

## COVID-19 and social vulnerability in the state of Sergipe, Brazil: an ecological study

COVID-19 e vulnerabilidade social no estado de Sergipe, Brasil: um estudo ecológico

COVID-19 y la vulnerabilidad social en el estado de Sergipe, Brasil: un estudio ecológico

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### Abstract

COVID-19 was characterized by the WHO as a pandemic on March 11, 2020. In Sergipe, northeastern Brazil, the first case was diagnosed on March 14, 2020. This study is part of analyzes on the first year of the pandemic of COVID-19 in Sergipe and aims to analyze, through an ecological study, deaths from the disease in its 75 municipalities, statistically correlating the crude and age-standardized mortality rates with indicators of social vulnerability and human development used in the country; and with the demographic density of the municipalities in the state. Mortality data were obtained by dividing the absolute number of deaths by the number of inhabitants in each municipality. Direct standardization of mortality rates and Spearman correlation ( $\rho$ ) were performed to test the described correlation. The study demonstrated a different correlation from that found in the literature between the Municipal Human Development Index and deaths by COVID-19: the greater the development, the more deaths by COVID-19 were identified. The effects of these indicators may be being offset by factors such as the greater demographic density of the cities with greater development, which could favor the transmission of the disease.

**Keywords:** COVID-19; Health Status Disparities; Social Vulnerability; Human Development.

### Resumo

A COVID-19 foi caracterizada pela OMS como pandemia em 11 de março de 2020. Em Sergipe, estado do nordeste do Brasil, o primeiro caso foi diagnosticado em 14 de março de 2020. Este estudo faz parte de análises sobre o primeiro ano da pandemia de COVID-19 em Sergipe e tem por objetivo analisar, através de estudo ecológico, os óbitos pela doença em seus 75 municípios, correlacionando estatisticamente as taxas de mortalidade brutas e padronizadas por idade com indicadores de vulnerabilidade social e desenvolvimento humano utilizados no país; e com a densidade demográfica dos municípios do estado. Os dados de mortalidade foram obtidos dividindo o número absoluto de óbitos pela quantidade de habitantes de cada município. Realizou-se a padronização direta das taxas de mortalidade e a correlação de Spearman ( $\rho$ ), para testar a correlação descrita. O estudo demonstrou uma correlação diferente do encontrado na literatura entre o Índices de Desenvolvimento Humano Municipal com os óbitos pela COVID-19: quanto maior o desenvolvimento, mais óbitos por COVID-19 foram identificados. Os efeitos destes indicadores podem estar sendo compensados por fatores como a maior densidade demográfica dos municípios com maior desenvolvimento, o que poderia favorecer a transmissão da doença.

**Palavras-chave:** COVID-19; Iniquidade em Saúde; Vulnerabilidade Social; Desenvolvimento Humano.

## Resumen

COVID-19 fue caracterizado por la OMS como una pandemia el 11 de marzo de 2020. En Sergipe, noreste de Brasil, el primer caso fue diagnosticado el 14 de marzo de 2020. Este estudio es parte de los análisis del primer año de la pandemia de COVID-19 en Sergipe y tiene como objetivo analizar, a través de un estudio ecológico, las muertes por la enfermedad en sus 75 municipios, correlacionando estadísticamente las tasas de mortalidad brutas y estandarizadas por edad con los indicadores de vulnerabilidad social y desarrollo humano utilizados en el país; y con la densidad demográfica de los municipios del estado. Los datos de mortalidad se obtuvieron dividiendo el número absoluto de defunciones por el número de habitantes de cada municipio. Se realizó la estandarización directa de las tasas de mortalidad y la correlación de Spearman ( $\rho$ ) para probar la correlación descrita. El estudio demostró una correlación diferente a la encontrada en la literatura entre el Índice de Desarrollo Humano Municipal y las muertes por COVID-19: a mayor desarrollo, más muertes por COVID-19 se identificaron. Los efectos de estos indicadores pueden estar siendo compensados por factores como la mayor densidad demográfica de las ciudades con mayor desarrollo, lo que podría favorecer la transmisión de la enfermedad.

**Palabras clave:** COVID-19; Disparidades em el Estado de Salud; Vulnerabilidad Social; Desarrollo Humano.

## 1. Introduction

At the end of the year 2019, a new coronavirus was identified as the cause of a number of cases of pneumonia in Wuhan, China, causing the emission of a warning by the World Health Organization (WHO). The virus spread rapidly around the world being designated as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), and the disease it causes, named coronavirus disease 2019 (COVID-19) (Cohen & Blau, 2021).

COVID-19 was characterized by the WHO as a pandemic on March 11, 2020. One year later, 118,119,333 cases of COVID-19 and 2,621,986 deaths in consequence had already been confirmed worldwide (Johns Hopkins University, 2021).

Following the progress of the disease, it was the first diagnosed case of COVID-19 in South America in Brazil, recorded on February 26, 2020, in the city of São Paulo (Cavalcante & Abreu, 2020). In Sergipe, a state located in northeastern Brazil, the first case was diagnosed on March 14, 2020 (Secretaria de Estado da Saúde de Sergipe, 2020).

According to the Epidemiological Report published on March 14, 2021 (Secretaria de Estado da Saúde de Sergipe, 2021), the panorama of the disease in Sergipe had 158,800 cases of the disease and 3,123 deaths as a result.

Social vulnerabilities impact the health of people and communities (Do Carmo & Guizardi, 2018; Kim & Bostwick, 2020). Studies conducted in Brazil and other countries have shown that the same occurs in relation to the COVID-19 pandemic, with higher incidence and mortality in the most vulnerable areas (Butler, 2020; Hallal et al., 2020; Hawkins et al., 2020).

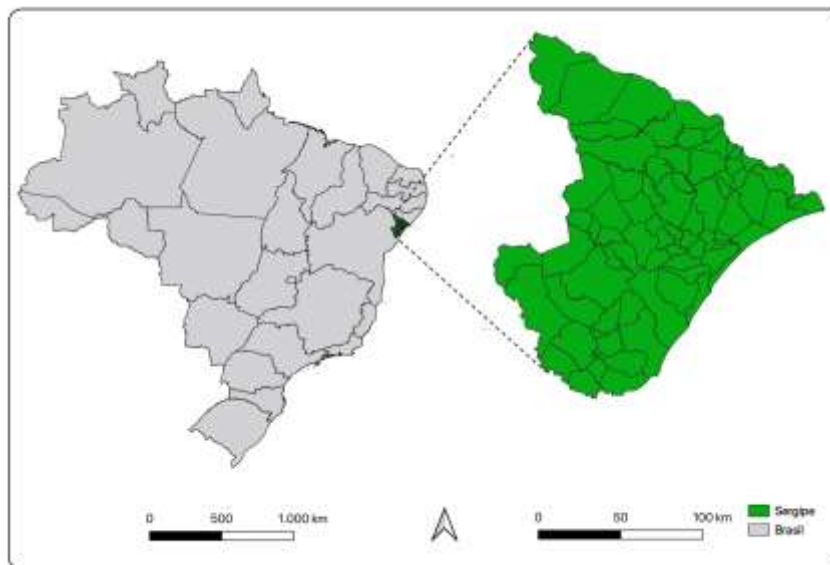
According to Andrade et al (Andrade et al., 2017) in a study analyzing the Atlas of Social Vulnerability of Brazilian Municipalities (Instituto de Pesquisa Economica Aplicada – IPEA, 2015), most municipalities in Sergipe have high social vulnerability.

This study is part of a series of analyzes on the first year of the COVID-19 pandemic in the state of Sergipe and aims to analyze deaths from the disease in its 75 municipalities, correlating age-standardized mortality rates with indicators of social vulnerability and human development used in the country, and with the demographic density of the state's municipalities.

## 2. Methodology

Ecological study of cases and deaths by COVID-19 that occurred in the State of Sergipe, located in the Northeast of Brazil (Figure 1), considering the unit of analysis of its municipalities, from March 2020 to March 2021.

**Figure 1.** Location of Sergipe in Brazil.



Source: Authors.

The population and territorial area data of the municipalities of the state were obtained on the website of the Brazilian Institute of Geography and Statistics (<https://cidades.ibge.gov.br/brasil/se/panorama>).

Information on COVID-19 events by city of Sergipe was taken from the Epidemiological Bulletins for Update on COVID-19, made available daily by the Sergipe State Department of Health on the website <https://todoscontrocorona.net.br/boletinscovid> tabulated with the aid of the Microsoft Excel 2019 program (version 2110, Microsoft Corporation, Redmond, Washington, United States). The date of notification was used to define the temporality of the event.

Mortality rates were standardized by age and considered the deaths registered for five age groups: 0-19, 20-39, 40-59, 60 years or more. Direct standardization by age used as reference the projection of the population of each city in 2020 and the standardization of age rates for the world population proposed by the World Health Organization (Ahmad et al., 2001)

The indicators used to correlate with age-standardized mortality rates were the Social Vulnerability Index and the Municipal Human Development Index, built by the Institute of Applied Economic Research.

The Social Vulnerability Index (SVI) is a synthetic index composed of 16 indicators structured in three dimensions: urban infrastructure, human capital and income and work. It allows a mapping of social exclusion and vulnerability for Brazilian municipalities. The SVI is an index that varies between 0 and 1. The closer to 1, the greater the social vulnerability of a municipality (IPEA, 2015).

Municipalities are classified according to the SVI as having very low vulnerability (SVI between 0 and 0.200), low vulnerability (between 0.201 and 0.300), medium vulnerability (between 0.301 and 0.400), high vulnerability (between 0.401 and 0.500) and very high vulnerability (between 0.501 and 1).

The Municipal Human Development Index (MHDI) is an index inspired by the Global Human Development Index (HDI) developed by the United Nations Development Program. It uses the same dimensions of the HDI in its construction - health, education and income - however, the HDI adapts the global methodology to the Brazilian context and to the availability of national indicators making it more appropriate to the reality of Brazilian municipalities. The MHDI is an index that varies between 0 and 1 and the closer to 1, the greater the human development of a municipality (Programa das Nações Unidas para o

Desenvolvimento, 2013). As for the MHDI, municipalities are classified as very low (0.000 to 0.499), low (0.500 to 0.599), medium (0.600 to 0.699), high (0.700 to 0.799) and very high human development (above 0.800).

Spearman's correlation ( $\rho$ ) was calculated with the BioEstat Software (version 5.3, Mamirauá Sustainable Development Institute, Belém, Pará, Brazil), to test the correlation of the vulnerability and development indices described, in addition to the demographic density of the municipalities, with the standardized mortality rate by COVID-19 in the state. Correlations with statistical significance were those with  $P \leq 0.05$  and a moderate ( $0.4 \leq r \leq 0.7$ ) or strong ( $0.7 < r < 1.0$ ).

The study was approved by the Research Ethics Committee of the Federal University of Sergipe in its Report No. 4,404,280 of November 17, 2020.

### 3. Results

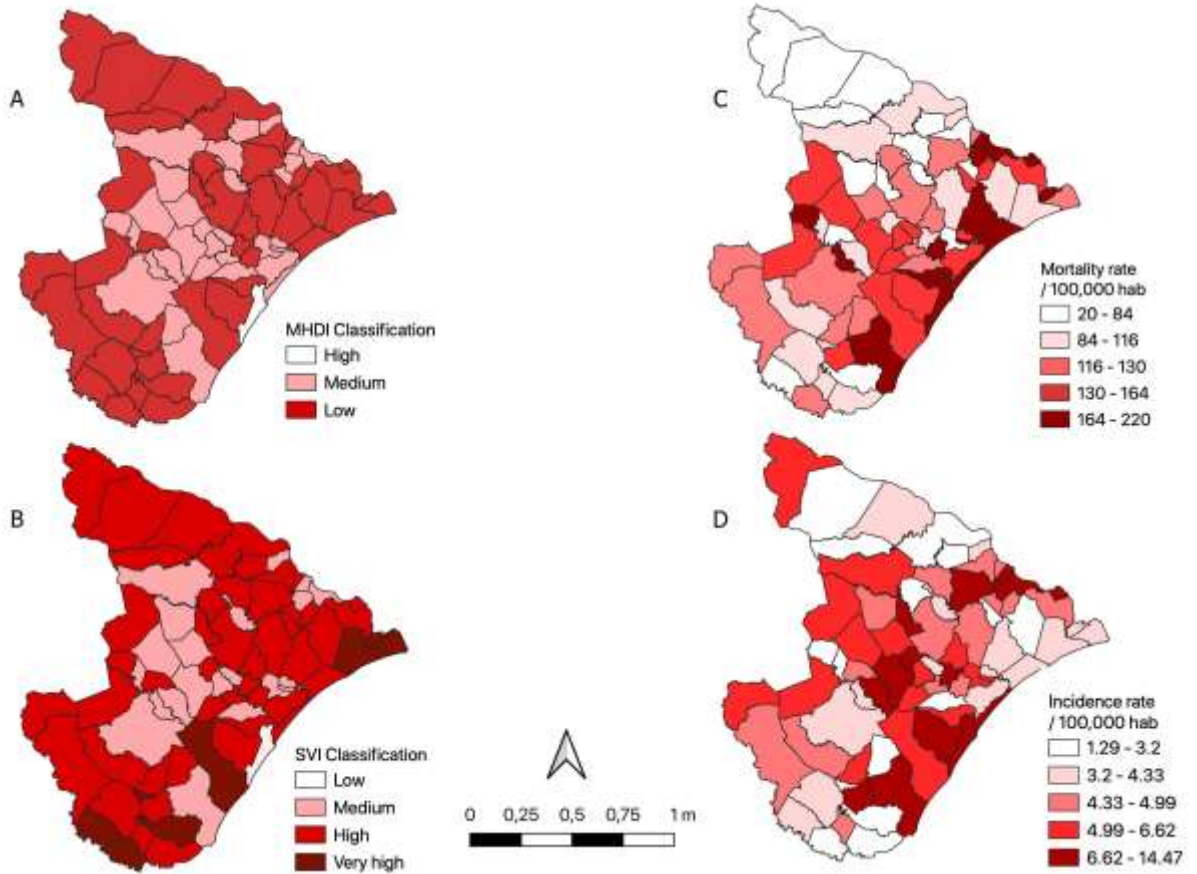
In the period from March 14, 2020 to March 31, 2021, Sergipe recorded 174,600 cases of COVID-19 and 3633 deaths as a result of the disease. Mortality in the state was 156.65 deaths / 100,000 inhabitants and a lethality rate - susceptible to possible underreporting of cases, either due to the moment of low diagnostic capacity or the number of undiagnosed asymptomatic cases - of 2.08% (Figure 2).

Most municipalities in Sergipe have high social vulnerability (60%) and low human development (57.3%) (Figure 2). Only the state capital, the city of Aracaju, has low social vulnerability (SVI - 0.287) and a high human development index (IDHM - 0.77).

Aracaju concentrates 20.66% of the population of Sergipe and in the city, we found the highest crude and age-standardized mortality rates when compared to the rates of municipalities with lower SVI and MHDI grouped in their respective classifications (Table 1).

Municipalities classified as Very High social vulnerability had the lowest crude and age-standardized mortality rates, as did municipalities with a Low Municipal Human Development Index (Table 1).

**Figure 2.** Spatial Distribution of Sergipe Municipalities. A) Classified by the Social Vulnerability Index; B) Classified by the Human Development Index; C) Crude Incidence Rate of coronavirus disease 2019 (COVID-19); D) Crude Mortality Rate per COVID-19.



Source: Authors.

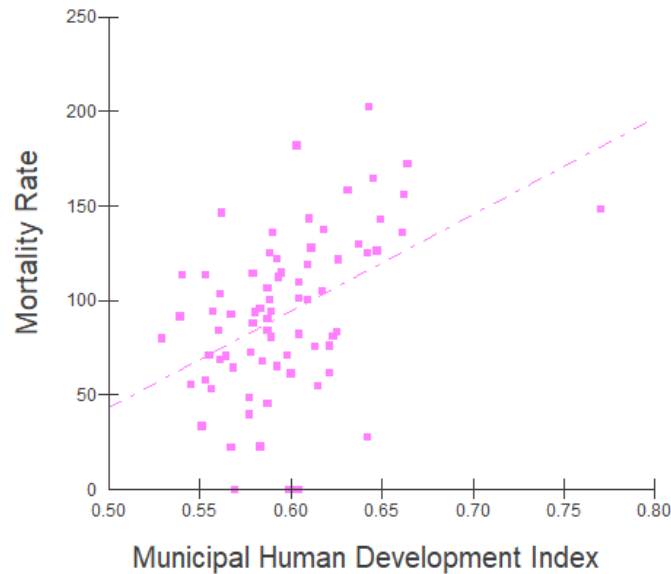
**Table 1.** Accumulated number of deaths, resident population, crude and age-standardized mortality rates per coronavirus disease 2019 (COVID-19) in the municipalities of Sergipe, classified by Social Vulnerability Index and Municipal Human Development Index.

Classification SVI/MHDI	N° of Cities	SVI	MHDI	Population	Deaths	Crude mortality rate/100000	Age-Standardized mortality rate/100000	Variation %
SVI - Low	1	0.287	-	664908	1402	210.86	199.92*	-5.19
SVI - Medium	21	0.374 (0.333 – 0.395)	-	515345	730	141.65	143.59	1.37
SVI - High	45	0.455 (0.403 – 0.498)	-	325356	1358	133.52	142.67	6.85
SVI – Very High	8	0.543 (0.506 – 0.605)	-	121473	141	116.08	131.99	13.70
MHDI - High	1	-	0.77	664908	1402	210.86	199.92*	-5.19
MHDI - Medium	31	-	0.625 (0.600 – 0.664)	986117	1493	151,40	159.13	5.11
MHDI - Low	43	-	0.573 (0.529 – 0.599)	325356	736	110.21	117.21	6.35
Sergipe	75	0.439 (0.287 – 0.605)	0.597 (0.529 – 0.77)	2318822	3633**	156.67	160.32*	2.33

Source: Authors.

When the correlations between age-standardized mortality rates and the municipalities' SVI and MHDI were performed, the relationship with the SVI was not statistically significant ( $P = 0.576$ ). However, when analyzing the relationship with the MHDI, there was a moderate positive correlation ( $\rho = 0.4395$ ;  $P < 0.0001$ ) (Figure 3).

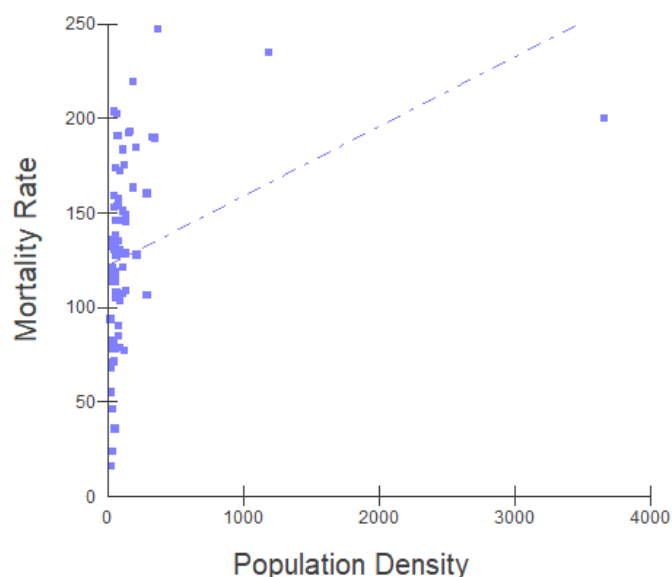
**Figure 3.** Relationship between the age-standardized Mortality Rate per COVID-19 and the Municipal Human Development Index in the cities of the state of Sergipe.



Source: Authors.

The correlation between demographic density and age-standardized mortality rates by COVID-19 was also analyzed. Sergipe is the smallest state in the Brazilian federation, and its capital, Aracaju, has a population density well above the state average: while Aracaju has a population density of 3,659.07 inhabitants/Km<sup>2</sup>, Sergipe has 105.70 inhabitants/Km<sup>2</sup>. There was a moderate positive correlation ( $\rho = 0.592$ ;  $P < 0.0001$ ) between the age-standardized mortality rate by COVID-19 and the demographic density of the municipalities of Sergipe. (Figure 4).

**Figure 4.** Relationship between age-standardized mortality rates by COVID-19 and demographic density of cities in the state of Sergipe.



Correlation coefficient = 0.5920; P-value < 0.0001. Source: Authors.

#### 4. Discussion

COVID-19 is not a socially neutral disease, it does not affect everyone equally (Bambra et al., 2020). As in other pandemics in our history, socioeconomic inequalities, ethnic issues, poor infrastructure or difficult access to health cause a change in the epidemiological profile when comparing populations. That is, some populations are more vulnerable.

This study demonstrates a different correlation between social vulnerability and human development indices with mortality rates -gross and standardized by age- by COVID-19: the higher the vulnerability measured by the SVI, the lower the mortality rate by COVID-19 and the higher the MHD, the higher this rate.

The results of this study are different from those found in national and international analyses.

According to Kim and Bostwick (2020), social vulnerability helps to understand the inequality in the results of health crises such as COVID-19, by linking social conditions to exposure to risk. They demonstrated that deaths by COVID-19 were clustered on the south and west sides of Chicago – United States, where predominantly poor and highly segregated African American communities are located.

According to Greenaway et al (2021), with the COVID-19 pandemic, vulnerable and marginalized populations, with low income and low socioeconomic status, in addition to being the most affected, had their health disparities widened, fueled by socioeconomic determinants of health and historical structural inequities.

Among its examples, a study from the United Kingdom (Platt & Warwick, 2020) that showed that minority groups, even being younger – which should make them less susceptible to severe forms of COVID-19 – were more likely to die than the white majority.

Studies in Brazil have also established a relationship between vulnerability and mortality rates. In Rio de Janeiro, the excess risk of the mortality rate was verified in the city's zones that concentrate people of medium and low income and areas of socially vulnerable populations (Cavalcante & Abreu, 2020).



In the city of Belo Horizonte (Passos et al., 2021) and in the state of Ceará (Maciel et al., 2020), higher mortality rates due to COVID-19 were also demonstrated in regions with the worst social vulnerability indices.

The indicators used in this study seek to overcome the reductionism of the concept of vulnerability – invariably focused on the absence or precariousness of access to income – by inserting in their construction dimensions related to urban infrastructure, human capital and income and labor (SVI); and health, education, income, and other socioeconomic indicators (MHDI).

SVI and MHDI are complementary and highly correlated. Together, they expand the possibilities regarding the living conditions of a population in a certain territory. While the SVI points to the absence of resources for the minimum welfare of a population, the MHDI points to the availability of these resources (Rotili et al., 2020).

Despite the improvement in the SVI and MHDI indices in recent decades, Brazil still presents great social inequality and millions of Brazilians do not have the minimum conditions for subsistence. Clusters in poor housing conditions and without basic sanitation, it is difficult for this population to follow the guidelines for combating the pandemic, such as social isolation and hand hygiene (Martins-Filho et al., 2021). This scenario is aggravated by low income, difficulty in accessing education and the health system itself.

A recent published study (Castro et al., 2021) pointed out very high attack rates and a disproportionately greater burden among the most vulnerable in Brazil. However, the lack of a coordinated, effective and equitable response on the part of the country's Federal Government - even though it has a free and universal health care system - probably fueled the widespread spatial spread of COVID-19.

Weak employment relationships and the Brazilian economic crisis aggravated by the pandemic, associated with the failure of public managers to carry out recommended measures to reduce the spread of COVID-19 are part of the scenario found in this study. In cities with greater economic activity (with greater MHDI), probably more people continued to work, facilitating the circulation of the virus (Maciel et al., 2020).

Another factor is the existing inequalities within the territory of each municipality, which could be demonstrated with sections by neighborhoods or census sectors in this territory, to be carried out in the next stages of this study. As well as the assessment of access to hospital beds, health care and diagnostic tests and its spatial relationship with vulnerability, raising the hypothesis of difficult access, increasing underreporting.

The effects of these indicators may also be being offset by the higher demographic density of municipalities with higher MHDI and lower vulnerability, which could favor the transmission of the disease.

In the last census conducted by the Brazilian Institute of Geography and Statistics (2010), Sergipe had 26.48% of its population in a rural area. It is possible that the indicators used have limitations in addressing the complexity of the rural-urban relationship (Marguti et al., 2016).

The study presents the limitations and the possibility of biases inherent to the methodology used and is subject to the ecological fallacy. The use of published official data brings the possibility of underreporting.

The mortality rates used in this study are less subject to underreporting, but not totally immune. The lack of standardization of death records can be a factor that contributes to underreporting.

## 5. Conclusion

The results of this study, by demonstrating a positive correlation between MHDI and mortality from COVID-19, contribute to the analysis of the greatest challenge for national health systems.

And reinforce the importance of studies that address the complexity of social vulnerability and its relationship with health using different methodologies, aiming at a better understanding of this scenario. And that these studies guide the construction of intersectoral public policies.

The necessary response to the greatest challenge faced by the Brazilian health system today involves protecting the most vulnerable and reducing social inequality in the country, in addition to improving its health surveillance and information systems.

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