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Profile of hospital admissions and deaths due to severe acute respiratory syndrome caused by COVID-19 in Piauí, Brazil: a descriptive study, 2020-2021

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ABSTRACT

Objective: To describe the profile and temporal variation of hospital admissions and deaths due to severe acute respiratory syndrome (SARS) caused by COVID-19 in Piauí, Brazil, according to place of hospitalization. **Methods:** We performed a descriptive study using data from the Influenza Surveillance Information System between 2020 and 2021. Case fatality ratio among hospital records with outcome and respective 95% confidence intervals (95%CI) were calculated. **Results:** We included 12,649 individuals who were mostly male (57.1%), Black (61.2%) and had one or two comorbidities (30.5%). Case fatality ratio among hospital records with outcome was higher in the state's interior region than in its capital, with proportion of 44.1% (95%CI 42.0;46.3) for those who were hospitalized, 82.3% (95%CI 79.7;84.8) for those admitted to intensive care units and 96.6% (95%CI 94.9;97.8) for those undergoing invasive mechanical ventilation. **Conclusion:** The study enabled characterization of the profile of SARS hospitalizations due to COVID-19 in Piauí and demonstrated high case fatality ratio, among hospital records with outcome, which remained high during the study period, especially in the interior of the state.

Keywords: COVID-19; Hospitalization; Respiration, Artificial; Critical Care Outcomes; Epidemiology, Descriptive.

INTRODUCTION

In-hospital deaths arising from hospitalizations of individuals with COVID-19 has varied depending on the place of hospitalization. For example, while the proportion of in-hospital deaths was 15% in the United States[1] and 26% in the United Kingdom,[2] the average proportion in Brazil was 38%, regardless of age group.[3] Less developed Brazilian regions where social inequality is greater have even higher in-hospital proportion deaths, such as the Northeast region, 48%, and the Northern region, 50%.[3]

COVID-19 in-hospital mortality from may vary with age, race/skin color, difficulty in accessing immediate care and treatment resources, and other factors such as severity of the clinical picture and need for ventilatory support.[1-3] In Brazil, in-hospital COVID-19 deaths have reached levels above 60% in individuals aged 80 years or older, reaching 80% in those undergoing invasive mechanical ventilation.[3]

The state of Piauí, located in Northeast Brazil, has health indicators of concern related to poverty and less access to health services, such as high maternal mortality rate,[4] and is one of the Brazilian states with high risk of social inequalities impacting the COVID-19 pandemic. In Piauí, precarious sanitary conditions, low availability of hospital beds, lack of teams trained in intensive care, and lower availability of tests for diagnosing COVID-19 are considered risk factors for in-hospital COVID-19 deaths.[5-7] The growth in the number of cases in the municipalities in the interior of the state has increased concern about the available capacity of health services and their ability to meet the demands of severe cases that require hospitalization. In the absence of these services in the interior, the search for high complexity care in the capital, Teresina, tends to increase even more.

With the increased demand for public health services due to COVID-19 and the absence of coordinated actions between the three levels of Brazilian government, the state governments strategically prepared their own plans of action to address the pandemic.

Study contributions	
Main results	In Piauí, among hospital records with outcome, case fatality ratio was higth, especially in the interior of the state, pointing to regional differences in health care as factors that influence hospital outcomes.
Implications for services	The evidence attributed to the study contributes to the implementation of strategies aimed at reducing in-hospital deaths among COVID-19 cases, such as allocating resources in an equitable manner, in order to strengthen the entire health care network.
Perspectives	It is expected that the weaknesses pointed out in the organization of services in the state's health system will contribute to reevaluation of strategies to address the pandemic, as well as to evaluative studies on in-hospital deaths in Piauí.

The objective of this study was to describe the profile and temporal variation of hospital admissions and deaths due to severe acute respiratory syndrome (SARS) caused by COVID-19 in Piauí, Brazil, according to place of hospitalization.

METHODS

Design

This was a descriptive ecological study based on hospitalization records of individuals with COVID-19 held on the Influenza Epidemiological Surveillance Information System (SIVEP-Gripe), between epidemiological week (EW) 12/2020 (beginning March 15, 2020) and EW 12/2021 (ending March 27, 2021), in the state of Piauí, Brazil.

Background

Piauí had an estimated population of 3,289,820 inhabitants in 2021, distributed over 224 municipalities, divided into 11 health regions: Carnaubais; Cocais; Chapada das Mangabeiras; Entre Rios; Planície Litorânea; Serra da Capivara; Tabuleiros do Alto Parnaíba; Vale do Canindé; Vale dos Rios Piauí e Itaueiras; Vale do Rio Guaribas; and Vale do Sambito. The state capital, Teresina, had 868,075 (26.5%) inhabitants and is in the Entre Rios health region. Even after the increased supply of hospital beds in the interior of the state during the pandemic, in March 2021, 71% (302/428) of intensive care unit (ICU) beds were concentrated in the state capital. Three health regions in Piauí have no ICU beds: Tabuleiros do Alto Parnaíba, Vale do Sambito and Carnaubais.[8]

SIVEP-Gripe is Brazil's information system for epidemiological surveillance of influenza, on which SARS cases requiring hospitalization are recorded. Data from hospitalized individuals are anonymized and aggregated based on the SARS notification forms, and these public access databases are made available on a platform provided by the Brazilian National Health System Information Technology Department (DATASUS).

Study participants

This study included all records of individuals hospitalized with diagnosis of severe acute respiratory syndrome (SARS) in the state of Piauí between EW 12/2020 and EW 12/2021. Those who did not have diagnosis of COVID-19 recorded as the cause of SARS were excluded. In this way we ensured that only individuals hospitalized with COVID-19 were included in the analyses.

The steps involving period selection, criteria for including and excluding participants and other analyses were performed using R software version 4.0.2, after downloading the databases from the DATASUS platform.

Variables

We analyzed the following variables retrieved from the SIVEP-Gripe database relating to COVID-19 cases hospitalized in the period covered by the study:

a) sex (male; female);
b) age group (in years: 0-59; 60 or over);
c) race/skin color [White; Black (Black and Brown); Yellow; Indigenous; Unknown];
d) schooling (no schooling; complete elementary education; complete high school education; higher education);
e) comorbidities (0; 1-2; 3 or more);
f) place of hospitalization (capital; interior);
g) place of hospitalization in ICU (capital; interior);
h) date of hospitalization (day, month and year);
i) hospitalized in ICU (yes; no);
j) ventilatory support (no; non-invasive; invasive); and
k) hospital outcome (cure; death).

Data source and measurement

The hospital data we analyzed, taken from the SIVEP-Gripe system and made available on the DATASUS platform, relate to 2020[9] and 2021,[10] this being the study period corresponding to the first year of the pandemic in Piauí. Information about the number of ICU beds was obtained from the Piauí State Health Department website.[8]

COVID-19 case fatality ratio among hospital records with outcome was calculated by dividing the total number of subjects who died by the total number of records of subjects containing the hospital outcome (hospital discharge or death) at the time of data collection. ICU case fatality ratio among records with outcome was calculated by dividing the total number of ICU inpatients who died by the total number of ICU inpatients with a verified outcome. Case fatality ratio among records of individuals submitted to invasive mechanical ventilation was calculated by taking the number of individuals submitted to invasive mechanical ventilation who died, divided by the total number of inpatients with outcome submitted to invasive mechanical ventilation whose hospital outcome had been recorded.

Bias control

Due to information being missing for some variables on the SIVEP-Gripe database, these data were classified as 'unknown' and were excluded from the case fatality ratio calculation. Completeness of the variables used in the study was 84.5%; however, some variables, such as 'schooling' and 'comorbidity', had high 'unknown' percentages, equivalent to 59.1% and 63.3% respectively.

Statistical methods

We performed the analysis using R software, version 4.0.2. We undertook descriptive analysis of the data, calculating means and standard deviations (SD) for quantitative variables; and relative frequencies for categorical variables. 'Unknown' and blank variables were excluded from the descriptive analysis. COVID-19 case fatality ratio among records with outcome and its respective 95% confidence intervals (95%CI) were calculated using the Agresti & Coull method.[11] When making the comparison between the state capital and the interior region of the state, we considered different the 95%CI that did not overlap. Regarding the temporal variation analysis, COVID-19 case fatality ratio among records with outcome was calculated for four-week periods and according to place of hospitalization, i.e. interior or capital of the state.

Ethical aspects

This study used public access anonymous secondary data, so that there was no need to submit the project to a research ethics committee.

RESULTS

Between epidemiological weeks 12/2020 and 12/2021, 18,014 cases of individuals hospitalized due to SARS were recorded in the state of Piauí, according to the SIGEP-Gripe system. Of these, 5,365 (29.8%) were excluded for not having confirmed diagnosis of COVID-19 (3,906 without etiologic diagnosis, 1,218 awaiting results or without etiologic diagnosis, 216 affected by other respiratory viruses, and 25 affected by other causes). Of the 12,649 hospitalized individuals who had COVID-19, 5,866 (46.4%) were discharged, 3,277 (25.9%) died, and 3,506 (27.7%) had no information on hospital outcome at the time of data collection (Figure 1).

The mean age of the hospitalized individuals was 60±19 years. A total of 5,761 (45.5%) individuals were up to 59 years old, and 6,888 (54.5%) were aged 60 or over. The majority were male (57.1%), of Black race/skin color (61.2%), and had one or two comorbidities (30.5%). Most of the individuals were hospitalized in the state capital, accounting for 79.5% of total admissions, and 76.6% of them occupied ICU beds (Table 1).

Among the 9,143 individuals for whom hospital outcome (discharge or death) was recorded, case fatality ratio increased as the percentage of cases requiring intensive care and invasive procedures increased, approaching 100%, especially in the interior of the state (Table 2). Among the 2,096 individuals hospitalized with COVID-19 in the interior of the state and who had information on hospital outcome, 925 died, resulting in an case fatality ratio of 44.1% (95%CI 42.0;46.3). Among the 872 hospitalized in ICUs in the interior of the state who had information on hospital outcome, 718 died, corresponding to an case fatality ratio of 82.3% (95%CI 79.7;84.8), while among those undergoing invasive mechanical ventilation (n=679), 656 died, resulting in an case fatality ratio of 96.6% (95%CI 94.9;97.8) (Table 2).

In the state capital, the COVID-19 case fatality ratio among all hospitalized individuals whit outcome was 33.4% (95%CI 32.3;34.5), while it was 66.8% (95%CI 65.0;68.7) among those in ICUs and 84.0% (95%CI 82.1;85.7) among those undergoing invasive mechanical ventilation (Table 2).

Hospitalized individuals who were male, of Black race/skin color and had comorbidities had higher COVID-19 case fatality ratios (Table 2). A decrease in case fatality ratio was found as level of schooling increased, especially among hospitalized individuals living in the interior of the state, for whom COVID-19 case fatality ratio was 80.7% (95%CI 72.3; 87.1) among those with no

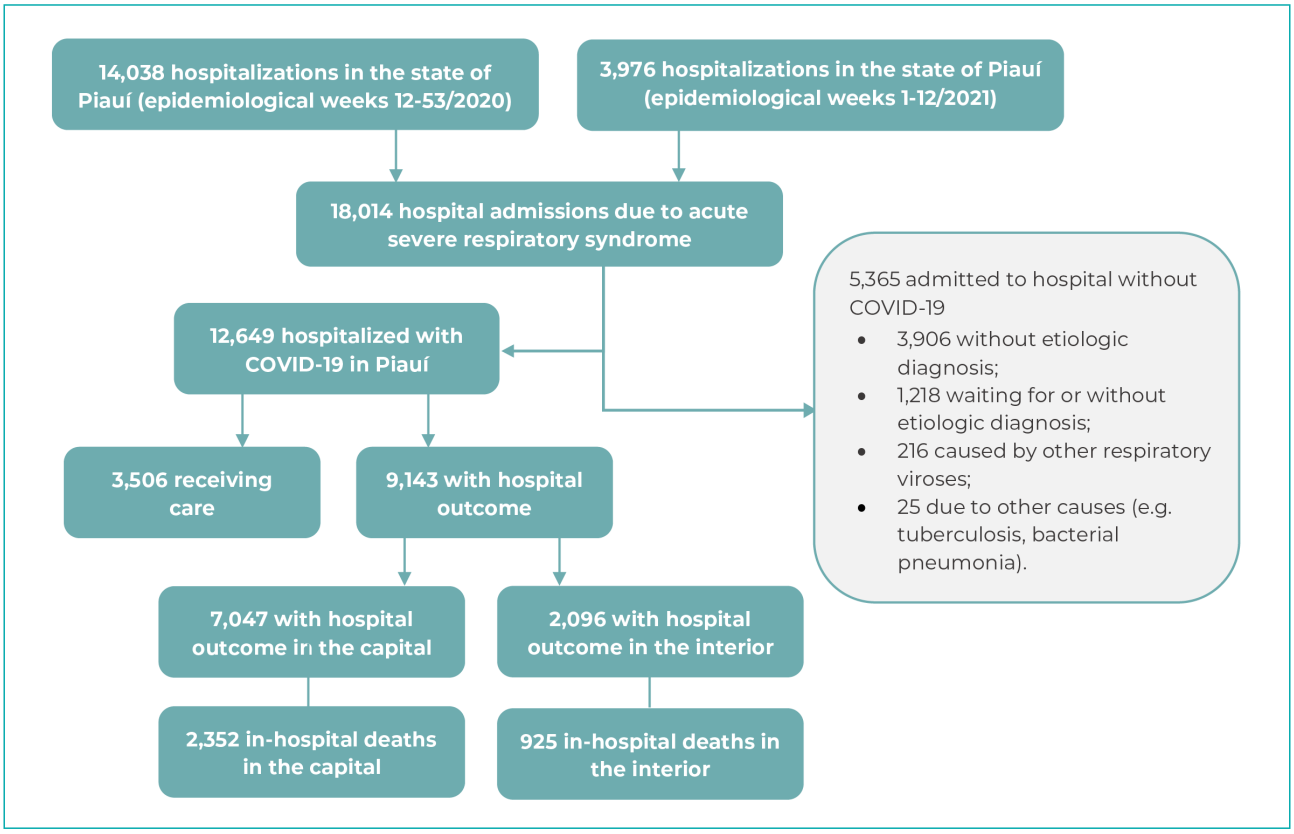


Figure 1 – Process for selection of hospitalized individuals diagnosed as having COVID-19 in Piauí, Brazil, March/2020 to March/2021

schooling, 77.8% (95%CI 71.7;82.9) among those with complete elementary education, 43.8% (95%CI 33.4;54.7) among those with high school education, and 41.9% (95%CI 26.4;59.3) among those with higher education qualifications (Table 2).

COVID-19 case fatality ratio among records with outcome was higher in the elderly, especially among those hospitalized in the interior of the state. Among individuals aged 60 years or older, case fatality ratio was 45.0% (95%CI 43.4;46.5) in the state capital and 55.4% (95%CI 52.8;58.1) in the interior. Among individuals of the same age group who required and received intensive care, case fatality ratio was 73.9% (95%CI 71.8;76.0) in the state capital and 86.5% (95%CI 83.6%;88.9) in the interior. With regard to those who underwent invasive ventilation, case fatality ratio in individuals aged 60 years or older was 88.9% (95%CI 86.9;90.7) in the state capital and 98.3% (95%CI 96.7;99.1) in the interior (Figure 2).

During the study period, differences were observed in the pattern of hospital admissions between the interior and capital of Piauí. In the capital, the peak in hospitalizations occurred between epidemiological weeks 24 and 27/2020, when 1,434 hospitalized individuals were recorded, whereas in the interior, the highest number of hospitalizations corresponded to epidemiological weeks 9 to 12/2021, when 351 hospitalizations were recorded (Figure 3A). In the capital, the peak in ICU admissions and in use of invasive respiratory support occurred between epidemiological weeks 24 and 27/2020, when 428 and 304 cases were recorded, respectively. In the interior of the state, the highest number of ICU hospitalizations and respiratory support use occurred between epidemiological weeks 9 and 12/2021, when 145 and 129 cases were recorded, respectively (Figures 3B and 3C).

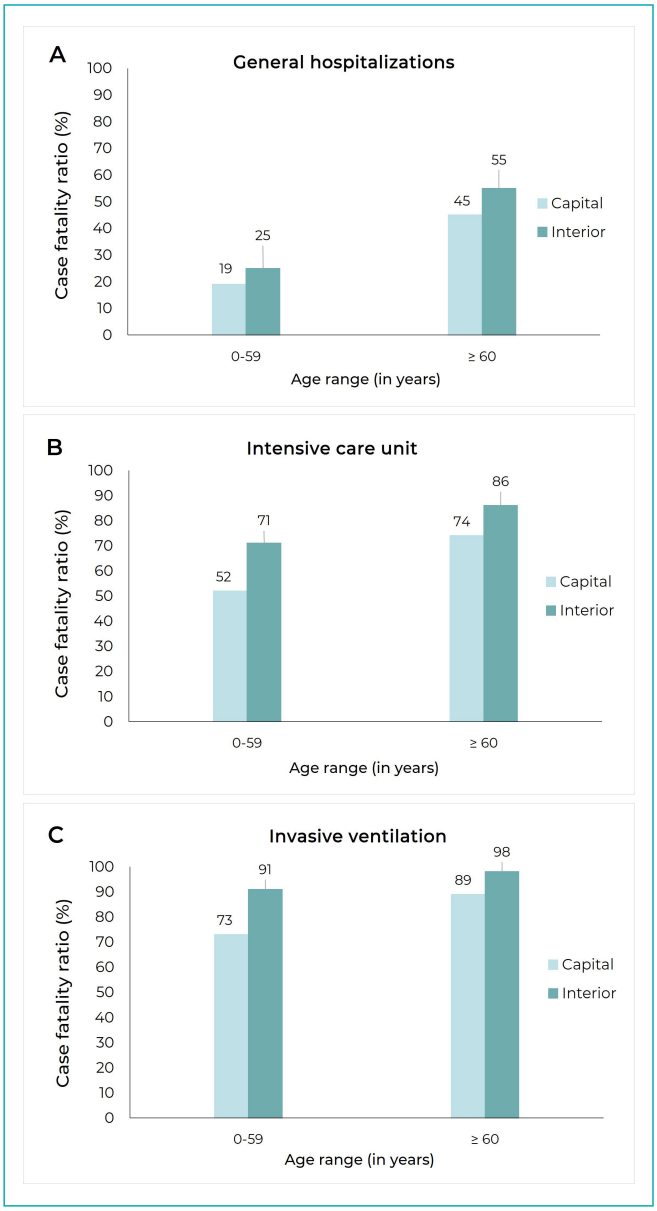
Table 1 – Individuals hospitalized with COVID-19 (n=12,649) according to sociodemographic, health condition and hospitalization characteristics, and place of hospitalization, in Piauí, Brazil, March/2020 to March/2021

Variables	n (%)
Sex	
Male	7,222 (57.1)
Female	5,427 (42.9)
Age group (years)	
0-59	5,761 (45.5)
≥60	6,888 (54.5)
Race/skin color	
White	1,541 (12.2)
Black (Black and Brown)	7,740 (61.2)
Yellow	269 (2.1)
Indigenous	17 (0.1)
Unknown	3,082 (24.4)
Schooling	
No schooling	681 (5.4)
Complete elementary education	1,828 (14.4)
Complete high school education	1,640 (13.0)
Higher education	1,029 (8.1)
Unknown	7,471 (59.1)
Comorbidities	
0	459 (3.6)
1-2	3,856 (30.5)
≥3	333 (2.6)
Unknown	8,001 (63.3)
Place of hospitalization	
Capital	10,054 (79.5)
Interior	2,595 (20.5)
Place of hospitalization = intensive care unit	
Capital	3,097 (76.6)
Interior	938 (23.4)
Total	**12,649 (100.0)**

Table 2 – Case fatality ratio and 95% confidence intervals among individuals with COVID-19 and hospital outcome (n=9,143), according to sociodemographic, health condition and hospitalization characteristics, in the capital and interior region of Piauí, Brazil, March/2020 to March/2021

Variables	Total		Capital		Interior	
	n	% (95%CI[a])	n	% (95%CI[a])	n	% (95%CI[a])
Sex						
Female	3,958	34.2 (32.7;35.7)	3,006	31.6 (30.0;33.3)	952	42.2 (39.1;45.4)
Male	5,185	37.1 (35.8;38.5)	4,041	34.7 (33.2;36.2)	1,144	45.7 (42.9;48.6)
Race/skin color						
Yellow	182	26.9 (21.0;33.8)	174	25.9 (19.9;32.9)	8	50.0 (21.5;78.5)
Black	5,748	38.6 (37.3;39.9)	4,315	33.8 (32.4;35.2)	1,433	53.1 (50.5;55.7)
White	1,023	40.4 (37.4;43.4)	909	36.6 (33.6;39.8)	114	70.2 (61.2;77.8)
Schooling						
No schooling	583	48.9 (44.8;52.9)	474	41.6 (37.2;46.0)	109	80.7 (72.3;87.1)
Complete elementary education	1,404	41.2 (38.6;43.8)	1,192	34.6 (32.0;37.4)	212	77.8 (71.7;82.9)
Complete high school education	1,003	22.3 (19.9;25.0)	923	20.5 (18.0;23.2)	80	43.8 (33.4;54.7)
Higher education	494	19.8 (16.6;23.6)	463	18.4 (15.1;22.1)	31	41.9 (26.4;59.3)
Comorbidities						
0	350	35.1 (30.3;40.3)	308	30.5 (25.6;35.9)	42	69.0 (53.9;81.0)
1-2	2,945	43.6 (41.9;45.4)	2,485	40.0 (38.1;41.9)	460	63.5 (59.0;67.8)
≥3	285	60.4 (54.6;65.9)	241	55.2 (48.8;61.3)	44	88.6 (75.6;95.5)
Intensive care unit						
No	5,080	14.7 (13.8;15.7)	4,195	14.5 (13.4;15.6)	885	16.0 (13.8;18.6)
Yes	3,366	70.9 (69.3;72.4)	2,494	66.8 (65.0;68.7)	872	82.3 (79.7;84.8)
Respiratory support						
No	2,066	9.1 (7.9;10.4)	1,859	9.5 (8.3;10.9)	207	5.3 (2.9;9.4)
Non-invasive	4,264	23.0 (21.7;24.3)	3,273	23.6 (22.2;25.1)	991	20.9 (18.5;23.5)
Invasive	2,222	87.8 (86.4;89.1)	1,543	84.0 (82.1;85.7)	679	96.6 (94.9;97.8)
Total	**9,143**	**35.8 (34.9;36.8)**	**7,047**	**33.4 (32.3;34.5)**	**2,096**	**44.1 (42.0;46.3)**

a) 95%CI: 95% confidence interval.



A) General case fatality ratio in the interior and the capital, by age group (in years); B) Intensive care unit (ICU) case fatality ratio, by place of hospitalization and age group (in years); C) Case fatality ratio among individuals who received invasive ventilation, by place of hospitalization and age group (in years).

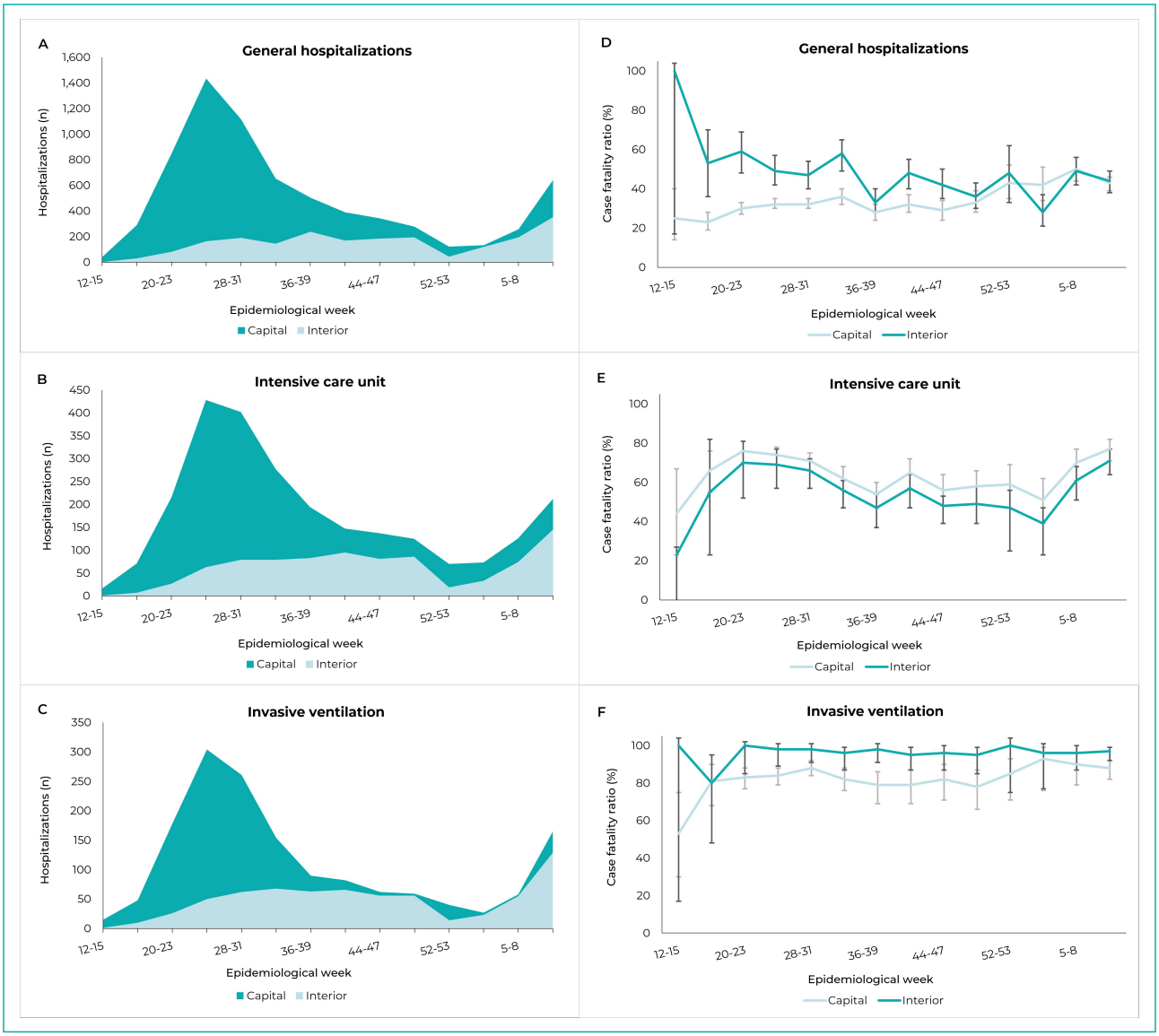
Figure 2 – Case fatality ratio among individuals with COVID-19 and hospital outcome (n=9,143), by age group (years) and hospitalization condition, in the capital and interior of Piauí, Brazil, March/2020 to March/2021

During the years analyzed, regardless of the variation in the number of hospital admissions, COVID-19 case fatality ratio among records with outcome in the interior of the state remained higher than in the capital Teresina for most of this period, especially in ICUs and among those undergoing invasive ventilation. The case fatality ratio, the coefficient ranged from 25.0% (95%CI 14.0;40.4) to 49.6% (95%CI 43.5;55.7) in the state capital, while in the interior it reached 59.3% (95%CI 48.4;69.3) between epidemiological weeks 20 and 23/2020 (Figure 3D). In the case of individuals admitted to ICUs, case fatality ratio ranged from 43.7% (95%CI 23.1;66.8) to 76.9% (95%CI 70.1;82.1) in the state capital, while in the interior it remained above 70.0% with effect from epidemiological week 19/2020 (Figure 3E). And for those undergoing invasive mechanical ventilation in the state capital, case fatality ratio remained above 78.0% (95%CI 65.7;86.8) for most of the period, while in the interior of the state, it remained close to 100.0% throughout the period analyzed (Figure 3F).

DISCUSSION

Our analysis of SARS hospitalizations due to COVID-19 in Piauí found high case fatality ratio among records with outcome, especially in the interior of the state and among individuals undergoing invasive mechanical ventilation. The study enabled characterization of the profile of hospitalized individuals in the state, finding a higher percentage of elderly people, males, those of Black race/skin color and those who had one or two comorbidities. Furthermore, our analysis identified temporal variation in the number of hospital admissions, in the capital and in the interior, revealing synchronization of the curves in the last epidemiological weeks analyzed. The case fatality ratio curves of individuals admitted to ICUs and submitted to mechanical ventilation with hospital outcome were higher in the interior of the state throughout the period studied.

It is important to emphasize that the study was based on secondary data and has limitations



A) Temporal variation of the number of COVID-19 hospitalization in the capital and interior of the state; B) Temporal variation of the number of individuals with COVID-19 submitted to intensive care; C) Temporal variation of the number of individuals with COVID-19 who received invasive ventilation; D) Temporal variation of case fatality ratio in hospitalized individuals; E) Temporal variation of case fatality ratio in individuals admitted to an intensive care unit; F) Temporal variation of case fatality ratio in individuals submitted to invasive ventilation.

Figure 3 – Temporal variation of number of hospitalizations and case fatality ratio among individuals with COVID-19 and hospital outcome (n=9,143), in the capital and interior of Piauí, Brazil, March/2020 to March/2021

inherent to it, such as outdated information, lower reliability and problems related to record accuracy. The data source used was the SIVEP-Gripe, which is mandatory system for recording cases. It is the main repository of hospital data at national level, although it may be influenced by the flow of data between levels of government, in addition to weaknesses regarding data completeness. In the state of Piauí, the 'schooling' and 'comorbidities' variables had the lowest percentages of completeness, which may have influenced the analysis of the profile of cases found and analyzed.

Another limitation of this study is related to the scarcity of molecular tests in Brazil, which are primarily used for individuals with more severe conditions. Our analysis, which was restricted to those with hospital outcome and diagnosis confirmed by molecular testing and therefore with potentially more severe conditions, may have overestimated case fatality ratio. To reduce this bias, we included in the study all individuals diagnosed with COVID-19 registered on the SIVEP-Gripe system.

In Piauí, more than one-third of hospitalized individuals with outcome died, this being a result similar to that found in a retrospective study on hospitalization data recorded on the SIVEP-Gripe system for all of Brazil, which reported a 38% of deaths.[3] On the other hand, the COVID-19 case fatality ratio for cases admitted to ICUs in the state of Piauí were higher than those previously reported, both for Brazil as a whole (59%) and for the Northeast region of Brazil (70%).[3] This difference in case fatality ratio becomes even more pronounced when making a comparison between hospitalizations of individuals requiring intensive care and ventilatory support in the interior of the state and in the capital.

Among individuals submitted to invasive mechanical ventilation with hospital outcome, the case fatality ratio in the capital Teresina and in the cities of the interior of Piauí were higher than those found for Brazil as a whole (80%) and for the Northeast region (87%).[3] Whereas case fatality ratio in regions with limited resources, such as the North and Northeast, is higher than in other regions of Brazil,[12] the results found in this study also exceed the findings of studies conducted in various regions of the world. A meta-analysis that included 69 studies involving 57,420 individuals from various countries found a 45% case fatality ratio among individuals severely affected by COVID-19 and submitted to invasive ventilation.[13] In Brazil, a cohort of 2,054 individuals admitted to 25 hospitals in 11 cities and three states, found a 59.5% of deaths among individuals who required invasive mechanical ventilation.[14] Several factors must be considered in relation to that outcome, including lower access to health care and lower availability of supplies, equipment and health professionals trained to care for individuals with COVID-19 and its complications. In addition, specialized services in the interior of the country, in general, may have fewer physicians, intensivists and professionals specialized in care for COVID-19 cases – this being a fact that has also been associated with higher in-hospital mortality.[15]

Factors already reported in the literature, such as comorbidities, age, sex and schooling, have also been relevant for increased in-hospital deaths. In this study, despite the large amount of 'unknown' information, the most frequent comorbidities – cardiovascular diseases, followed by diabetes *mellitus* and obesity – corroborate the results of a systematic review involving 53 studies identified by means of a database search and conducted as at September 2020, which included 375,859 participants from 14 countries.[16] The presence of comorbidities, especially in the elderly, can increase the need for ICU admission, mechanical ventilation and, consequently, risk of death.[13,17,18] Regarding schooling, a clear decrease in in-hospital deaths was observed as the individuals' level of education increased, regardless of where hospitalization took place, i.e. in the state capital or interior, corroborating similar results already reported, such as sociodemographic indicators associated with high in-hospital mortality in Brazil.[19,20]

The spread of COVID-19 cases to the interior of the state and the increased demand for care in all available health services in the state may influence mortality, due to the population's demand for hospital beds, especially in the case of individuals most severely affected and in need of intensive care. As such, synchronization of the increase in the disease in the capital and in interior region cities is one of the factors aggravating and contributing to the collapse of the health system. The expansion and spread of COVID-19 in Piauí, confirmed by the hospitalization frequency curves, showed temporal variations like those in other Brazilian states, whereby the disease is seen to spread from the capital to smaller cities and to cities in the interior region of the state. Up until epidemiological week 53 of the period covered by the study, hospital admissions were higher in the state capital. This was followed by synchronization of COVID-19 hospitalization trend curves between the various points of care.

In general, community transmission of COVID-19, which started in the country's state capitals, spreads to smaller municipalities due to the dynamics of human mobility; however, the most severe cases return to the capital in search of more specialized care.[5] In Piauí, the object of this study, coronavirus cases spread from the capital to the interior, while the flow of care went from the interior to the capital, with most hospitalizations having occurred in Teresina. Average hospitalization due to COVID-19 for the Brazilian state capitals as a whole is 54%.[3] Taking each of the Brazilian regions, on average their capital cities have the following COVID-19 hospitalization percentages: Midwest, 71%; Northeast, 70%; North, 61%; Southeast, 50%; and South, 32%.[3] As such, centralization of health care in Piauí is higher than in most Brazilian regions and one of the highest in the country.

Also noteworthy is the increase in the number of clinical and ICU beds, throughout the period analyzed and in all the COVID-19 care regions in Piauí. Despite the increase in hospital care capacity, case fatality ratio remained high, revealing that the increased number of facilities, by itself, was not enough to reduce the high number of deaths.

The results of this study provide evidence of the high levels of case fatality ratio found in the interior of the state of Piauí, especially in individuals undergoing invasive mechanical ventilation. We hope that this evidence will contribute to the implementation of strategies aimed at reducing hospital deaths among COVID-19 cases and cases of other diseases, such as allocation of resources in a regionalized and equitable way, respecting health territories and enabling the strengthening of the entire health care network.[21] In Brazil, health regions with a scarcity of high technology resources have had the highest average mortality rates.[22]

Our analysis of hospital admissions in Piauí enabled the profile of COVID-19 hospitalizations in the state to be described, as well as identifying high case fatality ratio among individuals treated in the interior of the state, especially those who underwent invasive mechanical ventilation. This evaluation points to weaknesses in health system organization in Piuaí, especially the most specialized services, and provides information for re-evaluating strategies for addressing the pandemic and potential public health emergencies.

AUTHORS' CONTRIBUTION

Aguiar BGA, Oliveira BFA, Matos Neto EM and Cardoso OO contributed to the concept and design of the study. Sousa EL, Gaído SB, Sousa RA and Meneses Júnior JMP analyzed and interpreted the data. Sousa EL, Gaído SB and Sousa RA contributed to the preliminary drafting of the manuscript. Aguiar BGA, Oliveira BFA, Matos Neto EM, Meneses Júnior JMP and Cardoso OO took part in relevant critical reviewing of the intellectual contents of the manuscript. All the authors have approved the final version of the manuscript and are responsible for all aspects thereof, including the guarantee of its accuracy and integrity.

CONFLICTS OF INTEREST

The authors declared that they have no conflicts of interest.

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