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ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Premature mortality due to non-communicable diseases in Brazilian municipalities estimated for the three-year periods of 2010 to 2012 and 2015 to 2017

Mortalidade prematura por doenças crônicas não transmissíveis nos municípios brasileiros, nos triênios de 2010 a 2012 e 2015 a 2017

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ABSTRACT: ***Objective:*** To estimate premature mortality due to noncommunicable diseases (NCDs) in Brazilian municipalities. ***Methods:*** This ecological study estimated premature mortality rates due to cardiovascular diseases, chronic respiratory diseases, cancer and diabetes in Brazilian municipalities, for the three-year periods of 2010 to 2012 and 2015 to 2017, and it analyzed the spatial and temporal distribution of these rates. Data treatment combined proportional redistribution of the missing data and ill-defined causes, and the application of coefficients for under-registration correction. The local empirical Bayesian estimator was used to calculate municipal mortality rates. ***Results:*** Rates for the set of chronic diseases decreased in Brazil between the three-year periods. The mean rates for total NCDs declined in the South, Southeast and Central-West regions, remained stable in the North and increased in the Northeast. Mortality rates due to cardiovascular diseases were the highest in all regions but showed the greatest declines between the periods. Cancers were the second leading cause of death. The North and Northeast regions stood out as having increased mean rates of cancer between the periods analyzed and showing the highest mean premature mortality rates due to diabetes in the 2015 to 2017 period. ***Conclusion:*** Spatial and temporal distribution of premature mortality rates due to NCDs differed between Brazilian municipalities and regions in the three-year periods evaluated. The South and Southeast had decreased rates of deaths due to cardiovascular and chronic respiratory diseases, as well as diabetes. The North and Northeast had increased rates of deaths due to cancer. There was an increase in the rate of deaths due to diabetes in the Central-West.

Keywords: Noncommunicable diseases. Mortality, premature. Mortality registries. Temporal distribution. Small-area analysis.

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RESUMO: ***Objetivo:*** Estimar a mortalidade prematura por doenças crônicas não transmissíveis nos municípios brasileiros. ***Métodos:*** Estudo ecológico com estimativa das taxas de mortalidade prematura por doenças cardiovasculares, respiratórias crônicas, neoplasias e diabetes nos municípios brasileiros, nos triênios de 2010 a 2012 e 2015 a 2017, e análise da distribuição espacial e temporal dessas taxas. Realizou-se redistribuição proporcional dos dados faltantes e das causas mal definidas, e aplicaram-se coeficientes para correção de sub-registro. As taxas municipais de mortalidade foram calculadas pelo estimador bayesiano empírico local. ***Resultados:*** No Brasil, houve redução das médias das taxas municipais para o conjunto das doenças crônicas entre os triênios. No Sul, Sudeste e Centro-Oeste, houve declínio das médias das taxas para o total das DCNT; e no Nordeste, viu-se acréscimo. As médias das taxas de mortalidade por doenças cardiovasculares foram as mais altas em todas as regiões, mas apresentaram os maiores declínios entre os períodos. As neoplasias representaram o segundo principal grupo de causas. Norte e Nordeste destacaram-se pelo aumento das taxas médias de neoplasias entre os períodos analisados, bem como pela concentração das taxas mais altas de mortalidade prematura por diabetes no triênio 2015 a 2017. ***Conclusão:*** Diferenças na distribuição espaçotemporal das taxas de mortalidade prematura por DCNT foram identificadas entre municípios e regiões brasileiras. Houve redução das taxas por doenças cardiovasculares, respiratórias crônicas e diabetes no Sul e no Sudeste; aumento das taxas por neoplasias no Norte e no Nordeste; e aumento por diabetes no Norte e no Centro-Oeste.

Palavras-chave: Doenças não transmissíveis. Mortalidade prematura. Registros de mortalidade. Distribuição temporal. Análise de pequenas áreas.

INTRODUCTION

Noncommunicable diseases (NCDs) represent an important challenge for countries on a global scale. The World Health Organization (WHO) states that, in 2016, this group of diseases was the cause of 41 million deaths, which corresponds to more than 70% of deaths worldwide[1,2]. NCDs generate important socioeconomic consequences by favoring the impoverishment of families and negatively impacting social and national economic development[3], contributing to the reduction of gross domestic product (GDP) in some countries[4].

About 80% of NCD deaths occur in low- and middle-income countries[5], and the poor are impacted differently[3]. While in high-income countries 13% of deaths from NCDs affect individuals aged between 30 and 69 years, in low and medium income this percentage increases to 30%[3]. In this sense, premature deaths from NCDs affect people with lower income, education and, in general, the most socially vulnerable, who are more exposed to risk factors, have less access to information, health services and treatments, which further accentuates social inequalities[3,6,7].

It is estimated that, without investments in prevention, treatment and actions to promote health and regulation, 15 million people will continue to die prematurely from NCDs each year worldwide[2]. Due to the global burden of NCDs and their respective

social, economic and health system impacts, WHO approved, in 2013, the Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020[8], and, in 2015, the United Nations (UN) established the target of a 30% reduction in the rate of premature mortality due to NCDs by the year 2030 within the scope of the Sustainable Development Goals (SDGs)[9].

In Brazil, NCDs represent the greatest health problem, corresponding in 2016 to 74% of the causes of death[2]. Data from the Global Burden of Disease (GBD) showed that, of the total number of deaths due to NCDs in the country, about one-third correspond to deaths of individuals aged 30 to 69 years[10]. In 2011, the Brazilian government launched the Strategic Action Plan for Coping with Noncommunicable Diseases in Brazil 2011-2022, which establishes actions and defines investments for their implementation, as well as targets to be achieved over a ten-year time horizon[11]. Among the national targets, there is a reduction of premature mortality due to NCDs by 2% per year. The monitoring of this target is an essential component for the surveillance of NCDs[11] and is made possible by access to data from the Mortality Information System (SIM).

In spite of being an important data source, failure to correctly fill in death certificates (DC) hampers the quality of SIM, resulting in data cleansing regarding inconsistencies, as well as the adoption of methods for treating missing data, treating excessive registration of ill-defined causes of death[12] and garbage codes (GCs), to minimize bias[13]. GCs refer to causes that cannot be considered underlying causes of death or causes for which there is no detail in the codification of the International Statistical Classification of Diseases and Health Related Problems (ICD-10)[13] and should be redistributed to other causes to improve the validity of mortality analyses[14]. In Brazil, there has been an improvement in the quality of mortality information in recent decades, advances related to the expansion of death coverage, more accurate notification of causes and a decrease in the proportion of GCs[13]; however, there are still problems with the quality of this information in the country, especially in the North and more so the Northeast[15].

In addition to the monitoring of premature NCD mortality on a national scale, it is necessary to monitor the temporal evolution of this event in smaller areas, such as states and municipalities. On the municipal scale, small numbers are observed, and fluctuations or high variability in mortality estimates are often found at this geographic level. Thus, it is necessary to use methods that minimize the effects of small numbers on the denominator and allow the estimation of mortality rates in locations with no occurrence of death in a given period of time[16]. Reliable estimates for small areas allow for better evaluation, planning and prioritization of public health actions, and in Brazil, as well as in other countries, there is knowledge of the existence of spatial-temporal variations in mortality rates that need further investigation[17].

In view of the above, this study aimed to estimate premature mortality from NCDs in Brazilian municipalities and to analyze the spatio-temporal distribution of these estimates, considering the three-year periods from 2010 to 2012 and 2015 to 2017.

METHODS

STUDY DESIGN AND DATA SOURCES

This is an ecological study in which data on the deaths of individuals of both sexes, aged between 30 and 69 years — premature mortality, as defined by the WHO[8] — were analyzed, referring to the three-year periods of 2010 to 2012 and 2015 to 2017, in Brazilian municipalities, for the following causes: cardiovascular diseases (I00-I99), chronic respiratory diseases (J30-J98), cancers (C00-C97) and diabetes mellitus (E10-E14).

The death data came from SIM of the Informatics Department of the Unified Health System (DATASUS), of the Ministry of Health. The population data were obtained from the municipal population projections carried out within the scope of the Brasil 3 Tempos Project, which used demographic methods based on population census data provided by the Brazilian Institute of Geography and Statistics (IBGE)[18].

TREATMENT OF MORTALITY DATA

The data provided by the SIM received treatment to minimize potential biases related to the local quality of the data[19], since the quality of the SIM is heterogeneous in the country[20]. The empirical Bayesian estimator technique was used to generate mortality rates, a specific methodological approach for estimates in small areas[21].

Proportional redistribution of data without information, missing and blank, was carried out each year, for the variables age, sex and municipality of residence[19]. It is noteworthy that the state of residence has always been filled in the DC.

As for underreporting, the state correction coefficients of the GBD 2017[22] were considered, according to age and sex, to correct the number of deaths not captured in each municipality. Thus, each municipality received the correction for the respective state (ratio between the total deaths estimated by the GBD and the total deaths observed in the SIM, in the states). This correction was applied only in the municipalities with a general mortality rate of less than five deaths per thousand inhabitants, to avoid overestimating the number of deaths in municipalities whose quality in reporting deaths was classified as good[23].

To optimize the proportional redistribution of ill-defined causes, a method for the redistribution of GCs was applied. The selection of this group of causes was based on the list proposed by the GBD 2017, which includes other causes in addition to the ICD-10 chapter of ill-defined causes.

More detailed information on the methods used to treat SIM data, the list of codes of defined causes of death investigated in this study and the list of GC can be accessed in another publication[24].

DATA ANALYSIS

Crude rates of premature mortality were calculated, defined as the relationship between the number of deaths and the number of people exposed to the occurrence of death on the basis of 100 thousand inhabitants[25]. The crude rates were standardized by the direct method, using the population of the 2010 demographic census as the standard population. To minimize the random fluctuations inherent in small areas, the local empirical Bayesian estimator (EBL) was used to calculate the empirical Bayesian rates for all municipalities in Brazil, according to the causes studied and the three-year periods.

The EBL represents a rate smoothing method that employs a correction that takes the information of the location and the information of geographic neighbors together as follows: calculating the weighted mean between the local rate and the neighborhood rate of that location[16]. It is influenced by the size of the population of the municipalities. Thus, the municipal Bayesian rate is close to the mean rate of the neighborhood when the population is small, and the closer it is to the gross rate the greater the population of the municipality[26]. In the present study, for each of the evaluated municipalities, the neighborhood structure of the eight closest municipalities was taken into account. In calculating the Bayesian rates, the expected number of deaths estimated by the standardized rates in the numerator and the total population of the three years studied in the denominator for each municipality were used.

The standardized mortality rates and those estimated by the EBL were compared using histograms. The mean Bayesian mortality rates for the studied causes were presented, according to regions and Brazil, in each three-year period, with their respective 95% confidence intervals (95%CI) and the percentage difference between the periods. To compare the difference between the three-year means, the *t*-test for paired samples was used and the level of statistical significance was set at 5%. Maps were created to visualize the geographic distribution of Bayesian rates of premature mortality in the municipalities in both three-year periods.

ETHICAL ASPECTS

This research was part of the project Inequalities in Small Geographic Areas of the Indicators of Noncommunicable Diseases, Violence and their Risk Factors, approved by the Ethics Committee for Research Involving Humans at the Federal University of Minas Gerais.

RESULTS

Figure 1 shows the frequency distribution of the municipal rates of premature mortality due to NCDs (the set of the four main groups) standardized and estimated by the EBL. It is observed that the rates estimated by the local empirical Bayesian method were smaller,

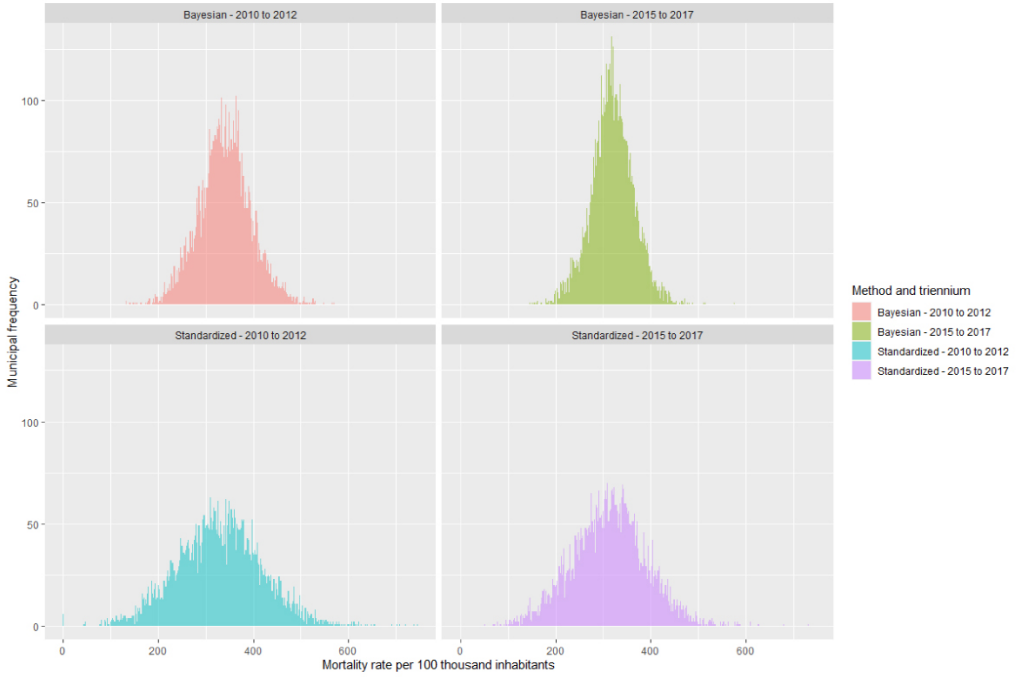


Figure 1. Histogram of municipal rates of premature mortality (30 to 69 years) due to noncommunicable diseases, according to standardized rates and rates estimated by the local empirical Bayesian method. Brazil, three-year periods 2010 to 2012 and 2015 to 2017.

being even smaller in the second three-year period, indicating less variability of the mortality estimates with this method.

Table 1 shows the mean Bayesian municipal rates of premature mortality due to NCDs for the country and macro-regions, in both three-year periods. Considering Brazil as a whole, the mean rate for the set of NCDs in the three-year period from 2010 to 2012 was 328.9 per 100 thousand inhabitants (95%CI 327.3 – 330.4), and in 2015 to 2017, it decreased to 314.1 per 100 thousand inhabitants (95%CI 312.8 – 315.4). The Southeast region showed a mean rate for the set of NCDs higher than the mean for Brazil in both three-year periods (353.8; 95%CI 351.5 – 356.2 and 327.5; 95%CI 325.5 – 329.5), as well as the South region (346.8; 95%CI 343.4 – 350.3 and 316.4; 95%CI 313.5 – 319.3). The South and Southeast showed the greatest declines in these rates between the periods studied, respectively -8.8% ($p = 0.00$) and -7.4% ($p = 0.00$). The mean premature mortality rates for the set of NCDs in the first three-year period were the lowest in the North (277.2; 95%CI 271.8 – 282.7) and in the Northeast (307.7; 95%CI 305.1 – 310, 3). There was a slight increase in these rates in the Northeast between the periods studied (1.1%; $p = 0.00$).

Analyzing each of the four main group of NCDs for Brazil, cardiovascular diseases accounted for the highest mean rates in both periods, followed by rates for cancer, diabetes

Table 1. Mean Bayesian municipal rates of premature mortality (30 to 69 years) due to noncommunicable diseases for Brazil and macro-regions, according to three-year periods, percentage variation and p-value of the hypothesis test. Brazilian municipalities, 2010 to 2012 and 2015 to 2017.

Place and disease	2010 to 2012		2015 to 2017		Difference between 3-year periods (%)	p***
	Mean**	(95%CI)	Mean	(95%CI)		
Brazil						
Total NCDs*	328.9	327.3 – 330.4	314.1	312.8 – 315.4	-4.5	0.00
Cardiovascular	158.5	157.6 – 159.4	143.4	142.6 – 144.3	-9.5	0.00
Chronic respiratory	20.6	20.4 – 20.8	19.4	19.2 – 19.6	-5.8	0.00
Diabetes	28.1	27.8 – 28.4	27.0	26.7 – 27.3	-3.9	0.00
Cancer	123.6	122.8 – 124.4	125.2	124.5 – 125.8	1.3	0.00
Central-West						0.00
Total NCDs*	324.8	320.7 – 328.9	305.7	302.1 – 309.4	-5.9	0.00
Cardiovascular	167.4	165 – 169.8	146.5	144.4 – 148.5	-12.5	0.00
Chronic respiratory	23.2	22.6 – 23.8	22.4	22 – 22.9	-3.4	0.01
Diabetes	24.9	24.3 – 25.5	26.1	25.4 – 26.7	4.8	0.00
Cancer	111.5	109.7 – 113.2	111.5	109.8 – 113.3	0	0.96
Northeast						
Total NCDs*	307.7	305.1 – 310.3	311.2	308.9 – 313.5	1.1	0.00
Cardiovascular	159.3	157.7 – 161	154.1	152.7 – 155.5	-3.3	0.00
Chronic respiratory	15.5	15.2 – 15.8	15.7	15.4 – 16	1.3	0.16
Diabetes	34.7	34.1 – 35.3	34.4	33.9 – 35	-0.9	0.27
Cancer	100.1	99.2 – 101	108.3	107.4 – 109.1	8.2	0.00
North						
Total NCDs*	277.2	271.8 – 282.7	278.4	273.7 – 283.2	0.4	0.54
Cardiovascular	142.8	139.6 – 146	135.3	132.7 – 137.9	-5.3	0.00
Chronic respiratory	16.3	15.7 – 16.9	15.6	15.0 – 16.1	-4.3	0.01
Diabetes	29.5	28.5 – 30.4	30.6	29.7 – 31.6	3.7	0.02
Cancer	95.7	93.7 – 97.8	100.6	98.5 – 102.7	5.1	0.00

Continue...

Table 1. Continuation.

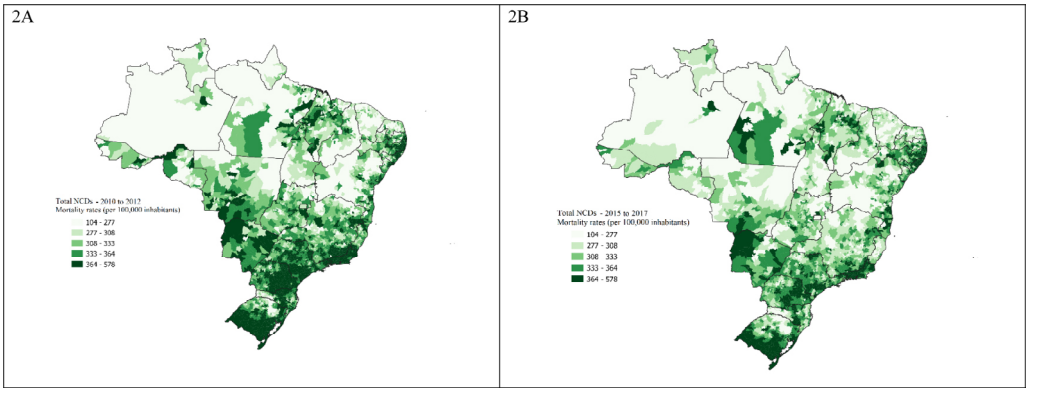
Place and disease	2010 to 2012		2015 to 2017		Difference between 3-year periods (%)	p***
	Mean**	(95%CI)	Mean	(95%CI)		
Southeast						
Total NCDs*	353.8	351.5 – 356.2	327.5	325.5 – 329.5	-7.4	0.00
Cardiovascular	170	168.6 – 171.5	147.7	146.4 – 149	-13.1	0.00
Chronic respiratory	21.1	20.8 – 21.4	19.7	19.5 – 20	-6.6	0.00
Diabetes	26	25.6 – 26.4	23	22.6 – 23.4	-11.5	0.00
Cancer	137.5	136.6 – 138.4	137.3	136.5 – 138.2	-0.1	0.68
South						
Total NCDs*	346.8	343.4 – 350.3	316.4	313.5 – 319.3	-8.8	0.00
Cardiovascular	143.5	141.3 – 145.7	123.3	121.5 – 125	-14.1	0.00
Chronic respiratory	28.1	27.6 – 28.6	24.6	24.2 – 25.1	-12.5	0.00
Diabetes	21.6	21.1 – 22.1	20.4	20.0 – 20.9	-5.6	0.00
Cancer	154.6	153.3 – 156	148.2	147.1 – 149.3	-4.1	0.00

*Set of the four main groups of NCDs (cardiovascular, chronic respiratory, diabetes and cancer); **per 100,000 inhabitants; ***p value of *t* test for comparison of means of paired samples.

and chronic respiratory diseases, in that order. The same pattern was observed for the macro-regions, with the exception of the South region, where the highest means were attributed to cancer, followed by cardiovascular diseases, chronic respiratory diseases and diabetes, in decreasing order (Table 1).

Still in the analysis of each group of NCDs, regarding the variation of the mean rates between 2010 to 2012 and 2015 to 2017, it is noteworthy that in Brazil there was a decline due to cardiovascular diseases (-9.5%; p = 0.00), chronic respiratory diseases (-5.8%; p = 0.00) and diabetes (-3.9%; p = 0.00) and an increase due to cancer (1.3%; p = 0.00). In all macro-regions, there was a significant decline in mortality from cardiovascular diseases. In the Central-West, North, Southeast and South regions there was also a statistically significant reduction in mean rates for chronic respiratory diseases. In the Southeast and South regions, there was a decline in the mean rates of diabetes (-11.5%; p = 0.00) and -5.6%; p = 0.00), and in the Central-West and North regions, there was an increase (4.8%; p = 0.00 and 3.7%; p = 0.02). There was a decline in cancer rates from one three-year period to the next in the South (-4.1%; p = 0.00) and an increase in the Northeast and North (8.2%; p = 0.00 and 5.1%; p = 0.00). In the South, there was a statistically significant temporal reduction in rates for all four groups of NCDs (Table 1).

Figures 2 and 3 make it possible to visualize the geographic distribution of Bayesian rates for the set of NCDs and for each group alone, by Brazilian municipalities, according to each three-year period.



DCNT: doenças crônicas não transmissíveis.

Figure 2. Geographic distribution of Bayesian rates of premature mortality (30 to 69 years) caused by the set of four main groups of noncommunicable diseases, according to three-year periods, by municipality. Brazilian municipalities: (A) 2010 to 2012 and (B) 2015 to 2017.

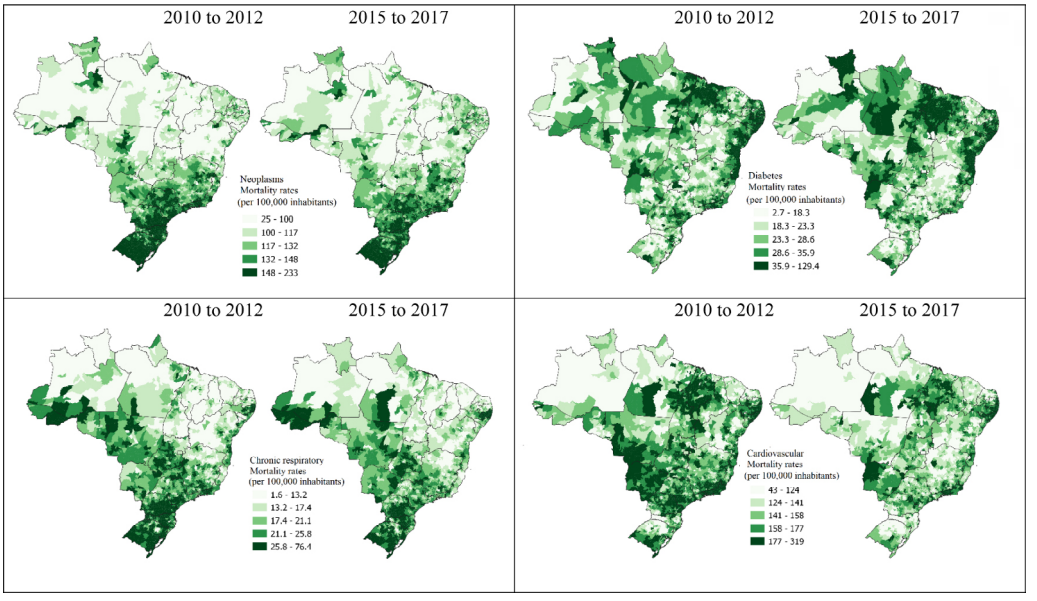


Figure 3. Geographic distribution of Bayesian rates of premature mortality (30 to 69 years) due to cancer, diabetes, chronic respiratory diseases and cardiovascular diseases, according to three-year periods. Brazilian municipalities, 2010 to 2012 and 2015 to 2017.

DISCUSSION

This study revealed differences in the spatiotemporal distribution of premature mortality rates due to NCDs between Brazilian municipalities and regions in the three-year periods evaluated. There was a reduction in the rates for cardiovascular diseases in all regions; for chronic respiratory diseases in the Central-West, North, Southeast and South, for diabetes in the Southeast and South, and for cancer in the South. There was an increase in rates for diabetes in the Central-West and North, and for cancer in the Northeast and North.

Studies that investigated the evolution of mortality rates due to noncommunicable diseases in Brazil based on the time series analysis method also identified a reduction in rates over the years[10,27,28]. Another publication, although it did not specifically assess premature mortality, revealed that, between 1996 and 2007, mortality attributable to NCDs decreased by 20% in the country, mainly due to the decline in rates for cardiovascular diseases and chronic respiratory diseases, and indicated stability in diabetes mortality rates over the period[27]. These authors pointed out that the greatest declines occurred in the South and Southeast, and that the North and Northeast regions, in addition to being responsible for the highest mortality rates due to NCDs in 2007, presented the greatest increases in mortality from diabetes. In turn, a study that analyzed the rates of premature mortality between 2000 and 2011 highlighted that no Brazilian state had a favorable scenario for meeting the goal of the national plan to reduce premature mortality due to cancer and diabetes[29].

Less developed countries and more socially and economically vulnerable populations are more affected by the burden of the morbidity and mortality of NCDs and their risk factors[3,6,7,30,31]. Contrary to this reasoning, considering both three-year periods, the most developed Brazilian regions, South and Southeast, had the highest mortality rates for the set of NCDs. On the other hand, considering the specific causes, observing the 2015-2017 three-year period, the present study identified a higher rate of premature mortality from cardiovascular diseases and diabetes in the Northeast, one of the least developed Brazilian regions.

Regarding this paradox, there are national studies that have found an inverse relationship between socioeconomic indicators and morbidity and mortality due to cardiovascular diseases, and others that have identified higher mortality rates for this group of causes in macro-regions with a higher development pattern[32]. These differences would be explained by the heterogeneity of the quality of information on mortality between Brazilian states and macro-regions[32]. It should be noted that SIM coverage and the quality of information on causes of death have progressed over the last decades in Brazil[33] as a result of the implementation of coordinated government interventions between the levels of municipal, state and federal government[19], which will contribute to the greater reliability of estimates in the future.

Other factors may help explain the aforementioned paradox. The epidemiological transition observed in Brazil does not exhibit the same patterns experienced by most industrialized countries, characterized by contrasting epidemiological situations between regions, as well as the coexistence of communicable and noncommunicable diseases[34,35]. Noncommunicable diseases account for the highest burden of disease in the most developed Brazilian regions

(South and Southeast), but these regions experience better conditions of access to health services, resulting in the temporal impact of the highest percentages of declining mortality from NCDs.

National research has shown, as well as the present study, that the greatest temporal reduction has occurred in the rates of premature mortality due to cardiovascular diseases[10]. Authors suggest that the decline in mortality rates for this group of causes observed in Brazil is a result of smoking control measures and the expansion of access to primary care[27], however studies have been pointing to a deceleration in the trajectory of reduction in mortality rates due to NCDs in Brazil[31,36] and even an increase after 2015[10]. The increase in the prevalence of risk factors such as hypertension and overweight, associated with the decrease in eating healthy foods and physical activity[27], the fiscal austerity measures established in recent years in Brazil[37] and, currently, the health crisis imposed by the COVID-19 pandemic represent challenges to the progression of the trend of reducing mortality due to NCDs.

Chronic respiratory diseases are among the leading causes of death globally, with asthma and chronic obstructive pulmonary disease the most contributing to the burden of morbidity and mortality in this group of diseases[38], representing 8% of the total premature deaths due to NCDs[39]. Authors have identified an important decline in mortality rates from chronic respiratory diseases in Brazil, second only to cardiovascular diseases[10,40]. It is suggested that the factors associated with this reduction are related to the smoking control measures implemented in the country and to the improvement in access to health services, especially primary care[27,40]. In the present study, the Central-West had the second highest rate of premature mortality from chronic respiratory diseases in the three-year period from 2015 to 2017, and there was a reduction between the periods, as well as in the South, Southeast and North. Conversely, it is important to mention a publication that found a steady trend in mortality from chronic respiratory diseases in the period from 2000 to 2011 in the states of Mato Grosso and Acre, which suggested a relationship with worse air quality due to the practice of burning[29].

In this article, the Northeast and North regions had the highest mean rates of premature mortality from diabetes in the most recent three-year period analyzed, corroborating findings from previous studies[41,42]. Other authors found that the Northeast and North regions had the greatest increases in mortality from diabetes[27]. In the present study, this increase was found in the Central-West and in the North. Brazil has a high burden of diabetes and obesity, considered its main biological risk factor, and states with the worst social indicators are especially affected[43]. In addition, the prevalence of risk factors and the quality of health care aimed at individuals with diabetes can also explain the differences in mortality from diabetes observed between Brazilian regions[41].

Cancer is the second leading cause of death in the world, accounting for 8.9 million deaths in 2016[44]. In Brazil, they were responsible for 17.4% of the total estimated deaths in 2015[45]. GBD data showed a lower percentage of decline in premature mortality rates due to cancer between the years 1990 and 2017 in Brazil than that observed for the other groups of NCDs[10]. This same study also pointed out an increase in premature mortality rates due to cancer for states in the Northeast and North, in agreement with the results found here.

It must be taken into account that the type of cancer, the gender and age of individuals[10], as well as socioeconomic inequalities, the organization of health systems[46] and access to services, are important factors in the variability of cancer morbidity and mortality estimates in Brazil and can explain this scenario of falling mortality in more developed regions and an increase in less developed regions[45].

There were some limitations in this study. The difficulty in analyzing small numbers of deaths on the municipal scale is a challenge and should be further explored in research. To minimize this limitation, the aggregation of data in triennials was adopted and the Bayesian estimator was used to calculate the rates. We sought to improve the quality of this mortality information by redistributing missing data and GCs and correcting underreporting. The application of the GBD 2017 state correction coefficients to correct underreporting of deaths on a municipal scale may underestimate or overestimate the number of deaths, even though such coefficients were applied only in municipalities with a general mortality rate below 5. Considering that the rates calculated were for the municipality and taking into account the combination of methods used, the estimates presented here may differ from others calculated for large areas, such as Brazil and regions.

This study consisted of a technical-scientific effort to estimate rates of premature mortality due to NCDs in small areas, with the application of a methodology to improve the quality of SIM data, and to analyze them in a spatiotemporal perspective. The treatment of GCs represents a methodological innovation, although it is highlighted that the redistribution applied here, suggested by Teixeira et al.[24], should also be validated in the future.

New methodological proposals should be encouraged so that estimates closer to local realities are produced and can support the monitoring of national and global targets for reducing premature mortality due to NCDs and the surveillance of these diseases.

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