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Obesity modifies the association of race and COVID-19 mortality: analysis of a retrospective cohort from Brazil

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COVID-19 and obesity are two concurrent, interrelated pandemics that share similarities in their social causes, including racism. It is essential to understand how their characteristics are interrelated and the possible role of obesity in the association between race and COVID-19 mortality. We investigated the relationship between race and COVID-19 mortality and the modifying effect of obesity on this relationship. It is a retrospective cohort study. We analyzed data from 113,737 adults aged ≥ 19 years hospitalized for COVID-19 in Rio Grande do Sul, Brazil. The study outcome was in-hospital COVID-19 mortality. Exposures included race, analyzed as white, Brown, and Black individuals and as white vs. Brown and Black individuals, and obesity. The cumulative incidence of COVID-19 mortality was 33.46% (95% CI 33.18–33.74). Compared with white individuals, Brown individuals had a 39% higher likelihood of death from COVID-19 (95% CI 1.28–1.52), while Black individuals had a 30% higher likelihood (95% CI 1.20–1.41). Brown women with obesity had the greatest likelihood of COVID-19 mortality (1.64 [95% CI 1.27–2.13]) compared with all other groups. Obesity was an effect modifier of the association between race and COVID-19 mortality, increasing the likelihood of mortality in the group of Brown women.

In the early 2020s, COVID-19 became a pandemic, with devastating consequences worldwide[1–3]. Since the beginning of this pandemic, studies have been denouncing racial/ethnic inequalities related to both infection and mortality rates[4]. As early as the first months of 2020, analyses showed a higher risk of hospitalization and mortality among the Black population in the United States[5,6] and in Brazil as well[7]. In addition to socioeconomic disparities, possible explanations for this association require an understanding of how racism poses challenges in implementing social distancing, the presence of pre-existing chronic noncommunicable diseases, and the difficulties experienced by Black and Indigenous populations in accessing quality healthcare or receiving appropriate treatment in healthcare services[7–9].

Meanwhile, the presence of obesity has been identified as a significant risk factor for severe COVID-19[10–13]. Obesity is also recognized as a disease of pandemic proportions due to its widespread prevalence worldwide[14]. In Brazil, obesity is attributed to well-known social causes, particularly its higher prevalence among Black women of low socioeconomic status[15]. Racism emerges as a risk factor for obesity through various causal pathways. As a persistent daily phenomenon, racial discrimination serves as a chronic social stressor, contributing to physiological, psychological, and behavioral consequences. When accumulated over a lifetime, these experiences can adversely impact both mental and physical health, ultimately leading to the development of chronic noncommunicable diseases, such as obesity[16].

It can be argued that COVID-19 and obesity represent concurrent, interrelated pandemics with shared social causes, including racism[17]. Thus, understanding the interconnectedness of their characteristics and the potential role of obesity in the association between race and COVID-19 mortality is essential. Moreover, exploring the hypothesis that pre-existing obesity partially accounts for the elevated COVID-19 mortality rates in the Black population, compared to the white population, could offer insights into the social determinants of disease. Therefore, this study aimed to investigate the relationship between race and COVID-19 mortality, as well as the

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potential modifying effect of obesity on this relationship, through the analysis of COVID-19 hospitalization data in a southern Brazilian state between 2020 and 202.

Methods

Study design, population

This is a retrospective cohort study of adults aged 19 years or older admitted to public and private hospitals for severe acute respiratory syndrome (SARS) due to COVID-19 (SARS-CoV-2 infection) in Rio Grande do Sul, the southernmost state of Brazil, from March 2020 to December 2021.

All data used in this study were extracted from the Brazilian Epidemiological Surveillance Information System (SIVEP for short, in Portuguese) for Influenza (SIVEP-Influenza), available at: https://opendatasus.saude.gov.br/dataset?tags=SRAG. SIVEP-Influenza is a public database derived from a mandatory reporting information system that does not contain any identifiable individual information. Therefore, this study was exempt from research ethics committee approval.

The inclusion criteria for the study were hospitalization for SARS-CoV-2 infection in the state of Rio Grande do Sul, Brazil, between March 2020 and December 2021, and age $\geq$ 19 years. The diagnosis of SARS-CoV-2 infection was based on individual records of SARS hospitalizations in SIVEP-Influenza. Confirmation of SARS-CoV-2 infection was established through clinical or laboratory criteria, or through epidemiological surveillance. Patients hospitalized for SARS who resided in other states or whose cause of death was not COVID-19 were excluded. Additionally, individuals who self-identified as Indigenous or Yellow were later excluded due to their small representation in the population, which could potentially skew the study's findings.

Variables and data collection

All information about the variables was collected from the individual records of cases of SARS hospitalization in the SIVEP-Influenza.

COVID-19 mortality

Measured by the cumulative incidence of in-hospital COVID-19 mortality (in-hospital COVID-19 death/live discharge). The data were extracted from death certificates completed by the attending physician.

Race

On admission, the patient was asked about how they identified their race among the following options: white, Black, Brown, Yellow, or Indigenous, according to the methodology adopted in Brazil by the Brazilian Institute of Geography and Statistics[18]. Therefore, the analyses were conducted considering the following categories of race: white (reference), Brown ("pardo" in Portuguese), and Black. In Brazil, Brown and Black individuals together represent the group defined as "Negros" in Portuguese[19] - "Negro" is not a pejorative term in Brazil. Thus, we also analyzed white (reference) vs. Brown and Black. We adopted self-reported race as an indirect measure of the experience of racism, as humans do not display biological race. In Brazil, the dynamics of racial prejudice and discrimination rely heavily on skin color as physical appearance[19].

Obesity

The reporting records included a checklist (with yes/no checkboxes) of 12 comorbidities, one of which was obesity. The patient or accompanying person self-reported their current comorbidities on admission. Due to the instruction for the question (check "yes" only for current comorbidities), patients were considered with obesity if this variable was checked "yes", and without obesity, if this variable was checked "no" or left blank. Patients with a status recorded as "unknown" were excluded from the analyses.

Covariates

The following demographic and socioeconomic data, self-reported on admission, were also collected from the reporting records: gender (female/male), age (in years, categorized into quartiles), and level of education (illiterate, incomplete elementary school / complete elementary school / high school / complete or incomplete higher education). The presence of risk factors as well as the presence of diabetes and heart disease, separately, were also included in the analyses. These data were also obtained from the checklist of 12 comorbidities. The question on the reporting record was as follows: "Does the patient have any risk factors or comorbidities? If yes, please check the appropriate box (es)". Followed by a list of 12 risk factors/comorbidities. Patients were considered to have risk factors, diabetes, and heart disease if these variables were checked "yes", and not to have these diseases if the respective variables were checked "no" or left blank. Patients with a status recorded as "unknown" were excluded from the analyses.

Information about the care received during hospitalization was also included in the analyses: admission to the intensive care unit (ICU) (no/yes) and need for ventilatory support (no / noninvasive ventilation / invasive ventilation).

Statistical analysis

The cumulative incidence was calculated by dividing the number of new cases of deaths by COVID-19 between March 2020 and December 2021 by the number of individuals admitted to public and private hospitals for SARS-CoV-2 infection in Rio Grande do Sul, from March 2020 to December 2021. This result is then multiplied by 100 to express it as a percentage. The cumulative incidence of mortality and its association with the covariates was assessed by Pearson's chi-square test of independence.

Logistic regression models were used to estimate the effect measures and respective 95% CIs of the associations between race, obesity, and COVID-19 mortality. The multivariate models were based on a previously constructed

directed acyclic graph (DAG) (available at: dagitty.net/m6vEhxb). The analyses were adjusted for age (model 1), with further adjustments for diabetes and heart disease (model 2) and for intensive care and ventilatory support (model 3). The covariates with $p<0.20$ in the test of association with the outcome remained in the models. Models 2 and 3 included possible mediators of the relationship between race, obesity, and COVID-19 mortality and, therefore, were presented as separate models.

All analyses were stratified by gender to analyze the data intersectionally between race and gender. Furthermore, to investigate the modifying effect of obesity on the association between race and COVID-19 mortality, the analyses were also stratified by the presence of obesity after a significant test of interaction ($p<0.001$). All analyses were performed using STATA, version 14.1, and the significance level was set at 5%.

Results

The original database comprised 157,441 individuals. Following eligibility screening, the final population comprised 113,737 individuals (Fig. 1).

The majority of participants self-identified as white (84.9%) and were male (54.7%), with a mean age of 59.28 (SD 16.53) years. Approximately 30.0% of the population had not completed elementary school. At least one risk factor was observed in 70.4% of patients, with heart disease and diabetes present in 35.4 and 24.3%, respectively. In terms of treatment, 86.9% required ventilatory support, and 36.1% required ICU admission (Table 1).

The cumulative incidence of COVID-19 mortality was 33.46% (95% CI 33.18–33.74). The highest cumulative incidences of COVID-19 mortality were observed in women with obesity, Black women, as well as in both men and women aged ≥74 years, with no schooling/illiterate, presenting risk factors, and with diabetes and heart disease. COVID-19 mortality was also associated with invasive mechanical ventilation and ICU admission (Table 1).

Obesity was reported by 14.2% (95% CI 14.0–14.41) of the participants. All population characteristics were associated with obesity. However, the highest prevalence of obesity occurred in women requiring invasive ventilation (26.4%) and ICU admission (24.9%), while the lowest prevalence was observed in men aged ≥74 years (4.8%) (data not shown in tables).

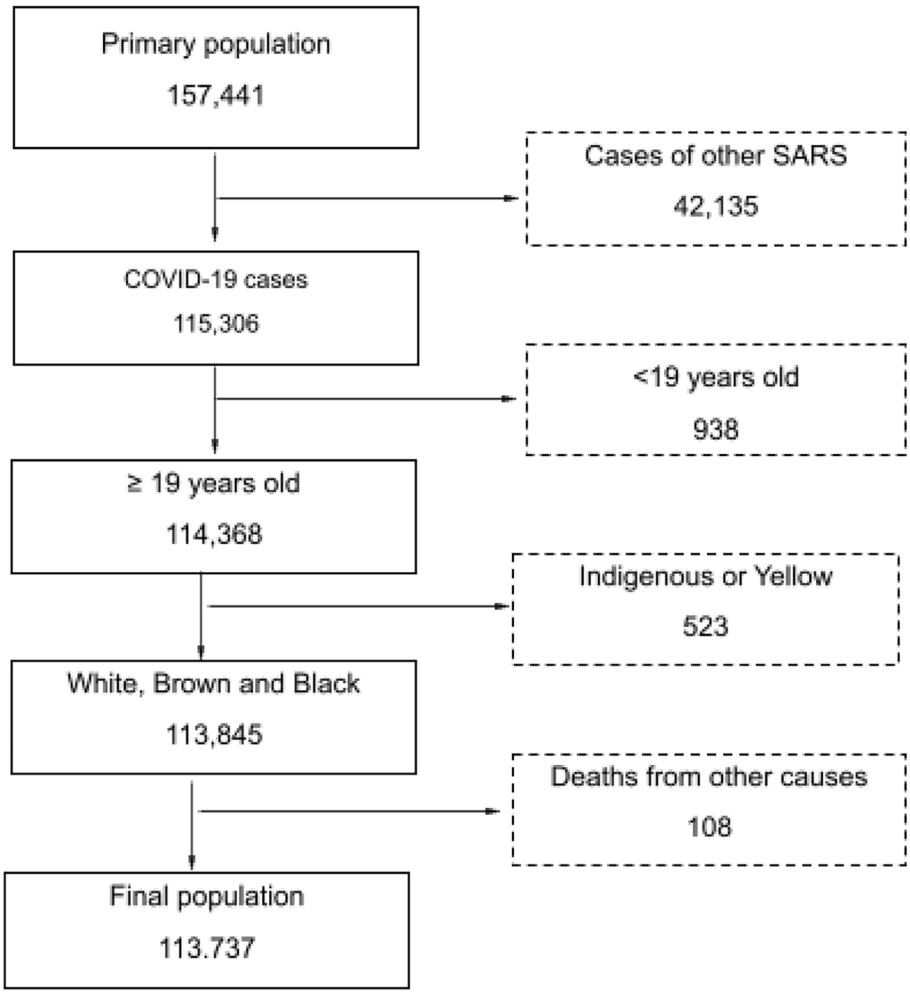

Fig. 1. Flow chart of participants selection. The final population represents individuals hospitalized for COVID-19 in Rio Grande do Sul, Brazil, during 2020 and 2021.

			COVID-19 mortality					
			All		Men		Women	
Variables	n	%	% (95%CI)*	p-value	% (95%CI)	p-value*	% (95%CI)	p-value*
Obesity No	96887	85.8	32.4 (32.1–32.7)	<0.001	32.5(32.1–32.9)	<0.001	32.2 (31.8–32.7)	<0.001
Yes	16048	14.2	39.2 (38.5–40.0)		37.5(36.4–38.6)		40.1 (39.8–42.0)	
Race								
White	96583	84.9	32.7 (32.4-33.0)	<0.001	32.6 (32.1–33.0)	<0.001	32.8 (32.4–33.3)	<0.001
Brown	4420	3.9	36.4 (35.0–37.8)		35.5 (33.5–37.9)		37.5 (35.2–39.7)	
Black	4581	4.0	39.4 (38.0–41.0)		38.7 (36.7–40.7)		40.2 (38.1–42.3)	
Brown and Black	9001	7.9	37.6 (36.5–38.7)		36.4 (35.0–37.9)		39.1 (37.5–40.8)	
Age								
=<46	27305	24.0	14.2 (13.7–14.6)	<0.001	13.8 (13.2–14.3)	<0.001	14.7 (14.0–15.3)	<0.001
47 a 59	29113	25.6	24.2 (23.7–24.7)		24.1 (23.4–24.7)		24.5 (23.7–25.2)	
60 a 73	33184	29.2	40.0 (39.4–40.5)		41.4 (40.6–42.1)		38.2 (37.4–39.0)	
>=74	24135	21.2	56.9 (56. 2–57.5)		59.6 (58.6–60.4)		54.5 (53.5–55.3)	
Level of education								
Illiterate	1427	2.9	45.9 (43.2–48.5)	<0.001	43.9 (39.9–47.8)	<0.001	47.5 (43.9–50.9)	<0.001
Incomplete elementary school	13981	28.7	37.9 (37.0–38.7)		38.2 (37.0–39.3)		37.5 (36.3–38.7)	
Complete elementary school	12582	25.9	32.1 (31.3–32.9)		32.7 (31.5–33.7)		31.4 (30.2–32.7)	
High school	14449	29.7	22.9 (22.2–23.6)		23.9 (22.9–24.8)		21.6 (20.5–22.6)	
Complete or incomplete higher education	6196	12.7	19.9 (18.9–20.9)		21.2 (19.8–22.5)		18.0 (16.4–19.5)	
Comorbidities								
No	33678	29.6	14.7 (14.3 -15.0)	<0.001	15.1 (14.5–15.5)	<0.001	14.0 (13.4–14.6)	<0.001
Yes	80059	70.4	41.2 (40.8–41.5)		42.1 (41.6–42.5)		40.2 (39.7–40.7)	
Heart disease								
No	73326	64.6	27.6 (27.2–27.9)		27.2 (26.7–27.6)	<0.001	28.1 (27.6–28.6)	<0.001
Yes	40110	35.4	44.0 (43.5–44.5)		45.0 (44.3–45.7)		42.8 (42.2–43.5)	
Diabetes								
No	85834	75.5	29.5 (29.1–29.7)		29.3 (29.0–29.7)	<0.001	29.7 (29.230.1)	<0.001
Yes	27550	24.3	46.2 (45.0–47.1)		46.2 (45.4–47.1)		44.9 (44.0–45.7)	
Ventilatory support								
No	14459	13.2	9.7 (9.2–10.2)	<0.001	9.9 (9.1–10.5)	<0.001	9.6 (8.8 -10.2)	<0.001
Noninvasive ventilation	69133	62.9	21.9 (21.5–22.2)		20.8 (20.3–21.2)		23.2 (22.7–23.6)	
Invasive ventilation	26357	24.0	76.5 (76.0–76.9)		76.8 (76.1–77.5)		76.0(75.2–76.8)	
Intensive care								
No	69348	63.9	17.6 (17.3–17.8)	<0.001	16.5 (16.1–16.8)	<0.001	18.9 (18.4–19.3)	<0.001
Yes	39238	36.1	60.8 (60.2–61.2)		60.5 (59.8–61.1)		61.1 (60.3–61.8)	

Table 1. Participant characteristics and cumulative incidence of mortality due to COVID-19 according to sociodemographic characteristics, comorbidities and treatment. *p-value for Pearson's chi-square test.

In the adjusted analysis for the entire model, compared with white individuals, Brown and Black individuals had a 39% (95% CI 1.28–1.52) and 30% (95% CI 1.20–1.41) greater likelihood of dying from COVID-19, respectively. When considering Black and Brown individuals together, they had a likelihood of death from COVID-19 that was 1.34 times higher (95% CI 1.26–1.43) compared to white individuals. In gender-stratified analyses, Brown women had a likelihood of death from COVID-19 that was 1.47 times higher (95% CI 1.29–1.66) compared to white women (Table 2).

Figure 2 shows the adjusted analyses for the association between race and COVID-19 mortality stratified by the presence of obesity. Among men, a significant association was found only in those without obesity. Among women, self-identifying as Black was significantly associated with higher COVID-19 mortality only in those without obesity. Although self-identifying as a Brown woman was associated with higher mortality in both groups, those with obesity had higher effect measures (1.64 [95% CI 1.27–2.13] and 1.40 [95% CI 1.21–1.62] with obesity and without obesity, respectively). When analyzed together, Brown and Black women also had a higher likelihood of mortality regardless of obesity.

Discussion

This study demonstrated that Brown and Black individuals had a higher likelihood of death from COVID-19 compared to white individuals, with Brown women being particularly affected. Obesity was an effect modifier of the association between race and COVID-19 mortality. When comparing white individuals to Black individuals,

	Covid-19 Mortality							
	Crude analysis	p-value	Model 1	p-value	Model 2	p-value	Model 3	p-value
All population								
Race								
White	1.00	<0.001	1.00	<0.001	1.00	<0.001	1.00	<0.001
Brown	1.18 (1.10–1.25)		1.36 (1.27–1.45)		1.32 (1.23–1.41)		1.39 (1.28–1.52)	
Black	1.34 (1.26–1.43)		1.50 (1.41–1.61)		1.42 (1.33–1.52)		1.30 (1.20–1.41)	
Brown and Black	1.26 (1.20–1.32)	<0.001	1.43 (1.36–1.50)	<0.001	1.37 (1.31–1.44)	<0.001	1.34 (1.26–1.43)	<0.001
Men								
White	1.00	<0.001	1.00	<0.001	1.00	<0.001	1.00	<0.001
Brown	1.14 (1.04–1.24)		1.30 (1.19–1.43)		1.28 (1.17–1.40)		1.33 (1.18–1.49)	
Black	1.31 (1.20–1.43)		1.49 (1.36–1.64)		1.43 (1.30–1.57)		1.38 (1.22–1.55)	
Brown and Black	1.22 (1.14–1.30)	<0.001	1.39 (1.30–1.49)	<0.001	1.35 (1.26–1.45)	<0.001	1.35 (1.24–1.47)	<0.001
Women								
White	1.00	<0.001	1.00	<0.001	1.00	<0.001	1.00	<0.001
Brown	1.23 (1.12–1.35)		1.42 (1.28–1.57)		1.37 (1.24–1.52)		1.47 (1.29–1.66)	
Black	1.37 (1.26–1.50)		1.53 (1.39–1.68)		1.43 (1.30–1.58)		1.24 (1.10–1.39)	
Brown and Black	1.30 (1.22–1.39)	<0.001	1.48 (1.38–1.59)	<0.001	1.40 (1.31–1.51)	<0.001	1.34 (1.23–1.46)	<0.001

Table 2. Odds ratio and 95% confidence intervals of the association between race and COVID-19 mortality stratified by gender. Model 1: ajusted by age. Model 2: ajusted by model 1 + heart disease and diabetes. Model 3: ajusted by model 2 + ventilatory support and intensive care.

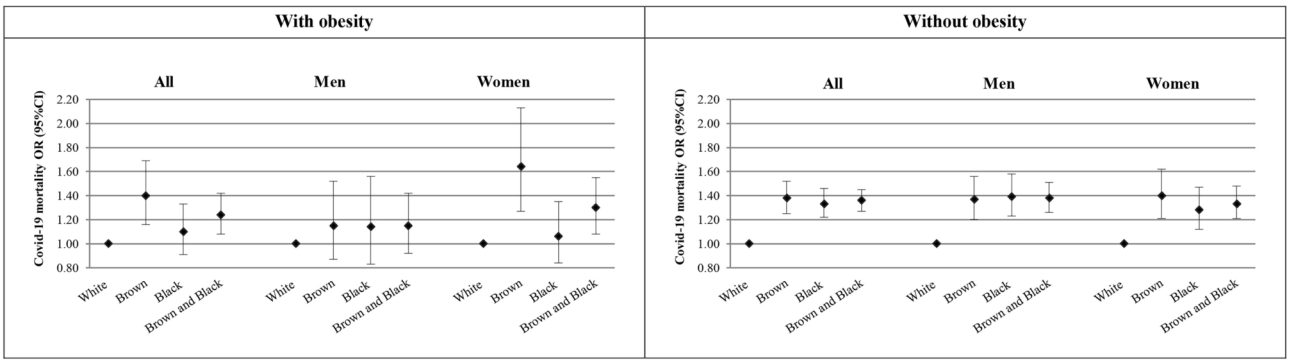

Fig. 2. Odds ratio and 95% confidence intervals of the association between race and COVID-19 mortality according to obesity status. Adjusted for age, heart disease, diabetes, ventilation support and intensive care.

or Brown and Black individuals, it was observed that the likelihood of mortality was higher among individuals without obesity. However, an exception was found within the group of Brown women with obesity, who exhibited higher odds of death compared to Brown women without obesity.

Our findings are consistent with those of previous studies showing higher COVID-19 mortality in racial-ethnic minorities[20,21]. In Brazil, descriptive studies have indicated higher odds of mortality in Black individuals, followed by Brown individuals[6,22,23]. A study analyzing data from more than 70 million Brazilians diagnosed with mild/moderate or severe COVID-19 between February 26, 2020, and November 15, 2021, demonstrated that Brown (odds ratio [OR] 1.11, 95% CI 1.10–1.12) and Black (OR 1.34, 95% CI 1.32–1.36) individuals had the highest odds of COVID-19 mortality compared with white individuals[23].

In this study, although the descriptive analyses also indicated a higher prevalence of mortality among Black individuals, the analyses stratified by gender identified Brown women as the main risk group. This highlights the importance of applying theory-based analytical approaches, such as intersectionality theory. The intersectionality approach allows the analysis of risk experiences in groups that are predominantly investigated as homogeneous, such as women and Black individuals. This approach assumes that multiple social categories, such as gender, race, and socioeconomic status, interact at the individual level and reflect interrelated systems of privilege and oppression at the macro level, such as racism and sexism[24–26]. Based on this theory, the intersectionality analysis of gender and race allows the recognition of multiple social identities that are hidden in traditional approaches, which analyze these identities separately[27].

This study relied on hospitalization data, potentially resulting in underreporting of COVID-19 mortality within Black individuals. Due to racial and social disparities, individuals from this population may have passed away without accessing tertiary healthcare facilities, such as hospitals. Moreover, while the population self-

identifying as Brown and Black in the Rio Grande do Sul constitutes 13.9 and 5.9% of the state's population, respectively[28], this study only captured 7.8% of it. Recent studies have indicated a growing number of individuals self-identifying as Black and Brown, reflecting an increasing awareness of racial issues in Brazil[29], particularly among young people. However, the mean age of our participants was approximately 60 years, comprising middle-aged and older adults residing in a region with the lowest proportion of Black individuals in Brazil. Consequently, they may be more inclined to report a lighter skin color (Brown), potentially leading to an underestimation of association estimates for Black individuals[30].

The increased severity and fatality rates of COVID-19 observed in Brown and Black individuals in Brazil can be attributed to the systemic racism experienced by this group. Racism manifests in poorer socioeconomic and labor conditions, limited access to nutritious food, higher prevalence of chronic illnesses, and restricted access to healthcare services and immunization[31,32]. These challenges stem from the historical, social, and political factors that perpetuate racism in Brazil, contributing to the systematic degradation of living and health conditions among Brown and Black individuals[9]. Racism is a structuring system that results in practices, beliefs and prejudices that underlie avoidable and unfair inequalities between social groups, based on race or ethnicity, and that, institutionally, restricts access to goods, services, and opportunities[33].

Although the presence of obesity has been recognized as a significant risk factor for COVID-19 mortality since the onset of the pandemic, meta-analyses have yielded conflicting findings[34–36]. While a review of meta-analyses revealed an association between obesity and an increased mortality risk in COVID-19 patients, a critical evaluation of the evidence quality indicated a high risk of bias and low certainty of evidence[37]. In this study, obesity was associated with higher odds of COVID-19 mortality only in white people and in Brown women. Studies that analyzed the association between obesity and COVID mortality did not consider characteristics such as race, which could be related to this association. Furthermore, most of the studies were conducted in the Global North[37]. One potential explanation for our findings is that Black individuals, being the most vulnerable to poverty, malnutrition, and food insecurity in Brazil, may be more susceptible to the obesity paradox[28]. This paradox refers to the inverse association between body mass index and mortality in critically ill patients, a phenomenon observed in certain studies within the context of COVID-19[38].

Finally, Brown women with obesity had the highest likelihood of death from COVID-19 in this study. Recent data from a technical report in the state of Rio Grande do Sul underscore the stark socioeconomic and living condition disparities between Brown and Black individuals compared to white individuals. Moreover, when comparing individuals self-identifying as Brown and Black, all indicators point to worse conditions for Black individuals[28]. These findings reflect the concepts of colorism and pigmentocracy, which posit that individuals are treated differently based on their skin tone, with the assumption that a Black person with a lighter skin tone will encounter less prejudice due to its proximity to whiteness[39]. This disparity in social standing also carries gender and class implications, reflecting an intersectional perspective where Black women find themselves in a position of lower social prestige[40]. In Brazil, this disparity is evident in income statistics, where Black women consistently earn the lowest income. It can be hypothesized that Black women face compounded vulnerabilities, including poverty, food insecurity, and malnutrition, to the extent that the presence of obesity may not significantly increase the risk of COVID-19 mortality, or it may even act as a protective factor (the obesity paradox)[41]. Conversely, in Brown women, who experience comparatively fewer vulnerabilities in their social position, obesity emerges as a factor that elevates the risk of mortality. Interestingly, the prevalence of obesity was similar in both groups in our study.

Limitations and strengths

This study has some limitations. Both obesity and race were self-reported or reported by the accompanying person, and in patients with more severe disease, they were probably more often reported by the accompanying person, which may have led to differential classification error in these cases. Regarding obesity, overweight people may have reported having obesity and vice versa, which may have introduced classification bias. Also, it was not possible to classify individuals according to different degrees of obesity. Furthermore, some variables, for which mandatory reporting is not obligatory, exhibited a substantial amount of missing data. For instance, the variable 'level of education' was not included in the adjustments due to a high percentage of missing data (57.2%). Although we conducted an analysis adjusted for education with a reduced population size, the results remained consistent. The variables race and mortality had 0.4 and 4.4% missing data, respectively, and we assumed a random pattern of missing data. Lastly, it's important to note that logistic regression may have potentially overestimated the association measures observed in this study[42].

This study has important strengths. We analyzed a large population of persons hospitalized for COVID-19 in the first two years of the pandemic in Brazil. The analyses followed a previous conceptual model and were stratified by gender, which allowed an intersectional analysis of the findings. Finally, to our knowledge, this is the first study to explore the role of race in the association between obesity and COVID-19 mortality, contributing to a better understanding of the impact of racial inequalities on the COVID-19 pandemic.

Conclusion

This study used COVID-19 hospitalization data in the state of Rio Grande do Sul from 2020 to 2021 to investigate the association between race and COVID-19 mortality and to assess the possible modifying effect of obesity on this association. Brown and Black individuals had a higher likelihood of death from COVID-19 than white individuals; when considering gender, the highest likelihood of death was among Brown women. Obesity was an effect modifier of the association between race and COVID-19 mortality, increasing the likelihood of death in the group of Brown women, after adjusting for age, presence of other comorbidities, and hospital care. While being a Black woman was associated with higher mortality only in the absence of obesity.

Future studies with direct measurement of weight, height, and adiposity, and even assessment of food security, may help better understand the role of nutritional status in the increased risk of mortality in the Brown and Black population in Brazil. These studies are crucial for the development of public policies on food, nutrition, and health that focus on combating social and racial inequities in Brazil.

Data availability

All data used in this study were extracted from the Brazilian Epidemiological Surveillance Information System (SIVEP for short, in Portuguese) for Influenza (SIVEP-Influenza), available at: https://opendatasus.saude.gov.br/dataset?tags=SRAG.

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Declarations

Competing interests
The authors declare no competing interests.

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