Rev Rene. 2024;25:e93109.
DOI: 10.15253/2175-6783.20242593109
www.periodicos.ufc.br/rene

Original Article

# Hospitalizations due to COVID-19 among individuals with cardiovascular diseases and their relationship with equity indicators

## Internações por COVID-19 de pessoas com doenças cardiovasculares e sua relação com indicadores de equidade

**How to cite this article:**
Silva RES, Lima EA, Silva DMC, Silva ARV, Oliveira EAR, Formiga LMF, et al. Hospitalizations due to COVID-19 among individuals with cardiovascular diseases and their relationship with equity indicators. Rev Rene. 2024;25:e93109. DOI: https://doi.org/10.15253/2175-6783.20242593109

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**Conflict of interest:** the authors have declared that there is no conflict of interest.

EDITOR IN CHIEF: Ana Fatima Carvalho Fernandes
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**ABSTRACT**

**Objective**: to analyze the relationship between chronic cardiovascular diseases and equity indicators in Brazilian adults hospitalized for COVID-19. **Methods:** this cross-sectional and analytical study utilizes secondary data from the Influenza Epidemiological Surveillance Information System, encompassing 1,204,767 cases with comorbidities. Initially, the association between cardiovascular diseases and sociodemographic characteristics was tested using Poisson regression with robust variance. Subsequently, the relationship (expressed in rates) of these diseases with equity indicators was assessed through Pearson's correlation test. **Results:** among the 1,204,767 hospitalized cases with comorbidities, 52.7% had cardiovascular diseases. There was an almost perfect inverse correlation (r = -0.9521) between the mean values of the Social Vulnerability Index and the outcome, whereas the mean values of the Human Development Index showed a direct correlation (r = 0.7636). **Conclusion:** the high prevalence of cardiovascular diseases is correlated with equity indicators in specific population strata of those hospitalized for COVID-19. **Contributions to practice:** the results can support practices that consider healthcare needs and the specific aspects of highly vulnerable population groups.

**Descriptors:** Cardiovascular Diseases; COVID-19; Chronic Disease; Equity; Social Vulnerability.

**RESUMO**

**Objetivo**: analisar a relação entre as doenças cardiovasculares crônicas e indicadores de equidade em adultos brasileiros hospitalizados por COVID-19. **Métodos**: estudo transversal e analítico com dados secundários do Sistema de Informação de Vigilância Epidemiológica da Gripe, totalizando 1.204.767 casos com comorbidades. Inicialmente, testou-se a associação entre doenças cardiovasculares e as características sociodemográficas utilizando-se regressão de Poisson com variância robusta e, posteriormente, a relação (expressa em taxas) dessas doenças com indicadores de equidade, por meio do teste de correlação de Pearson. **Resultados**: dos 1.204.767 casos hospitalizados com comorbidades, 52,7% apresentavam doenças cardiovasculares. Constatou-se correlação inversa quase perfeita (r = -0,9521) entre os valores médios do Índice de Vulnerabilidade Social e o desfecho, enquanto os valores médios do Índice de Desenvolvimento Humano apresentaram correlação direta (r =0,7636). **Conclusão**: a alta prevalência das doenças cardiovasculares está correlacionada a indicadores de equidade em estratos populacionais específicos dos hospitalizados por COVID-19. **Contribuições para a prática**: os resultados podem subsidiar práticas que considerem, além das necessidades assistenciais à saúde, os aspectos específicos de grupos populacionais de maior vulnerabilidade social.

**Descritores:** Doenças Cardiovasculares; COVID-19; Doença Crônica; Equidade; Vulnerabilidade Social.

Received: Mar. 9th 2024; Accepted: June 28th 2024.

## Introduction

Noncommunicable chronic diseases (NCDs) represent a severe public health issue globally. In Brazil, in 2019, more than half of recorded deaths were caused by these diseases, with the age group most affected (41.8%) being individuals aged 30 to 69 years[1]. These diseases have become the primary cause of reduced life expectancy, with cardiovascular diseases (CVDs) being particularly prominent[2].

However, even in the current demographic and epidemiological transition scenario, infectious diseases, particularly viral ones, remain significant. These infections persist despite immature preventive and protective measures against emerging infections, leaving sequelae or causing losses on a global scale, as seen with influenza H1N1, yellow fever, Chikungunya, and dengue in the past decade[3]. Moreover, the impacts on the prognosis of chronic diseases are partially inseparable from the presence of infections, i.e., pre-existing comorbidities can be exacerbated by association with other conditions, as observed in the recent COVID-19 pandemic[4].

Data from the Mortality Information System (Ministry of Health) characterizes the epidemiological profile of deaths due to CVDs from 2016 to 2019. The highest rates were in the Southeast region, among men aged 60-79 years, and among individuals of white and mixed-race ethnicity[5]. Additionally, international research suggests that obesity, diabetes, hypertension, chronic kidney failure, and advanced age are factors associated with poorer prognosis in COVID-19 patients[6]. However, in this context, there is still limited evidence that social inequities affect the distribution of adult Brazilians hospitalized for COVID-19 with NCDs, particularly cardiovascular diseases.

It is essential to highlight that social inequity differs from social inequality in that the former generally refers to external conditions affecting the individual and a deficiency in implementing equity that can be overcome through public policy interventions for vulnerable population strata. In contrast, the latter involves a simple equal distribution of resources. From this perspective, it is understood that individuals have different needs and, therefore, require specific interventions[7].

Thus, equity is understood as the absence of unjust disparities among groups facing evident inequalities. Its assessment can be conducted through the analysis of socioeconomic determinants of health, including education, financial resources, and social and material living conditions. These determinants form the basis of equity indicators, allowing the observation of health patterns regarding socioeconomic inequalities[8].

In this context, studies evaluating inequities associated with chronic morbidity in the country can provide fundamental insights for promoting health and delivering more effective and equitable care by health professionals. This is because they allow understanding how social, economic, and cultural factors influence the development and progression of these diseases, especially considering the regional differences observed in Brazilian reality. Therefore, this study was guided by the following research question: What is the relationship between hospitalizations due to COVID-19 of individuals with cardiovascular diseases and social equity indicators?

Thus, this study aimed to analyze the relationship between chronic cardiovascular diseases and equity indicators in Brazilian adults hospitalized for COVID-19.

## Methods

This cross-sectional and analytical study utilized secondary data from Brazilian adults (≥ 18 years) hospitalized with COVID-19 from 2020 to 2022. It was presented according to the guidelines for reporting observational studies: Strengthening the reporting of observational studies in epidemiology (STROBE).

The population consisted of all adults hospi-

talized with COVID-19, treated nationwide, and registered in the Influenza Epidemiological Surveillance Information System (SIVEP Gripe)[9], considering notifications from Epidemiological Weeks 11 (2020) to 52 (2022).

A positive COVID-19 case was defined according to clinical, clinical-epidemiological, clinical-imaging, and laboratory criteria, with field 65, "Final Classification of SIVEP-Gripe," enabling selection. For the sample composition, to avoid overestimation or underestimation of the outcome, only hospitalized patients who reported having a risk factor (field 35-Risk factors: yes; no) were included in this study. Pregnant and postpartum women, outliers, and records with missing outcomes or state of residence information were excluded. Additionally, covariates were evaluated for incompleteness, retaining cases with less than 30% incompleteness, totaling 1,204,767 individuals.

In this study, the outcome was the presence of chronic cardiovascular disease (yes; no), considered based on the history of risk factors reported by the patient or guardian at the time of filling out the notification form (field 35-Risk factors/Chronic cardiovascular disease).

Independent variables included sociodemographic and clinical characteristics and equity indicators. Sociodemographic characteristics: sex (male; female), age (18-24; 25-39; 40-59; 60 years or older), race/color (white; non-white), residence area (urban; rural), and region of the country (North; Northeast; Southeast; South; Central-West). Clinical characteristics were intra-hospital treatment (admission to Intensive Care Unit [ICU], use of ventilatory support, and case progression) and another comorbidity (diabetes mellitus). It is noteworthy that the cutoff used to assess the incompleteness of variables (< 30%) did not allow including other chronic comorbidities such as hematological, hepatic, neurological, and renal diseases, and obesity.

The equity indicators were the Social Vulnerability Index (SVI), Municipal Human Development Index (MHDI), and Gini Index (GINI). Although equity is widely discussed in the country, its monitoring is still quite superficial because there is no specific indicator for evaluating equity-related issues[10]. However, combining different indicators provides a more comprehensive and accurate analysis of health equity, increasing sensitivity in identifying inequities[8].

The SVI comprises 16 variables distributed across three dimensions (urban infrastructure, human capital, and income and work), which, like the general index, range from 0 to 1. The closer to 1, the higher the region's vulnerability (0 to 0.200 - very low social vulnerability; 0.201 to 0.300 - low social vulnerability; 0.301 to 0.400 - medium social vulnerability; 0.401 to 0.500 - high social vulnerability; and > 0.500 - very high social vulnerability)[11]. In this study, the "very low" and "low" classifications, as well as "high" and "very high," were combined.

The MHDI is represented by a score ranging from 0.000 to 1.000, with higher values indicating higher levels of human development in a geographic area. A value from 0.000 to 0.499 is considered very low; from 0.500 to 0.599 - low; from 0.600 to 0.699 - medium; from 0.700 to 0.799 - high; and from 0.800 to 1.000 - very high[12]. Similarly, the classifications "very low" and "low" as well as "high" and "very high" were combined in this study.

Finally, the Gini Index is a metric used to measure the disparity between the income of the richest and the poorest individuals in a population[13]. Numerically, it ranges from 0 to 1, with values closer to 0 indicating lower income inequality and values closer to 1 indicating higher inequality. In this study, the index was measured through tertiles in income distribution.

Information on the sociodemographic and clinical characteristics of adults was obtained from the Severe Acute Respiratory Syndrome (SARS) database, registered in SIVEP-Gripe[9].

The Social Vulnerability Atlas from the Institute of Applied Economic Research (IPEA)[11] and the Human Development Atlas in Brazil[12] were used to ob-

tain data on equity indicators. Population information was acquired from the Brazilian Institute of Geography and Statistics, considering the population projection of Brazil by sex, age, and Federation Unit for the period 2010-2060. All characteristics referred to the base year of 2021. Additionally, since the age group (e.g., 15-19 and 20-24) determines the population projection, data from individuals aged 20 years and older were considered in this stage of the research.

Descriptive statistics (simple and relative frequencies) were used to characterize the sociodemographic and clinical variables of adults with CVD hospitalized for COVID-19. Subsequently, the association between sociodemographic and clinical variables and the presence of CVD was evaluated using Poisson regression analysis with robust variance, observing the prevalence ratio (PR) and its respective 95% confidence interval (95% CI). Initially, bivariate analysis was tested, where all variables with $p<0.20$ were included to obtain the multiple model using backward stepwise regression, considering significant variables with $p<0.05$. Poisson regression analysis with robust variance was applied in both the bivariate and multivariate stages.

The evaluation of equity indicators was carried out using Pearson's correlation test, considering the normality of the variable distribution. Initially, hospitalization rates were obtained by dividing the number of cases of individuals with CVD hospitalized for COVID-19 (numerator) by the population number in each Federation Unit, according to sex, age, and region of the country (denominator), multiplied by 100,000 inhabitants. Subsequently, correlation coefficients and their respective p-values were obtained, which, when significant ($p<0.05$), were assessed in five categories: very weak (0.00-0.19); weak (0.20-0.39); moderate (0.40-0.59); strong (0.60-0.79); and very strong (0.80-1.00). After downloading, the databases were imported, and all analyses were performed using Stata software version 16.0.

Regarding ethical aspects, this study used freely accessible secondary data, thus waiving the need for submission/approval by the Research Ethics Committee, according to Resolution No. 510/2016 from the National Health Council.

## Results

Data from 1,204,767 individuals with Severe Acute Respiratory Syndrome (SARS) due to COVID-19 were analyzed during the 2020-2022 period. Among these, 52.8% who confirmed having some morbidity had some form of heart disease. The majority of individuals with cardiovascular disease (CVD) were male (54.3%) and reported as non-white (54.1%). Hospitalization was more prevalent in the age group of 60 years or older (70.2%). Over 94% of individuals with heart disease resided in urban areas, and the Southeast region had the highest number of hospitalizations (53.0%). Notably, 40.2% of the hospitalized individuals also had diabetes.

Regarding in-hospital treatment, over half of the patients (60.3%) were not treated in intensive care units. The majority received some form of ventilatory support, with 22.2% undergoing invasive support and 52.8% receiving non-invasive support. As for the outcome of cases, a little less than half of those with CVD died due to COVID-19 (42.6%).

In the adjusted model, it was observed that individuals in the oldest age group had a 5.11 times higher association compared to the youngest group among those with cardiovascular diseases. The highest prevalences were found in the Southeast region (PR = 1.10; 95% CI = 1.09-1.11) and among those admitted to the ICU (PR = 1.03; 95% CI = 1.03-1.04), regardless of the type of ventilatory support used. Individuals residing in rural areas had a 4% lower prevalence of hospitalization due to COVID-19. As for recovery, the death rate from COVID-19 among hospitalized individuals with CVD was only 2% lower (PR = 0.98; 95% CI = 0.98-0.99) (Table 1).

**Table 1** – Characterization and crude and adjusted associations among Brazilian adults with chronic cardiovascular diseases hospitalized for COVID-19, according to sociodemographic and clinical characteristics (n=1,204,767). Picos, PI, Brazil, 2023

| Variables | n (%) | Crude PR | 95% CI | p-value* | Adjusted PR | 95% CI | p-value |
|---|---|---|---|---|---|---|---|
| Sex | | | | | | | |
| Male | 345,254 (54.3) | 1 | | | 1 | | |
| Female | 290,221 (45.7) | 1.03 | 1.02–1.03† | < 0.001 | 1 | 1.00–1.01 | < 0.001 |
| Age (years) | | | | | | | |
| 18-24 | 1,096 (0.2) | 1 | | | 1 | | |
| 25-39 | 20,871 (3.3) | 2.19 | 2.07–2.32† | < 0.001 | 2.13 | 2.00–2.26† | < 0.001 |
| 40-59 | 167,385 (26.3) | 4.08 | 3.86–4.32† | < 0.001 | 3.92 | 3.69–4.17† | < 0.001 |
| ≥ 60 | 446,123 (70.2) | 5.35 | 5.03–5.66† | < 0.001 | 5.11 | 4.81–5.43† | < 0.001 |
| Race/Color | | | | | | | |
| White | 291,820 (45.9) | 1 | | | 1 | | |
| Non-white | 343,655 (54.1) | 0.97 | 0.97–0.98† | < 0.001 | 1 | 1.00–1.00 | 0.004 |
| Residence area‡ | | | | | | | |
| Urban | 538,407 (94.2) | 1 | | | 1 | | |
| Rural | 26,705 (4.7) | 0.96 | 0.95–0.97† | < 0.001 | 0.96 | 0.96–0.97† | < 0.001 |
| Peri-urban | 2,056 (0.4) | 1.02 | 0.99–1.05 | 0.064 | 1.03 | 1.00–1.06 | 0.047 |
| Region of the Country | | | | | | | |
| North | 31,779 (5.0) | 1 | | | 1 | | |
| Northeast | 103,728 (16.3) | 1.05 | 1.04–1.06† | < 0.001 | 1.04 | 1.03–1.05† | < 0.001 |
| Southeast | 337,099 (53.0) | 1.13 | 1.12–1.14† | < 0.001 | 1.1 | 1.09–1.11† | < 0.001 |
| South | 114,153 (17.9) | 1.04 | 1.03–1.05† | < 0.001 | 1.03 | 1.02–1.04† | < 0.001 |
| Central-West | 48,716 (7.7) | 0.91 | 0.90–0.92† | < 0.001 | 0.91 | 0.90–0.92† | < 0.001 |
| Associated Comorbidity | | | | | | | |
| Diabetes mellitus | | | | | | | |
| No | 255,571 (40.2) | 1 | | | 1 | | |
| Yes | 379,904 (59.8) | 1.13 | 1.13–1.14† | < 0.001 | 1.06 | 1.06–1.07† | < 0.001 |
| Hospital treatment | | | | | | | |
| Admitted to ICU | | | | | | | |
| No | 252,169 (39.7) | 1 | | | 1 | | |
| Yes | 383,306 (60.3) | 1.06 | 1.06–1.07† | < 0.001 | 1.03 | 1.03–1.04† | < 0.001 |
| Use of ventilatory support | | | | | | | |
| No | 141,308 (22.2) | 1 | | | 1 | | |
| Yes, non-invasive | 335,782 (52.8) | 1.09 | 1.09–1.10† | < 0.001 | 1.08 | 1.07–1.08† | < 0.001 |
| Yes, invasive | 158,385 (24.9) | 1.12 | 1.12–1.13† | < 0.001 | 1.09 | 1.08–1.09† | < 0.001 |
| Case outcome‡ | | | | | | | |
| Recovery | 342,230 (57.0) | 1 | | | 1 | | |
| Death | 255,702 (42.6) | 1.09 | 1.08–1.09† | < 0.001 | 0.98 | 0.98–0.99† | < 0.001 |
| Death from other causes | 2,845 (0.5) | 0.95 | 0.93–0.98† | 0.002 | 0.91 | 0.88–0.93† | < 0.001 |

Source: Influenza Epidemiological Surveillance Information System

*Significance level; †Significant associations by 95% CI; ‡Variables with missing data; ICU: Intensive Care Unit; PR: Prevalence Ratio; CI: Confidence Interval

Regarding equity indicators, the SVI showed a significant and inverse correlation with the total rate of adults with CVD hospitalized due to COVID-19, indicating a moderate magnitude (r = -0.4930). There was an almost perfect inverse correlation between the total hospitalization rate and the mean SVI values (r = -0.9521), similarly among sexes, with a very strong magnitude (r = -0.8746 for men and r = -0.8526 for women); and in the age groups of 25 to 39 years (r = -0.8592) and 40 to 59 years (r = -0.8592), both inverse and with very strong magnitudes.

With a strong magnitude (r = 0.6842), there was a direct and significant correlation between the total rate of adults with CVD hospitalized due to COVID-19 and the MHDI. This magnitude remained regardless of the MHDI classification, but it was higher and significant for mean values (r = 0.7636). Both sexes showed strong and significant correlations between total rates and MHDI, with a notable strong correlation for mean values of this indicator among the female population (r = 0.7522). Regarding age groups, the correlation strengths between total rates were higher and significant among the populations aged 20 to 24 years and 40 to 59 years, remaining strong and significant for mean MHDI values among the population aged 20 to 24 years (r = 0.7625) (Table 2).

**Table 2** – Correlation between rates of Brazilian adults (≥ 20 years) with chronic cardiovascular diseases hospitalized for COVID-19 (per 100,000 inhabitants) and equity indicators, by sex and age (n=1,203,063). Picos, PI, Brazil, 2023

| Equity indicators | Total | Sex | | Age (years) | | | |
|---|---|---|---|---|---|---|---|
| | | Male | Female | 20-24 | 25-39 | 40-59 | ≥ 60 |
| | r* | r | r | r | r | r | r |
| Social Vulnerability Index | -0.4930† | -0.5054† | -0.5399† | -0.5637† | -0.5230† | -0.4876† | -0.3468 |
| Very low and low | -0.2894 | -0.2433 | -0.2829 | -0.3186 | -0.2767 | -0.2261 | -0.0871 |
| Medium | -0.9521† | -0.8746† | -0.8526 | -0.8774 | -0.8592† | -0.8012† | -0.6835 |
| High and very high‡ | – | – | – | – | – | – | – |
| Municipal Human Development Index | 0.6842† | 0.6711† | 0.6627† | 0.7386† | 0.6774† | 0.5702† | 0.3154 |
| Low and very low‡ | – | – | – | – | – | – | – |
| Medium | 0.7636† | 0.7074† | 0.7522† | 0.7625† | 0.6619 | 0.7075† | 0.6112 |
| High and very high | 0.7010† | 0.6971† | 0.6871† | 0.7450† | 0.6969† | 0.6255† | 0.4334 |
| Gini Index | -0.0718 | -0.1704 | -0.1968 | -0.2401 | -0.2155 | -0.1375 | 0.0322 |
| 1st tertile | -0.1244 | -0.2463 | -0.2872 | -0.2607 | -0.1895 | -0.2399 | -0.3981 |
| 2nd tertile | -0.1120 | 0.1241 | 0.1518 | 0.1287 | 0.1256 | 0.1975 | 0.3351 |
| 3rd tertile | -0.0183 | -0.1365 | -0.0795 | -0.1412 | -0.1692 | -0.0322 | 0.2009 |

Source: Influenza Epidemiological Surveillance Information System
*Pearson correlation coefficient; †Significant values: p<0.05; ‡Insufficient data

In Table 3, only the mean SVI values showed an inverse and very strong magnitude correlation with hospitalization rates according to the country's region, concentrating in the Northeast Region (r = -0.9611).

**Table 3** – Correlation between rates of Brazilian adults (≥ 20 years) with chronic cardiovascular diseases hospitalized for COVID-19 (per 100,000 inhabitants) and equity indicators, by region of the country (n=1,203,063). Picos, PI, Brazil, 2023

| Equity indicators | Country's Region | | | | |
|---|---|---|---|---|---|
| | North | Northeast | Southeast | South | Central-West |
| | r* | r | r | r | r |
| Social Vulnerability Index | -0.5838 | -0.6186 | 0.5116 | 0.8802 | -0.0224 |
| Very low and low | -0.3891 | -0.0203 | 0.5116 | 0.8802 | 0.4344 |
| Medium‡ | -1.0000 | -0.9611† | – | – | – |
| High and very high‡ | – | – | – | – | – |
| Municipal Human Development Index | -0.2522 | 0.3064 | 0.4608 | -0.6757 | 0.7925 |
| Low and very low‡ | – | – | – | – | – |
| Medium‡ | 0.8288 | 0.7649 | – | – | – |
| High and very high | -0.3749 | -0.2980 | 0.4608 | -0.6757 | 0.7925 |
| Gini Index | 0.0497 | 0.0346 | 0.5294 | 0.6392 | 0.8776 |
| 1st tertile‡ | – | – | -1.0000 | 0.6392 | 0.7606 |
| 2nd tertile‡ | -0.1506 | -0.9694 | – | – | – |
| 3rd tertile‡ | – | -0.1553 | – | – | – |

Source: Influenza Epidemiological Surveillance Information System
*Pearson correlation coefficient; †Significant values: p<0.05; ‡Insufficient data

## Discussion

There was a high prevalence of CVD among individuals reported with SARS due to COVID-19, many of whom succumbed to the disease. Overall, higher prevalences were observed with advancing age, among those hospitalized in the Southeast region, those with diabetes mellitus, and those who required ventilatory support. Additionally, hospitalization rates for adults with CVD (per 100,000 inhabitants) may have varied because of social vulnerability and municipal human development, both in stratification by sex and by age.

The prevalence of cardiovascular diseases is considerably high, making them a significant factor for hospitalizations, mainly when associated with other health issues[14]. Another possible explanation for this high prevalence among hospitalized patients during the pandemic is the interruption of regular consultations and exams. Due to social isolation, for instance, there was a significant reduction in the demand for health services to avoid virus exposure. In this context, health status and/or disease control could be overlooked and neglected, predisposing individuals to other conditions[15].

Among the outcomes for hospitalized individuals with CVD, the high number of deaths observed in this study stands out—a finding similar to that of a previous study[14]. Moreover, it is suggested that some NCDs can increase the number of deaths by up to 15%[16], highlighting the importance of monitoring and controlling chronic diseases.

Regarding age, it is already a consensus that aging increases susceptibility to CVD because of greater cardiovascular system fragility during the aging process and the multifactorial burden accumulated over time[17]. Furthermore, since aging is an intrinsic process in which older individuals are in a chronic inflammatory state due to chronic comorbidities, they become predisposed to other inflammatory/infectious conditions, such as severe forms of COVID-19[18].

In terms of regions, the Brazilian Southeast, characterized by high structural development, revealed the highest concentration of CVD among hospitalized patients evaluated in this study. Such a result was expected, as this region has the highest prevalence of NCDs, particularly those involving the cardiovascular system[5]. On the other hand, the North and Northeast regions, which are more vulnerable, exhibited lower prevalences of these diseases compared to the persistence of premature mortality related to poverty-associated diseases[19].

Despite the correlation with population aging, the severity of COVID-19 morbidity is also associated with the burden of chronic conditions. Our study also found that the high prevalence of CVD among hospitalized patients is associated with an increased prevalence of diabetes mellitus[13]. The results are similar to those of a study conducted with patients over 60 years old admitted to ICUs, where only 20% did not have any NCDs[20].

In this study, nearly 40% of hospitalized patients were admitted to the ICU; the majority required ventilatory support; and high mortality from COVID-19 associated with CVD was observed. These results may be related to the older population, which predominantly has the highest number of comorbidities such as cardiovascular diseases, diabetes, and hypertension, often under treatment with multiple medications[21]. Additionally, the mortality rate is even higher in population strata with more unfavorable socioeconomic indicators, highlighting the influence of social inequalities in this scenario[22].

In the present study, the negative correlation between the rates of adults with CVD hospitalized for COVID-19 and the SVI and the positive correlation of these rates with the MHDI suggest that the demographic and epidemiological transition process is not occurring homogeneously in Brazil. A previous study concluded, for example, that the highest rates of cerebrovascular diseases were observed in the most developed states with lower social vulnerability, but the trend decreased over nearly 20 years. Conversely, in states with lower development and higher vulnerability, the rates were lower, but the trend was increas-

ing[22]. These findings highlight the presence of social inequalities and inequities in the country.

The SVI is measured based on indicators of urban infrastructure, human capital, income, and work, increasing the sensitivity to individual social factors such as access to water supply and sewage, garbage collection, infant mortality rates, illiteracy rates by age groups, and prevalence of unemployed or low-paid workers[11]. Thus, it is believed that the more vulnerable population has greater difficulty accessing health services, leading to underdiagnosis and underreporting, which could suggest the inverse correlation between the SVI and hospitalization rates of adults with CVD and COVID-19 found in this study. Notably, the top seven places for underreporting rates are occupied by states in the North and Northeast regions[23].

In the present study, a significant correlation for the SVI was observed only in the Northeast region. This fact does not mean that there are no different indices and associated risks in other regions. However, it reinforces the importance of spatial analyses that reveal municipal and regional socioeconomic differences and, thus, the resizing of public and private policies according to geographically associated needs and vulnerabilities[24].

The positive correlation identified between the MHDI and hospitalization rates aligns with previous studies, which indicate a higher incidence of hypertension in geographic areas with a higher HDI[25-26]. The association found may be related to the greater exposure of residents in developed regions to factors predisposing to cardiovascular system compromise: the fast-paced lifestyle of these regions, with significant time spent in physical inactivity, a habit of eating fattier foods, and a higher prevalence of obesity[27].

Moreover, a spatial analysis of COVID-19 case incidence in a Brazilian metropolis found that the disease incidence was higher in neighborhoods located in urban areas with a higher HDI and lower population density, precisely where the first cases of the disease were reported. This finding strengthens the assumption that there may be difficulties in accessing health services and underreporting among the more vulnerable population, characterized by a lower MHDI[23].

Another noteworthy result was the stronger correlation between the MHDI and the younger population hospitalized with COVID-19 having CVD as a comorbidity. This outcome can be explained, among other reasons, by the fact that this population is economically active and has a higher employment rate, thus having greater difficulty in isolating due to work and income, greater exposure to risk, and consequently higher disease incidence[23].

In this regard, there is also a direct relationship between age and income, where, as individuals become economically active, there is also a tendency for higher monetary gains[28], which explains the decreased risk of developing heart diseases as age advances in regions where people are poorer. The increase in income in less developed regions benefits the health of the population[29], and this is found in regions with a medium HDI, which was the lowest level of development index observed in this study.

Understanding the construction process of the indicators used in this study is essential for adequately comprehending the social context behind CVD, especially among those hospitalized due to COVID-19. It is also necessary to recognize that there is still no index capable of encompassing all dimensions relevant to the human social condition, although existing ones gather important variables that help understand different exposures to health risk factors and conditions. In this sense, it is valid to meticulously analyze these context indicators to increase sensitivity in the search for social inequities present in the population with cardiovascular diseases.

## Study limitations

This study presents limitations that need to be discussed. The presence of social inequities cannot be directly measured. It is only perceived through the insufficiency of the equity principle in addressing different demographic profiles and the diverse needs

marked by social inequalities. These should be overcome through strategic public health policies with a broader distribution of health services across various population groups in the country.

Additionally, since it relies on secondary sources, poorly recorded data may sometimes alter the results. However, none of the evaluated variables reached the maximum percentage stipulated for missing data.

## Contributions to practice

The analysis of different indices proposed in this study was stratified, aiming to provide a broad view of the various relevant dimensions experienced by the Brazilian population. One contribution of this integrated analysis was to include indicator variables capable of highlighting possible inequities and needs of the population with cardiovascular diseases affected by COVID-19 on a national scale, addressing strategic areas of responsibility for public authorities.

Moreover, the results can support practices that consider, in addition to health care needs, the specific aspects of socially vulnerable population groups.

## Conclusion

It is concluded that the prevalence of cardiovascular diseases among those hospitalized for COVID19 in Brazil was high and correlated with the studied social inequity indicators. The analysis allowed the identification of population groups (young people, regardless of sex) and areas (Northeast Region) that could be targeted for priority public policies to reduce morbidity and mortality from cardiovascular diseases among patients with COVID-19.

## Authors' contribution

Conception and design or data analysis and interpretation: Silva RES, Carvalho RBN. Drafting the manuscript or critically revising it for important intellectual content: Carvalho RBN. Final approval of the version to be published: Silva RES, Carvalho RBN. Responsibility for ensuring the accuracy and integrity of any part of the manuscript in all its aspects: Lima EA, Silva DMC, Silva ARV, Oliveira EAR, Formiga LMF.

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