazil, it should be highlighted that, due to the lack of age group distribution data of the indigenous population of each state, it was not possible to calculate age-adjusted mortality rates.

CONCLUSION

The present study identified an increase in the absolute number of deaths in three of the five regions of Brazil between 2000 and 2010. The all-cause mortality rate also increased in four of the five regions of the country and in ten of the 27 Brazilian states between 2000 and 2010. The North region recorded the highest absolute number of deaths in the two years analyzed, while the Midwest region had the highest all-cause mortality rate. The indigenous population showed a reduction in the South and Southeast regions, the two most developed regions of Brazil. Moreover, the states of Rondonia and Mato Grosso do Sul, located in areas of historical deforestation and land conflicts, were highlighted due to the highest percentage increase in the all-cause mortality rate and the higher mortality rate calculated in 2010, respectively. This makes it essential to increase and improve public health and protection policies for indigenous peo-

ples based on existing legislation.

Finally, the socioeconomic and health indicators studied did not present a significant correlation with the indigenous mortality rates of the respective states. In eight of the 14 correlation tests, the *r* value indicated no degree of correlation between the variables. In addition, the findings of this study indicated that the all-cause mortality rate in Brazil increased in an unequal way, according to regions and states of the country. Thus, it is suggested the elaboration of more studies to evaluate and/or create indicators with the possibility of demonstrating the socioeconomic and health scenario of the indigenous population in Brazil. In addition, we highlight the need for open data on the age distribution of the indigenous populations of each state, so that studies of age-adjusted mortality rate can be conducted.

FINANCING: The study received financial support from the following institutions: United Nations Office for Project Services (UNOPS) and the Public Ministry of Labor of Amapá (pet. PA-PR 000048.2020.08.001/7); DPQ/UNIFAP (scholarship awarded to Arthur Arantes da Cunha); Agreement CNPq/Fundacao Tumucumaque (Proc. 250.203.009/2021) and CAPES (PROCAD-AM88887.200546/2018-00).

Author Statement CRediT

Conceptualization: Cunha, AA; Corona, RA; Alves, GC; Nazima, MTST; Castilho-Martins, EA. Methodology: Cunha, AA; Corona, RA; Alves, G.C. Validation: Cunha, AA; Corona, RA; Alves, GC; Nazima, MTST; Castilho-Martins, EA. Statistical analysis: Cunha, AA; Corona, RA; Alves, G.C. Formal analysis: Cunha, AA; Corona, RA; Alves, GC; Nazima, MTST; Castilho-Martins, EA. Research: Cunha, AA; Corona, RA; Alves, GC; Nazima, MTST; Castilho-Martins, EA. Resources: Wedge, AA; Nazima, MTST; Castilho-Martins, EA. Writing-original writing: Cunha, AA; Corona, RA; Alves, G.C. Writing-revision and editing: Nazima, MTST; Castilho-Martins, EA. Visualization: Wedge, AA; Corona, RA; Alves, GC; Nazima, MTST; Castilho-Martins, EA. Orientation: Castilho-Martins, EA. Project administration: Nazima, MTST; Castilho-Martins, EA.

All authors read and agreed with the published version of the manuscript.

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Submitted: 24 february 2022.
Accepted: 10 october 2022.
Published: 21 december 2022.