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Evaluation of the case fatality rate in 2 031 309 hospitalised Brazilian patients due to COVID-19: An observational study of the first 3 years of the pandemic in Brazil

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ABSTRACT

Introduction Since the beginning of the COVID-19 pandemic, in Brazil, there has been a high rate of deaths, mainly among those who were hospitalised due to the disease and those who needed intensive care units (ICUs) and mechanical ventilation support.

Methods The study evaluated the hospitalised patients with COVID-19 as well as subgroups considering those hospitalised patients who needed ICU treatment and those who received invasive mechanical ventilation in an ICU. The risk of death was compared in these three groups with adjustments for gender, age, race and comorbidities. A multivariable analysis was performed to identify the main predictors of death. A hospitalised patient was considered COVID-19 positive if they had a positive real-time polymerase chain reaction (RT-PCR) or serological test, followed by a notification form completed by a health professional, usually a medical doctor. The study was approved by the ethics committee of the institution (Certificate of Presentation of Ethical Appreciation n° 67241323.0.0000.5514; Study Approval Technical Opinion n° 5.908.611).

Results The study evaluated 2 031 309 hospitalised individuals with COVID-19. The case fatality rate was 33.2% (673 527/2 031 309). The case fatality rate was even higher among those patients who required ICU (372 031/665 621; 55.9%) treatment with the need for invasive ventilation support (240 704/303 505; 79.3%). In the multivariable analysis, the male sex (OR=1.14; 95% CI=1.13–1.15), older age [61 to 72 years old (OR=2.43; 95% CI=2.41–2.46), 83 to 85 years old (OR=4.10; 95% CI=4.06–4.14) and+85 years (OR=6.98; 95% CI=6.88–7.07)], race [mixed individuals (*Pardos*) (OR=1.33; 95% CI=1.32–1.34), Black people (OR=1.57; 95% CI=1.55–1.60) and Indigenous peoples (OR=1.82, 95% CI=1.69–1.97)] and the presence of comorbidities [mainly, hepatic disorder (OR=1.80; 95% CI=1.73–1.87), immunosuppressive disorder (OR=1.80; 95% CI=1.76–1.84) and kidney disorder (OR=1.67; 95% CI=1.64–1.70)] were associated with an increased chance of death, except asthma (OR=0.77; 95% CI=0.75–0.79). In addition, among all admitted patients with COVID-19, the need for an ICU (OR=2.08; 95% CI=2.06–2.13) and invasive ventilatory support (OR=14.86; 95% CI=14.66–15.05) had an impact on death as an outcome.

Conclusion Although the number of daily deaths from the coronavirus dropped during the COVID-19 pandemic in Brazil, our retrospective analysis showed a higher case fatality rate in patients requiring ICU, mainly when using invasive ventilation, compared with the rest of the world.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ COVID-19 has wide phenotypic variability with mild to severe symptoms that can culminate in the need for hospitalisation and intensive support with the need for mechanical ventilation. During the COVID-19 pandemic, many countries presented high rates of infection, which culminated in a negative impact on health services, especially those of universal healthcare systems. Brazil experienced a significantly high incidence of SARS-CoV-2 infection and mortality rates compared with other nations. Furthermore, although significant advances in understanding the disease have been reported, there is still much to learn about the disease.

INTRODUCTION

Brazil is one of the countries most affected by the COVID-19 pandemic, with high rates of death, mainly among those who were hospitalised due to the disease, culminating in the need for intensive care units (ICUs) and mechanical ventilation support.[1–3] To date, on 13 April 2024, SARS-CoV-2 infection affected 704 753 890 individuals, causing the deaths of 7 010 681 individuals worldwide.[4] At the same time, Brazil counted 38 743 918 cases and 711 380 deaths.[4]

In such context, we performed an epidemiological study using the data available at Open-Data-SUS (https://opendatasus.saude.

WHAT THIS STUDY ADDS

⇒ The present study describes the mortality rates associated with hospitalisation due to COVID-19 in Brazil during the 3 years of the pandemic. The study calculated the death rate in three groups: (a) all hospitalised patients, (b) hospitalised patients who required intensive care and (c) hospitalised patients who required intensive care with invasive ventilatory support. Among the study findings, there were higher mortality rates in Brazil in patients who need intensive care, mainly associated with invasive ventilation compared with the global scenario. Furthermore, demographic and clinical factors were associated with a higher risk of death. In this context, there is a need for effective management and resource allocation strategies. These findings highlight the importance of contextualised approaches in combating COVID-19, offering crucial insights into the determinants of mortality, to guide public health efforts to reduce fatalities, especially in our country, which was one of the epicentres of the disease.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study could have significant implications for research, practice and policies related to the management of COVID-19, especially in scenarios of health service collapse like the one that occurred in Brazil. The findings provide insights into the factors that contribute to mortality among hospitalised patients, enabling further investigation into the underlying mechanisms and the development of effective interventions for populations, especially those at high risk. Healthcare professionals can use the results shown to optimise management strategies, especially in intensive care units and in individuals requiring invasive ventilation, adapting treatment approaches to improve infection outcomes through personalised medicine. Health managers can use the findings of this study to direct public health policies to reduce mortality rates, including improving access to critical services and health infrastructure. Preventative measures, such as the use of masks and social distancing, should also be highlighted. This multifaceted approach is highlighted as crucial to meeting the challenges of the current pandemic and future events.

gov.br/)[5] from 1 January 2020 to 6 April 2023, which comprised 3 years of the pandemic in Brazil to evaluate the case fatality rate in hospitalised Brazilian patients due to COVID-19, particularly among those who required ICU treatment or even to receive invasive mechanical ventilation.

METHODS

The severe acute respiratory infection surveillance data were recorded by the Brazilian Ministry of Health using the Information System Platform for Epidemiological Surveillance of Influenza (SIVEP-Flu, acronym for *Sistema de Informação de Vigilância Epidemiológica da Gripe*). From this dataset, the patients with COVID-19 were classified into the following groups: (a) the entire population of hospitalised patients with COVID-19, (b) hospitalised patients with COVID-19 who needed intensive care treatment and (c) hospitalised patients with COVID-19 who received invasive mechanical ventilation (figure 1). The dataset is representative of the entire Brazilian population since the Brazilian Ministry of Health records it from the entire Brazilian territory.

The clinical characteristics included in the study were gender (male and female), age (grouped in the following categories: <1-year-old, 1 to 12 years old, 13 to 24 years old, 25 to 60 years old, 61 to 72 years old, 73 to 85 years old and +85 years old, race (White people, Black people, Asian individuals, Mixed (*Pardos* or Brown) individuals and Indigenous peoples) and comorbidities (comorbidity (any), cardiopathy, haematological disorder, Down syndrome, hepatic disorder, asthma, diabetes mellitus, neurological disorder, chronic lung disease, immunosuppressive disorder, kidney disorder, obesity and other comorbidities). The comorbidities evaluated in the study were obtained directly from the original data published by the Brazilian Ministry of Health. Finally, the number of vaccines against COVID-19 distributed in Brazil was presented in the online supplemental material of the study and was not included as an adjustment because of the high rate of missingness.

The race classification was performed according to the Brazilian Institute of Geography and Statistics,[6] and the age stratification was performed according to the literature and previous study from our study group.[7–12] The 'comorbidities (any)' category includes anyone with at least one comorbidity. The 'other comorbidities' category includes anyone with at least one comorbidity not included in the other comorbidity categories. The data collection for gender, age, race and comorbidities was performed during the admission of the patient at the hospital by a health professional, usually a medical doctor.

A hospitalised patient was considered COVID-19 positive if they had a positive real-time polymerase chain reaction (RT-PCR) or serological test, followed by a notification form completed by a health professional, usually a medical doctor.[13]

Missing data were imputed for characteristics that had between 5% and 40% missingness in the database. Characteristics with more than 40% missing data were excluded from the inferential statistical plan such as the vaccination status against COVID-19. We included the missing data only for the independent variables such as gender, age, race and comorbidities. Patients with missing data for dependent variables were not included in the study. Missing data were thus imputed using XLSTAT Statistical Software for Excel (Addinsoft Inc, Paris, Île-de-France, France). Missing qualitative data (categorical data) were estimated using the NIPALS (Nonlinear Iterative Partial Least Squares) algorithm. In our study, we did not evaluate non-categorical data. The XLSTAT statistical software generated a new Excel data set (.xls), which was used to perform statistical analyses in the Statistical Package for the Social Sciences (SPSS) software (IBM SPSS Statistics for Macintosh, Version 27.0, IBM Inc., Armonk NY, USA) and OpenEpi software (OpenEpi: Open-Source Epidemiologic Statistics for Public Health, Version 3.01. www.OpenEpi.com, April 06, 2013). The chance of death

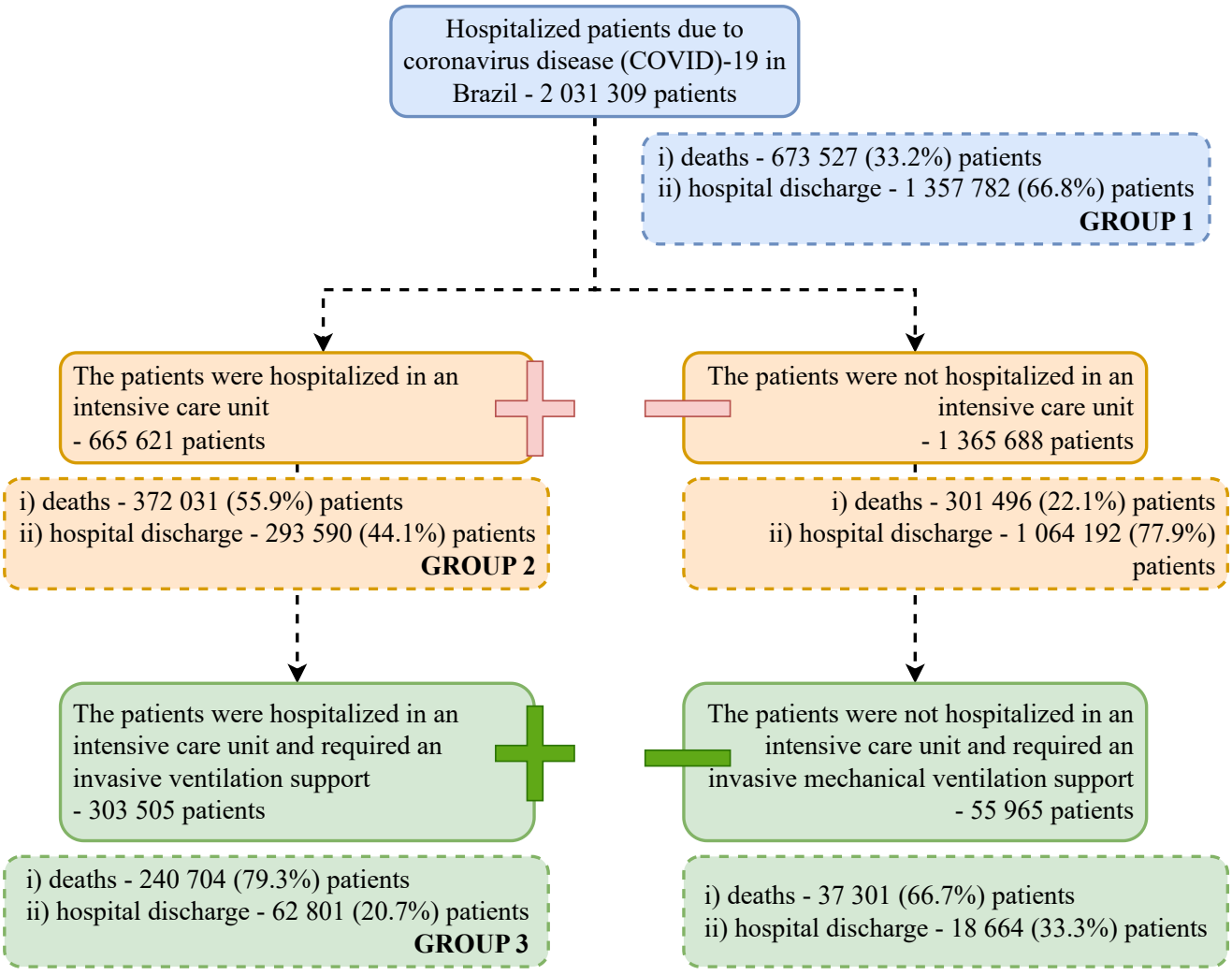

Figure 1 Flowchart of inclusion of patients with COVID-19 in Brazil. The data are presented according to the absolute (N) and relative (%) numbers. The entire population was evaluated as Group 1. The patients who needed intensive care unit (ICU) were accounted for in the group of hospitalised patients due to COVID-19 (Group 2). The patients who needed ICU and received invasive mechanical ventilation were accounted for in the group of hospitalised patients due to COVID-19 as well as in the group of patients who needed ICU (Group 3). The data presented in the study are available at Open-Data-SUS (https://opendatasus.saude.gov.br/).

among the patients was estimated and stratified by clinical characteristics in each of the three groups.

The X^2 test was used to evaluate the differences and significance of the presence of death or clinical recovery (hospital discharge) according to the clinical characteristics of the individuals with a positive SARS-CoV-2 infection. In our data, the results from the X^2 test were used to select the markers to be included in the multivariable analysis. The OR and 95% CI were calculated to estimate the association of each marker with death. The study presented the OR and its CI as measures of association according to the main characteristics of our dataset. The OR was calculated using the OpenEpi software for 2×2 tables, including the value for each patient characteristic.

Multivariable analysis was performed using the Binary Logistic Regression Model with the Backward Stepwise method. The response variable was the health outcome (recovery—hospital discharge or death). Data for comorbidities (any) or others and patient characteristics with *P* value >0.05 in the bivariate analysis were not used. Multicollinearity among the study markers considering cut-off points <0.1 for tolerance and >10 for the variance inflation factor was tested before carrying out the statistical inference analysis.

The results were compiled in tables and figures. Figures were created using GraphPad Prism version 10.2.3 for Mac (http://www.graphpad.com, GraphPad Software, San Diego CA, USA). In the figures, the ORs and their 95% CI are presented using a Log_{10} rank scale due to the higher OR identified for the use of invasive mechanical ventilation. An alpha value of 0.05 was set as statistically significant.

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institution's Ethics Committee (Certificate of Presentation of Ethical Appreciation n° 67241323.0.0000.5514; Study Approval Technical Opinion n° 5.908.611).

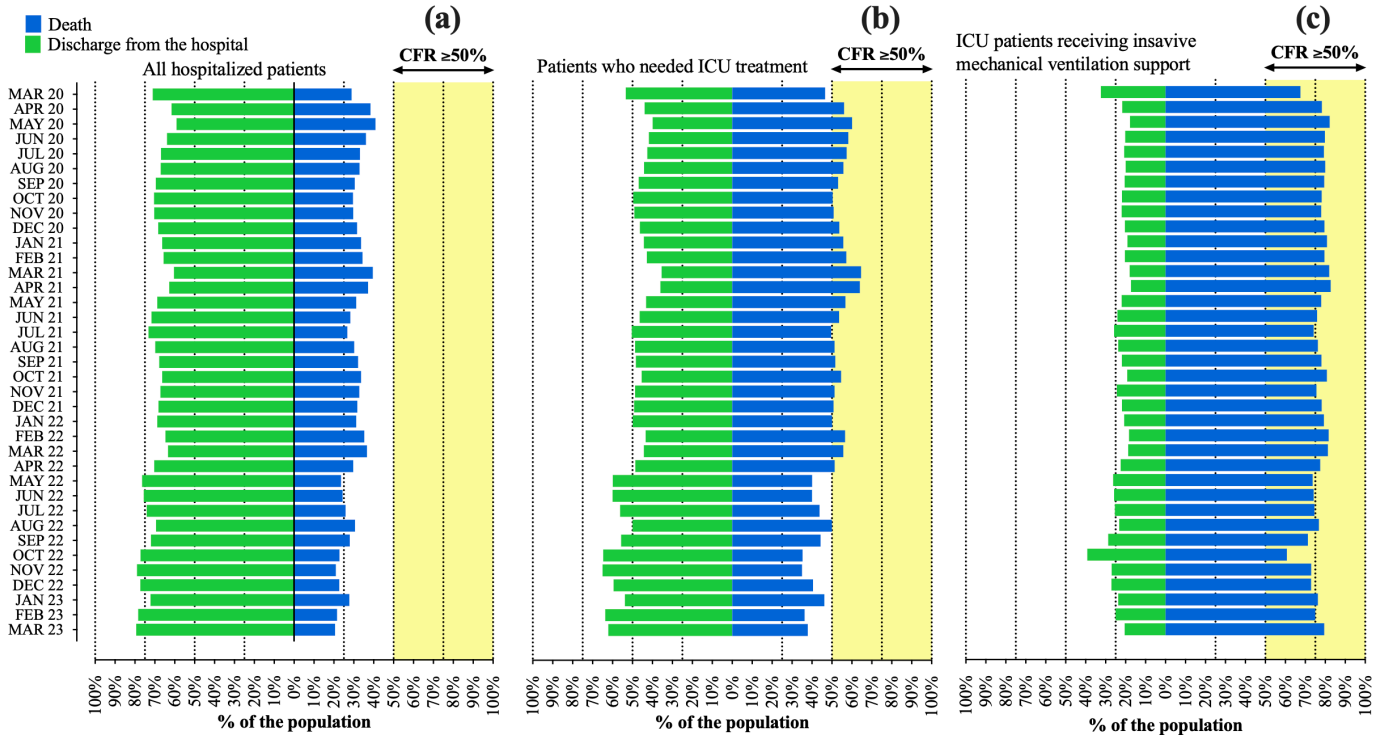

Figure 2 (a) Percentage of deaths (case fatality rate, CFR) among hospitalised patients due to COVID-19 in Brazil according to the months of filling out the notification form. (b) Percentage of deaths among hospitalised patients due to COVID-19 in Brazil who needed intensive care treatment according to the months of filling out the notification form. (c) Percentage of deaths among hospitalised patients due to COVID-19 in Brazil who received invasive mechanical ventilation support according to the months of filling out the notification form. The individuals' data were retrieved from the Brazilian Ministry of Health – Open-Data-SUS (https://opendatasus.saude.gov.br/) platform and corresponded to 3 years of the COVID-19 pandemic (from 1 January 2020 to 6 April 2023). In March 2020, 11 cases from February 2020 were included; and in March 2023, 13 cases from April 2023 were included. The complete information is presented in table 1. The vaccination against COVID-19 started in January 2021 in Brazil. The patients who needed intensive care unit (ICU) admission were accounted for in the group of hospitalised patients due to COVID-19. The patients who needed ICU admission and received invasive mechanical ventilation were accounted for in the group of hospitalised patients due to COVID-19 as well as in the group of patients who needed ICU admission. The complete information about the study grouping can be assessed in figure 1.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

RESULTS

Our study had an initial sample of 3 551 556 hospitalised patients presenting severe acute respiratory infections. Of those patients, 2 031 309 individuals had COVID-19 and 673 527 (33.2%) died. Of the entire study population, 665 621 patients were hospitalised in an ICU, and, among them, death occurred for 372 031 (55.9%) cases. Also, among the patients treated in an ICU, 303 505 used invasive mechanical ventilation support with a case fatality rate of 79.3% represented by the death of 240 704 individuals (figure 1).

In Brazil, there were high rates of deaths associated with COVID-19 in the entire study population. The rates varied from 20.6% (March 2023) to 40.9% (May 2020) (online supplemental table 1, figure 2). In addition, among those patients who needed intensive care treatment, the rates varied from 35.4% (March 2021) to 65.0% (November 2022) (online supplemental table 1, figure 2). Those rates were even higher in patients who were hospitalised in an ICU and required invasive mechanical ventilation support. The case fatality rates varied from 60.8% (October 2022) to 82.7% (April 2021) (online supplemental table 1, figure 2). Among patients who required invasive mechanical ventilation support, there were 8 months where the case fatality rate was above 80% ((2020) May and August, (2021) January, March, April, and November, (2022) February and March). COVID-19 vaccination was rolled out in January 2021 in Brazil. After the vaccination, there was a huge reduction in the number of hospitalisations, which dropped from 139 903 (March 2021) to 2716 (March 2023). The reduction in the number of hospitalisations was accompanied by a reduction in the need for intensive care and invasive ventilatory support. The complete information about the case fatality rates as well as the number of discharges from the hospital are presented in online supplemental table 1 and figure 2.

Table 1 presents the clinical characteristics of hospitalised patients due to COVID-19 in Brazil. Among

Table 1 Distribution of the clinical characteristics among hospitalised Brazilian patients due to COVID-19 according to notification date and the need for intensive care unit (ICU) treatment and ICU plus invasive mechanical ventilation (IMV) treatment

Marker	Data	Hospitalised patients with COVID-19 (n=2 031 309)	Patients who needed ICU** (n=665 621)	Patients who needed ICU and received IMV†† (n=303 505)
Gender	Male	1 118 526 (55.1%)	378 675 (56.9%)	172 754 (56.9%)
	Female	912 783 (44.9%)	286 946 (43.1%)	130 751 (43.1%)
Age	<1 year old	16 700 (0.8%)	4589 (0.7%)	1356 (0.4%)
	1 to 12 years old	26 038 (1.3%)	5707 (0.9%)	1462 (0.5%)
	13 to 24 years old	41 242 (2.0%)	9164 (1.4%)	3384 (1.1%)
	25 to 60 years old	984 220 (48.5%)	291 745 (43.8%)	126 581 (41.7%)
	61 to 72 years old	462 106 (22.7%)	170 771 (25.7%)	85 840 (28.3%)
	73 to 85 years old	369 429 (18.2%)	139 190 (20.9%)	67 661 (22.3%)
	+85 years old	131 574 (6.5%)	44 455 (6.7%)	17 221 (5.7%)
Race	White people	1 166 448 (57.4%)	389 697 (58.5%)	175 905 (58.0%)
	Black people	86 408 (4.3%)	29 050 (4.4%)	13 780 (4.5%)
	Asian individuals	19 955 (1.0%)	6602 (1.0%)	2824 (0.9%)
	Mixed individuals (*Pardos*)	754 479 (37.1%)	239 319 (36.0%)	110 503 (36.4%)
	Indigenous peoples	4019 (0.2%)	953 (0.1%)	493 (0.2%)
Comorbidities	Comorbidity (any)‡	1 479 585 (72.8%)	526 933 (79.2%)	247 209 (81.5%)
	Cardiopathy	928 332 (45.7%)	327 842 (49.3%)	153 425 (50.6%)
	Haematological disorder	13 448 (0.7%)	5409 (0.9%)	2686 (0.9%)
	Down syndrome	5491 (0.3%)	2345 (0.4%)	1217 (0.4%)
	Hepatic disorder	15 396 (0.8%)	6688 (1.0%)	3658 (1.2%)
	Asthma	49 663 (2.4%)	17 225 (2.6%)	7777 (2.6%)
	Diabetes mellitus	614 977 (30.3%)	220 313 (33.1%)	106 596 (35.1%)
	Neurological disorder	74 087 (3.6%)	28 596 (4.3%)	13 583 (4.5%)
	Chronic lung disease	67 112 (3.3%)	29 204 (4.4%)	15 270 (5.0%)
	Immunosuppressive disorder	46 836 (2.3%)	18 545 (2.8%)	9554 (3.1%)
	Kidney disorder	69 090 (3.4%)	33 249 (5.0%)	17 123 (5.6%)
	Obesity	160 729 (7.9%)	77 275 (11.6%)	42 529 (14.0%)
	Other comorbidities‡	853 575 (42.0%)	298 734 (44.9%)	137 892 (45.4%)
ICU	Presence	665 621 (32.8%)	NA	NA
	Absence	1 365 688 (67.2%)	NA	NA
Mechanical ventilatory support	Invasive	359 470 (17.7%)	303 505 (45.6%)	NA
	Non-invasive	1 294 610 (63.7%)	309 691 (46.5%)	NA
	None	377 229 (18.6%)	52 425 (7.9%)	NA

The data is presented according to the absolute (N) and relative (%) numbers.
The data presented in the study is available at Open-Data-SUS (https://opendatasus.saude.gov.br/).
*The patients who needed ICU were accounted for in the group of hospitalised patients due to COVID-19.
†The patients who needed ICU and received invasive mechanical ventilation support were accounted for in the group of hospitalised patients due to COVID-19 as well as in the group of patients who needed ICU admission. The complete information about the study grouping can be assessed in figure 1.
‡About the comorbidities, the comorbidity (any) marker represents the presence of at least one comorbidity. In addition, the other comorbidity marker represents the presence of at least one comorbidity that was not classified in the other groups of clinical markers.
NA, not applicable.

the patients, there was a high prevalence of male sex (55.1%), individuals aged between 25 and 60 years (48.5%) and White people (72.8%). The similar clinical profile was observed for the patients who were hospitalised in an ICU even using invasive mechanical ventilation. At least 72.8% of the patients presented one comorbidity in the entire population. However, this number increased to 79.2% among those individuals hospitalised in an ICU and to 81.5% in the cases of patients hospitalised in an ICU using invasive mechanical ventilation support. The main comorbidities in the entire study population were cardiopathies (45.7%), diabetes mellitus (30.3%) and obesity (7.9%). The same comorbidities presented higher prevalence in the other study groups (patients treated in an ICU and patients treated in an ICU using invasive mechanical ventilation support).

The association between the clinical markers evaluated in the study and the chance of death is presented in detail for the three groups as follows: (a) all admitted patients with COVID-19 (figures 3 and 4, online supplemental table 2); (b) among those who needed ICU treatment (figures 3 and 4, online supplemental table 3); (c) and among those who received invasive mechanical ventilation support (figures 3 and 4, online supplemental table 4).

Among all admitted patients with COVID-19, the male sex (33.6% vs 32.6%), older age [61 to 72 years old (40.7% vs 21.7%), 83 to 85 years old (50.9% vs 21.7%) and +85 years (58.7% vs 21.7%)], race [Black people (39.5% vs 31.6%), Indigenous peoples (35.9% vs 31.6%) and Mixed individuals (*Pardos*) (34.8% vs 31.6%)] and the presence of comorbidities [mainly, kidney disorder (55.0% vs 32.4%), hepatic disorder (52.4% vs 33.0%) and neurological disorder (51.6% vs 32.5%)] were associated with an increased chance of death, except asthma (28.2% vs 33.3%). In addition, among all admitted patients with COVID-19, the need for an ICU admission (55.9% vs 22.1%) and invasive ventilatory support (77.3% vs 13.4%) had an impact on death as an outcome (figures 3 and 4, online supplemental table 2).

In the group of patients who required ICU treatment, the following clinical characteristics were associated with a higher chance of death: older age [61 to 72 years old (63.3% vs 44.2%), 83 to 85 years old (70.8% vs 44.2%) and +85 years (73.1% vs 44.2%)], race [Black people (61.2% vs 54.1%), Indigenous peoples (61.2% vs 54.1%) and Mixed individuals (*Pardos*) (58.2% vs 54.1%)] and the presence of comorbidities [mainly, hepatic disorder (72.4% vs 55.7%), kidney disorder (71.0% vs 55.1%) and chronic lung disease (69.9% vs 55.3%)], except asthma (50.5% vs 56.0%). In addition, the need for invasive mechanical ventilatory support (79.3% vs 22.2%) had an impact on death as an outcome (figures 3 and 4, online supplemental table 3).

Among the patients who required invasive mechanical ventilation in an ICU, the following clinical characteristics were associated with a higher chance of death: male sex (79.7% vs 78.8%), older age [61 to 72 years old (84.0% vs 70.1%), 83 to 85 years old (90.2% vs 70.1%) and +85 years (93.1% vs 70.1%)], race [Black people (83.2% vs 77.4%), Mixed individuals (*Pardos*) (81.9% vs 77.4%) and Indigenous peoples (81.5% vs 77.4%)] and the presence of comorbidities [mainly, kidney disorder (88.8% vs 78.7%), hepatic disorder (87.6% vs 79.2%) and chronic lung disease (87.2% vs 78.9%)], except asthma (75.4% vs 79.4%) (figures 3 and 4, online supplemental table 4).

In the multivariable analysis, male sex, older age [61 to 72 years old, 83 to 85 years old, and +85 years], race [mixed individuals (*Pardos*), Black people and Indigenous peoples] and the presence of comorbidities [mainly, hepatic disorder, immunosuppressive disorder and kidney disorder] were associated with an increased chance of death. In addition, among all admitted patients with COVID-19, the need for an ICU and invasive ventilatory support had an impact on death as an outcome (figure 4, online supplemental table 5).

In Brazil, there is a great difference in the number of cases by Federal Units (online supplemental table 6). Also, during the pandemic, some Brazilian states presented higher rates of deaths, for example, Espírito Santo (55.3%), Sergipe (52.0%), Rio de Janeiro (43.6%), Rondônia (43.3%) and Maranhão (42.9%). In contrast, the Federal District (24.2%) and other states presented lower rates, such as Mato Grosso (22.7%), Santa Catarina (27.6%), Amapá (29.5%) and São Paulo (29.7%). Finally, the description of vaccination status among hospitalised Brazilian patients due to COVID-19 according to notification date and the need for ICU treatment or ICU treatment plus invasive mechanical ventilation support is presented in online supplemental table 7 where it is possible to identify an increase in vaccination coverage against COVID-19 among the hospitalised individuals [24.2% (January 2021) to 85.5% (December 2022) in 2 years]. An overview of the results is presented in online supplemental figure 1 (Graph Abstract).

DISCUSSION

The overall case fatality rate related to COVID-19 in hospitalised patients in Brazil was 33.2%. This was higher than rates in other countries, which were between 9 and 17%.[14] For patients who required treatment in an ICU, the observed case fatality rate was 55.9%. This rate is also above the world rate, which varies between 24 and 51.0%.[14] The case fatality rate for patients undergoing invasive mechanical ventilation in an ICU was 79.3% as the worldwide mortality estimated rate was 39 and 52%.[15]

Some factors that may explain the higher case fatality rate of these patients in Brazil are the lack of governmental support measures in the fight against the COVID-19 pandemic, the lack of proper equipment to perform the invasive mechanical ventilation support and the shortage of beds in ICUs in the pandemic onset, which was associated with changes in health services in a disorganised manner so that there was an increase in

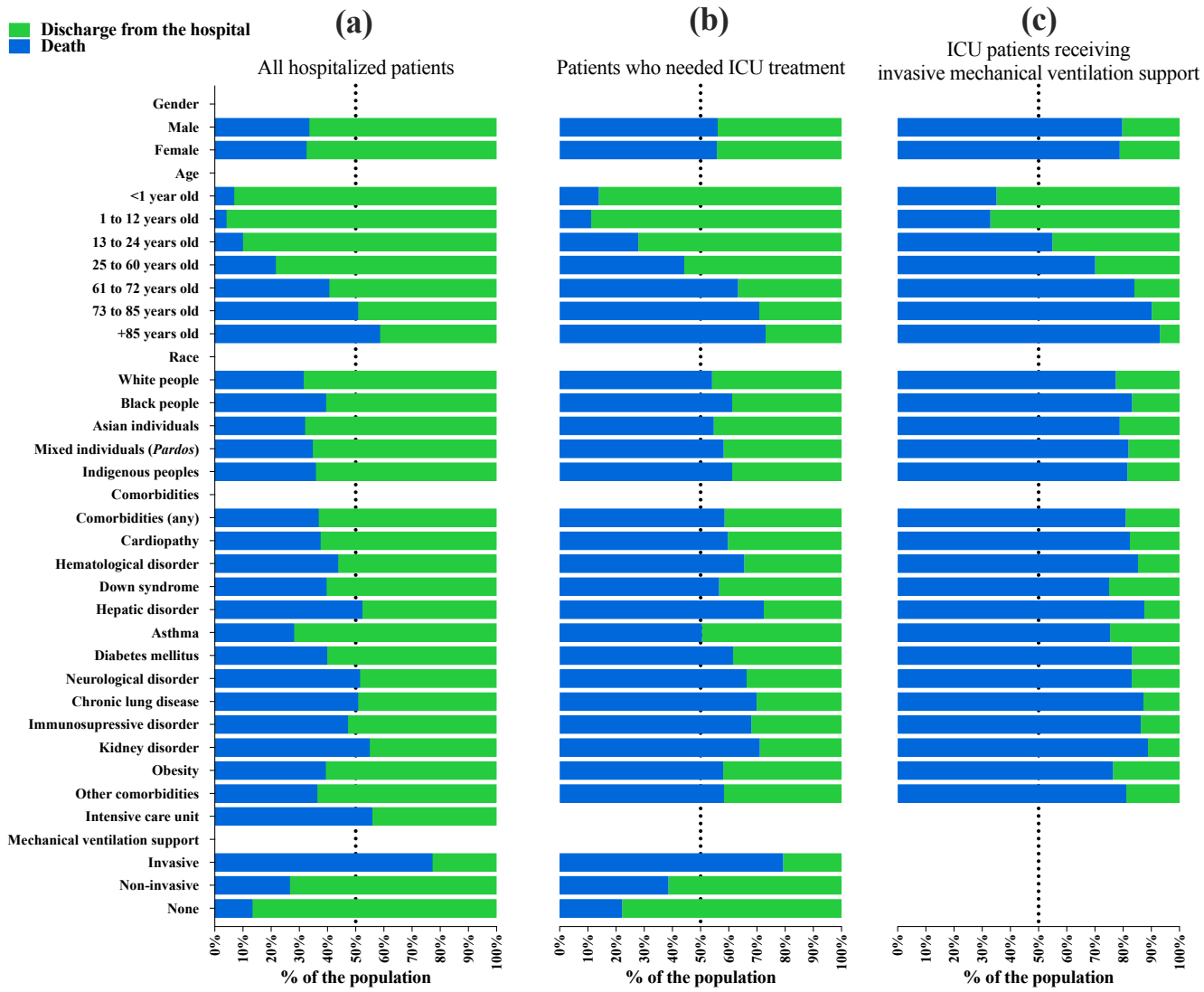

Figure 3 Clinical characteristics of the hospitalised patients with COVID-19 in Brazil. (a) Percentage (%) of deaths among hospitalised patients due to COVID-19 in Brazil according to the clinical characteristics. (b) Percentage (%) of deaths among hospitalised patients due to COVID-19 in Brazil who needed intensive care treatment according to the clinical characteristics. (c) Percentage (%) of deaths among hospitalised patients due to COVID-19 in Brazil who received invasive mechanical ventilation support according to the clinical characteristics. The individuals' data were retrieved from the Brazilian Ministry of Health – Open-Data-SUS (https://opendatasus.saude.gov.br/) platform and corresponded to 3 years of the COVID-19 pandemic (from 01 January 2020 to 06 April 2023). In March 2020, 11 cases from February 2020 were included; and in March 2023, 13 cases from April 2023 were included. The complete information is presented in online supplemental tables 2–4. The patients who needed intensive care unit (ICU) admission were accounted for in the group of hospitalised patients due to COVID-19. The patients who needed ICU admission and received invasive mechanical ventilation were accounted for in the group of hospitalised patients due to COVID-19 as well as in the group of patients who needed ICU admission. The complete information about the study grouping can be assessed in figure 1.

adapted ICUs.[15–17] In addition to the burden imposed on Brazil's public healthcare system, other factors may also have contributed to the alarming rates, such as social inequality, travel time and conditions to access health services with resources necessary for the management of critical patients, shortage of professional specialists and poor training of professionals, the unpreparedness of pre-pandemic healthcare providers and inappropriate use of drugs.[1 3 18–23]

Especially in the first 2 years of the pandemic, Brazil experienced a major health collapse in the public healthcare system.[24–26] The emergency to deal with the pandemic involved analysing data relating to the rate of spread of the virus in the population and how to implement effective measures against the growth in the number of cases, diagnosis and management of patients, especially those with a critical phenotype.[3 27] However, Brazil still needs to better understand the complexity and multidisciplinary

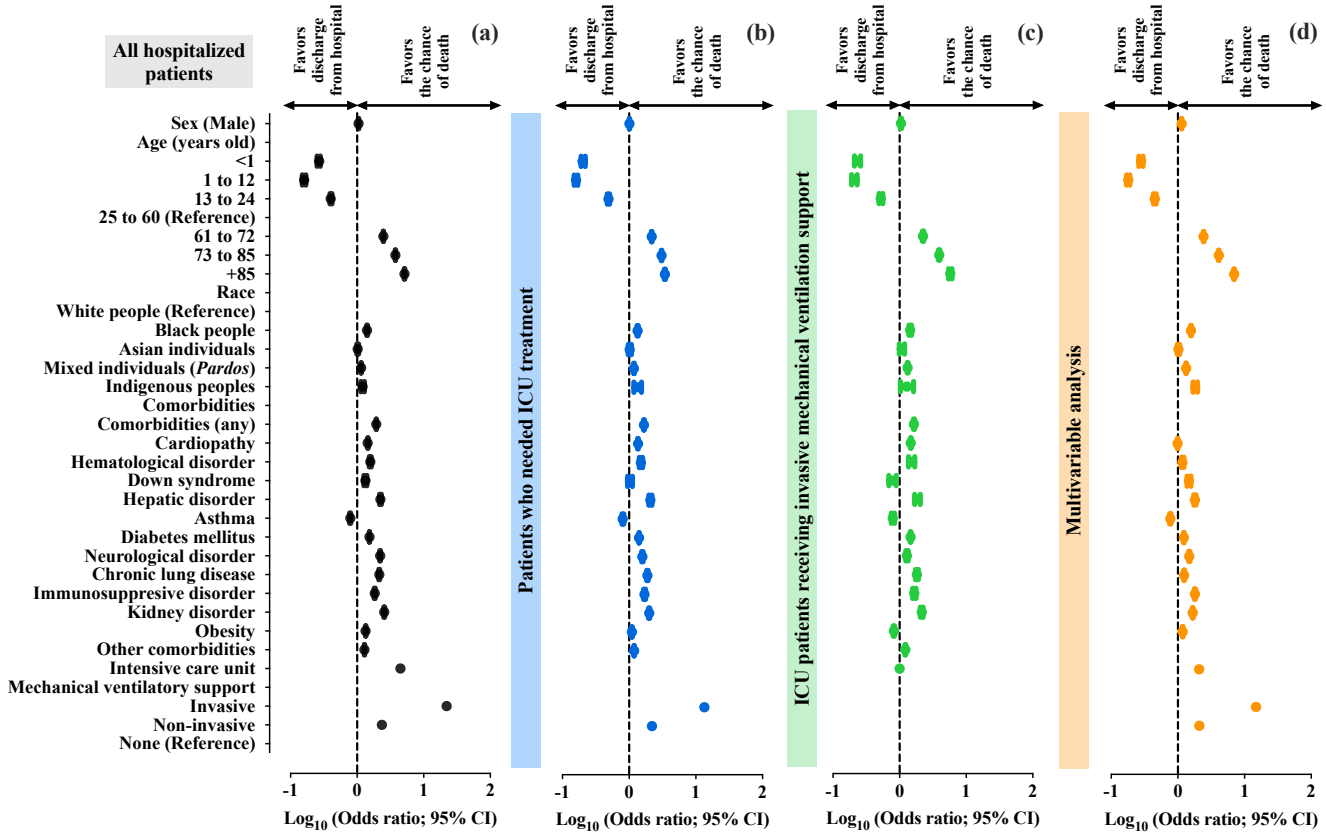

Figure 4 (a) Association between the clinical characteristics evaluated in the study with the chance of death among hospitalised patients due to COVID-19 in Brazil—among all admitted patients with COVID-19. (b) Association between the clinical characteristics with the chance of death among hospitalised patients due to COVID-19 in Brazil who needed intensive care treatment. (c) Association between the clinical characteristics and the chance of death among hospitalised patients due to COVID-19 in Brazil who received mechanical ventilation support in an intensive care unit (ICU). (d) Multivariable analysis for all admitted patients with COVID-19. The individuals' data were retrieved from the Brazilian Ministry of Health – Open-Data-SUS (https://opendatasus.saude.gov.br/) platform and corresponded to 3 years of the COVID-19 pandemic (from 1 January 2020 to 6 April 2023). In March 2020, 11 cases from February 2020 were included; and in March 2023, 13 cases from April 2023 were included. The statistical analysis was performed using the X^2 test, and multivariable analysis was performed using the Binary Logistic Regression Model with the Backward Stepwise method. Markers with *P* values ≤0.05 in the bivariate analysis (from the X^2 test) were included in the regression model. The response variable was the health outcome (hospital discharge or death). Data for comorbidities (any) or others and patient characteristics with *P* values >0.05 were not used. An alpha error of 0.05 was adopted in the study. The data are presented using a Log_{10} scale with the format Log. The complete information is presented in online supplemental table 2 to 5.

nature of the healthcare system in order to implement more effective treatments with fewer health inequalities for patients, especially in the context of pandemic situations.[28 29]

Regarding the association between the epidemiological and clinical markers with the chance of death, our study follows the literature which pointed to higher risk factors for poor outcomes for the male sex,[10 30] older age[31 32] and race—mainly among Black people, Mixed individuals and Indigenous peoples compared with White people.[7 12 21] In addition, the presence of comorbidities, including Down syndrome, diabetes mellitus, arterial hypertension, immunosuppressive disorder and obesity, has previously been found to be associated with death in patients infected by the SARS-CoV-2.[31 33 34] In contrast, asthma was protective against poor outcomes related to COVID-19.[11 35 36] The literature describes that asthma is not over-represented in hospitalised patients with severe pneumonia due to SARS-CoV-2 infection, and there was no increased risk of asthma exacerbations triggered by SARS-CoV-2.[35] Also, asthma was not found to be a risk factor for COVID-19-related morbidity and mortality.[36]

The epidemiological analysis of deaths related to COVID-19 in Brazil requires a comprehensive approach, based on robust data and scientific studies. Studies such as that by Bastos *et al* (2020) and Lana *et al* (2021) highlighted the association between pre-existing comorbidities and an increased risk of mortality from COVID-19 as demonstrated by us.[37 38] Additionally, longitudinal investigations, such as those conducted by Raimundo *et al* (2021), highlighted significant regional disparities in the lethality of the disease, pointing out the importance of unequal access to health services and disparities in health infrastructure as crucial determinants of mortality.[17]

These findings highlight the need for targeted public health policies and specific interventions to mitigate the adverse effects of the pandemic in the country.

In this context, in Brazil and around the world, concern must be maintained regarding investments in the health sector to promote better diagnosis and management of patients and, when possible, improving disease precautionary measures to avoid a health collapse like what occurred during the COVID-19 pandemic in Brazil.[31 33 34 39]

Despite the important contributions that our study presents to the scientific community and health management, mainly in the public sector, the study had some limitations. The study used a public database that may have been susceptible to data-recording errors. Our data did not contain important variables such as genetic variants associated with a SARS-CoV-2 infection. The study only covers the period that includes the date of hospitalisation and the outcome (hospital discharge or discharge); thus, it is not possible to assess the presence of sequelae. There was a high degree of missingness in vaccination data, which made it infeasible to include this variable in our multivariable analyses. Comorbidities were assessed on admission, and their classification was carried out individually by different health professionals. In Brazil, a high rate of underreporting of COVID-19 cases was described, which may reduce the generalisability of our findings.[40]

CONCLUSION

Although the number of daily deaths from the coronavirus dropped during the COVID-19 pandemic in Brazil, our retrospective analysis showed a higher case fatality rate in patients requiring ICU admission, mainly when using invasive ventilation, compared with the rest of the world.

Contributors CVCP, TMC, FEV and FALM substantially contributed to the conception and design of the work; FALM substantially contributed to the acquisition, analysis or interpretation of data for the work; CVCP, TMC, FEV and FALM drafted the work or reviewed it critically for important intellectual content; CVCP, TMC, FEV and FALM approved the final version to be published; CVCP, TMC, FEV and FALM agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. FALM accepts full responsibility for the finished work and/or the conduct of the study, had access to the data, and controlled the decision to publish. FALM is the scientific guarantor of the study's data and controlled the decision to publish.

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Patient consent for publication Not applicable.

Ethics approval The Ethics Committee of São Francisco University approved the research [Certificate of Presentation of Ethical Appreciation nº 67241323.0.0000.5514; Study Approval Technical Opinion nº 5.908.611]. We obtained the waiver of the Informed Consent Term since only the data from the patient's medical records were obtained without the individual description of the patient.

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Data availability statement Data are available upon reasonable request. The full dataset can be freely downloaded at the following link https://opendatasus.saude.gov.br. The dataset comprised information about hospitalised patients with COVID-19 from Brazil. The data were recorded by the Brazilian Ministry of Health. The image used in online supplementary figure 1 is part of the Microsoft 365 stock images. Microsoft 365 stock images are free to use for individuals with an approved license.

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