



Incidence of hip fractures during the COVID-19 pandemic in the Brazilian public health care system

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Received: 1 October 2021 / Accepted: 12 February 2022
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Abstract

Summary This study compared the incidence of hip fractures before and during the COVID-19 pandemic in Brazil, aged ≥ 60 years excluding all fractures related to any trauma. There was a significant reduction in the number of hip fractures and the length of hospital stay during the period of social isolation.

Purpose To compare the incidence of hip fractures before and during the COVID-19 pandemic in Brazil and in the main regions of the country in patients covered by the Brazilian public health care system (SUS). As far as we are aware, no studies have evaluated the impact of COVID-19 pandemic on hip fractures in Brazil.

Methods Descriptive, cross-sectional study in individuals aged ≥ 60 years who presented with a hip fracture before and during the COVID-19 pandemic and received treatment covered by the SUS. The data were collected from the DATASUS electronic database. We calculated the incidence, mortality, lethality, duration of hospitalization, and average reimbursement associated with the treatment of the fractures.

Results There was a significant reduction in the incidence of hip fractures among individuals aged ≥ 60 years in Brazil during the period of social isolation due to COVID-19. The observed incidence was 15.58/10,000 inhabitants between March and December 2020 and 16.07/10,000 inhabitants in the same period of 2019 ($p < 0.005$; main decline observed in the age groups > 70 years). The average length of hospital stay reduced from 8.35 days in 2019 to 7.33 days in 2020, following a similar pattern of reduction across all regions. The Southeast was the only region with a significant reduction in mortality during the pandemic (relative risk 0.90, 95% confidence interval 0.84–0.97, $p < 0.005$).

Conclusion During the COVID-19 pandemic in Brazil, the incidence rate of hip fractures and the associated duration of hospital stay decreased among patients aged ≥ 60 years.

Keywords Hospital reimbursement · Hip fracture · COVID-19 · Coronavirus · Pandemic · Mortality

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Introduction

The pandemic associated with the SARS-CoV-2 virus that causes COVID-19 has led several Brazilian states to recommend social isolation measures to control the spread of the virus. This measure had a huge impact on the country's health care system. On March 20, 2020, the Brazilian Ministry of Health announced a state of community transmission of the virus and instructed individuals aged 60 years and older to restrict movement outside their homes [1].

This social isolation during the pandemic was fundamental to protect elderly individuals but may have limited the access of this population to the health care system [2] and negatively affected their health status by promoting worse lifestyle habits (e.g., changes in diet, physical activity, access to material

resources, and consumption of tobacco and alcoholic beverages). Osteoporosis is highly prevalent in this age group [3], and these lifestyle habits are known risk factors for decreased bone mass and increased risk of fractures.

In Brazil, 10 million individuals have osteoporosis [4]. Hip fragility fracture—a sign of osteoporosis—results from mechanical forces that usually do not lead to fracture, quantified by the World Health Organization (WHO) as equivalent to a fall from the same level or less [5].

The epidemiology of hip fractures follows the progressive loss of bone mass that occurs with aging. In Brazil, the prevalence of hip fractures in individuals above the age of 60 years is estimated at 19.46 per 10,000, yielding approximately 57,117 elderly individuals with this injury in the country [6]. The change in lifestyle habits caused by social isolation during the COVID-19 pandemic may have interfered with potential risk factors for osteoporotic fractures, and the incidence of hip fractures may have consequently changed during this period [3].

Studies carried out in other countries [7–12] have shown both increases [13] and decreases [11] in prevalence rates of hip fractures during the COVID-19 pandemic compared with periods before the pandemic. Most of these studies were restricted to hospitals, municipalities, or states, and no study to date has analyzed these data in Brazil. Making matters worse, patients with hip fracture and concomitant SARS-CoV-2 infection have significantly higher mortality rates than those not infected with the virus [8] [10, 14, 15].

Our hypothesis in the present study was that the lifestyle changes and the decreased access to medical care experienced by elderly individuals during the COVID-19 pandemic have increased both the incidence and the mortality associated with hip fractures in Brazil. No studies have analyzed the impact of COVID-19 and social isolation on the incidence of hip fractures in the public health system in Brazil, while only two studies have reported data from Latin America [16] [17].

Based on these considerations, the aim of this study was to compare the incidence of hip fractures and the mortality rates associated with this injury among elderly individuals receiving care covered by the Brazilian public health system before and during the COVID-19 pandemic. The analysis was performed across the entire country and within its five main regions; this analysis by region is crucial considering that the isolation policies and the care offered within the health care system vary across states.

Methodology

Approval by the ethics committee

The study project was approved by the Human Research Ethics Committee of the *Hospital de Clínicas* at

Federal University of Paraná (UFPR; CAAE number 44105321.0.0000.0096, approval number 4.708.220).

Study design

This was a descriptive, cross-sectional study in individuals aged 60 years and older presenting with a hip fracture before and during the COVID-19 pandemic and receiving care covered by the Brazilian public health care system (*Sistema Único de Saúde*, SUS).

DATASUS website (<https://datasus.saude.gov.br/informacoes-de-saude-tabnet/>) was accessed separately for the entire country and the five main regions of the country: Health Information (TABNET) → Epidemiological and Morbidity → SUS Hospital Morbidity SIH/SUS → General, by place of residence from 2008 onwards. We then selected in the map the entire country and each federative unit of the country (regions). The selected result of interest was the diagnosis of “hip fracture” (ICD-10 72.0 to 72.9). DATASUS give access only to the collective data; no individual data are available.

We further set the following filters: March 2019 to December 2019, morbidity list of all ICD-10 codes for hip fracture, emergency care assistance, age of 60 years or more, sex, race, number of hospitalizations, length of hospital stay (days), total and average reimbursement of hospitalization, number of deaths whose underlying cause was a hip fracture. A second search was performed using the same filters applied to the period of March 2020 to December 2020. The data on the number of deaths available on DATASUS was based on the hospital death records.

The demographic data of the Brazilian population as a whole and within the five macroregions of the country were retrieved from a projection of the Brazilian population for the years 2019 and 2020 by sex and age presented by the Brazilian Institute of Geography and Statistics (IBGE) and made publicly available in the DATASUS system. The population monthly data was not used due to the IBGE failure to carry out the 2020 demographic census.

Patients

The study included men and women of any ethnicity, aged ≥ 60 years, with hip fractures, hospitalized and receiving care coverage by the SUS from March 2019 to December 2020, and with data available in the DATASUS. Individuals younger than 60 years, those with fractures caused by a car accident or related to trauma of any kind, and patients who received elective care were excluded from the analysis.

Statistical analysis

From the collected data, we calculated the hip fracture incidence, mortality, and lethality, the average duration of the patients' hospital stay, and the average reimbursement of hospitalization for the years 2019 (March to December) and 2020 (March to December). Incidence was calculated as the number of hip fractures divided by the number of individuals in the population. SUS is a universal public health system offered to the total Brazilian population, including those who have private health insurance can have access to it. Taking this into account, the denominator of the incidence calculation includes the whole population. Mortality was calculated as the number of deaths associated with hip fractures during the periods from March to December 2019 to 2020 divided by the study population. Lethality was calculated as the number of hip fracture deaths divided by the number of hip fractures in the study cohort from March to December 2019 to 2020 (data were not analyzed monthly).

Continuous numerical variables were described as mean and standard deviation values and compared using Student's *t* test for independent samples. Possible associations between the independent variable "pandemic year" and the dependent variables "number of hospitalizations," "deaths," and "lethality" are represented as relative risk (RRs) and 95% confidence intervals (95% CIs). The RR estimates were calculated using the statistical software Open Epi, version 3.01 (Open-Source Epidemiologic Statistics for Public Health). Comparisons between mean values were performed using the chi-square test and the software SPSS version 25 (IBM Corp., Armonk, NY, USA). *P* values < 0.05 were considered significant.

Review of the literature on hip fractures during the pandemic

A PubMed search of the current literature regarding hip fractures during the COVID-19 pandemic was carried out on June 10, 2020. The search strategy included the following entry terms and Boolean operators: "COVID" OR "Coronavirus" AND "hip fracture" OR "hip neck fracture" OR "hip fracture." The search was limited to studies published in 2020 and 2021.

The studies were initially selected by abstract and then by full-text review. To be included in the review, the retrieved studies had to include a comparison of hip fractures in the years 2019 and 2020. We excluded letters to the editor, studies without a clear indication about the number of hip fractures, and articles published in languages other than English, Spanish, or Portuguese.

Results

Incidence of hip fracture

During the pandemic period included in the study (March to December 2020), a total of 45,645 hip fractures in patients covered by the SUS were registered in Brazil, yielding an incidence of 15.58 per 10,000 inhabitants in individuals aged 60 years and older. This rate was significantly lower than the rate registered in the same period in 2019, specifically, 16.07 fractures per 10,000 inhabitants ($p < 0.005$). The decreased incidence was also significant in the age groups of 70–79 years and ≥ 80 years and in women (Table 1).

As described in Table 1, the Southeast, Midwest, and North regions presented a decrease in the incidence of hip fractures in line with the national trend. In these three regions, the age groups of 70–79 and ≥ 80 years and the female sex presented significant reductions in the incidence rates. The age group of 60–69 years in the North region also had a significant reduction in the incidence of hip fractures. The Northeast was the only region in which the hip fracture incidence increased, which occurred specifically in the age group of 70–79 years and in men. Unlike the other regions, the incidence rates in the South had no significant change (Fig. 1).

Average hospitalization duration

The average length of hospital stay after a hip fracture in Brazil decreased from 8.35 days in 2019 to 7.33 days in 2020; this change was significant across all age groups and both in men and women. The average length of hospital stay also decreased in each Brazilian region, except for the Midwest, where it had no significant change. In 2020, the length of hospital stay was shortest in the South (6.75 days) and longest in the Northeast (8.37 days) (Table 2).

Mortality and lethality after hip fracture

A nonsignificant reduction in death after hip fracture in individuals aged ≥ 60 years was observed in Brazil after the onset of the COVID-19 pandemic; the same trend was observed in subgroup analyses by sex and age. The Southeast was the only region showing a significant decrease in mortality in 2020 compared with 2019 (Table 3). No significant change in mortality was observed across all regions on analyses by age and sex, except for women in the Southeast, in whom the mortality rate decreased from 2019 to 2020. The lethality after hip fracture remained had no significant change from 2019 to 2020 (Table 2).

Table 1 Incidence of hip fracture in the overall country and in the five Brazilian regions

Hip fracture	2019		2020	
	Per 10,000 (n)	Per 10,000 (n)	RR (95% CI)	P value
Brazil	16.07 (45,224)	15.58 (45,645)	0.97 (0.96–0.98)	< 0.005
By age (years)				
60 to 69	5.70 (9097)	5.62 (9296)	0.99 (0.96–1.01)	0.32
70 to 79	17.02 (14,015)	16.53 (14,247)	0.97 (0.95–0.99)	0.01
≥ 80	55.82 (22,112)	53.50 (22,102)	0.96 (0.94–0.98)	< 0.005
By sex				
Women	19.69 (30,836)	18.94 (30,864)	0.96 (0.95–0.98)	< 0.005
Men	11.53 (14,388)	11.37 (14,781)	0.99 (0.96–1.01)	0.24
South	18.70 (8848)	18.57 (9158)	0.99 (0.97–1.02)	0.66
By age (years)				
60 to 69	6.39 (1706)	6.08 (1681)	0.95 (0.89–1.02)	0.14
70 to 79	19.77 (2766)	19.95 (2928)	1.01 (0.96–1.06)	0.75
≥ 80	65.83 (4,376)	65.30 (4549)	0.99 (0.95–1.03)	0.70
By sex				
Women	24.00 (6277)	23.88 (6504)	1.00 (0.96–1.03)	0.77
Men	12.14 (2571)	12.03 (2654)	0.99 (0.94–1.05)	0.73
Southeast	17.15 (23,073)	16.43 (23,020)	0.96 (0.94–0.98)	< 0.005
By age (years)				
60 to 69	6.13 (4664)	6.06 (4782)	0.99 (0.95–1.03)	0.62
70 to 79	18.21 (7080)	17.13 (7001)	0.94 (0.91–0.97)	< 0.005
≥ 80	57.97 (11,329)	55.23 (11,237)	0.95 (0.93–0.98)	< 0.005
By sex				
Women	20.68 (15,609)	19.68 (15,441)	0.95 (0.93–0.97)	< 0.005
Men	12.63 (7464)	12.30 (7579)	0.97 (0.94–1.01)	0.11
Midwest	19.50 (3601)	17.67 (3429)	0.91 (0.87–0.95)	< 0.005
By age (years)				
60 to 69	7.38 (805)	7.18 (820)	0.97 (0.88–1.07)	0.58
70 to 79	21.64 (1148)	19.77 (1105)	0.91 (0.84–0.99)	0.03
≥ 80	73.13 (1648)	63.06 (1504)	0.86 (0.81–0.93)	< 0.005

Table 1 (continued)

Hip fracture	2019		2020	
	Per 10,000 (n)	Per 10,000 (n)	RR (95% CI)	P value
By sex				
Women	23.09 (2293)	20.50 (2142)	0.89 (0.84–0.94)	< 0.005
Men	15.31 (1308)	14.38 (1287)	0.94 (0.87–1.01)	0.11
Northeast	12.08 (7998)	12.46 (8541)	1.03 (1.00–1.06)	0.05
By age (years)				
60 to 69	4.22 (1544)	4.43 (1680)	1.05 (0.98–1.13)	0.16
70 to 79	12.32 (2472)	13.19 (2739)	1.07 (1.01–1.13)	0.01
≥ 80	41.85 (3982)	41.69 (4122)	1.00 (0.95–1.04)	0.87
By sex				
Women	14.86 (5560)	15.09 (5849)	1.02 (0.98–1.05)	0.40
Men	8.48 (2438)	9.04 (2692)	1.07 (1.01–1.13)	0.02
North	11.45 (1704)	9.60 (1497)	0.84 (0.78–0.90)	< 0.005
By age (years)				
60 to 69	4.15 (378)	3.49 (333)	0.84 (0.73–0.98)	0.02
70 to 79	13.32 (549)	10.97 (474)	0.82 (0.73–0.93)	< 0.005
≥ 80	47.04 (777)	39.82 (690)	0.85 (0.77–0.94)	< 0.005
By sex				
Women	14.33 (1097)	11.55 (928)	0.81 (0.74–0.88)	< 0.005
Men	8.40 (607)	7.53 (569)	0.90 (0.80–1.00)	0.06

Hospital reimbursement of hospitalization

The average reimbursement of hospitalization in Brazil had no significant variation between 2019 and 2020, except for the Northeast, where the average amount increased (Table 4; the values presented were converted from Brazilian real to US dollar).

Review of the literature on hip fractures during the pandemic

The initial literature search identified 92 articles, but one article was a duplicated study and was removed. Of the remaining 91 articles, 57 were considered potentially relevant for abstract review, while 36 were eliminated after the abstracts were analyzed. Of the remaining 21 articles, two

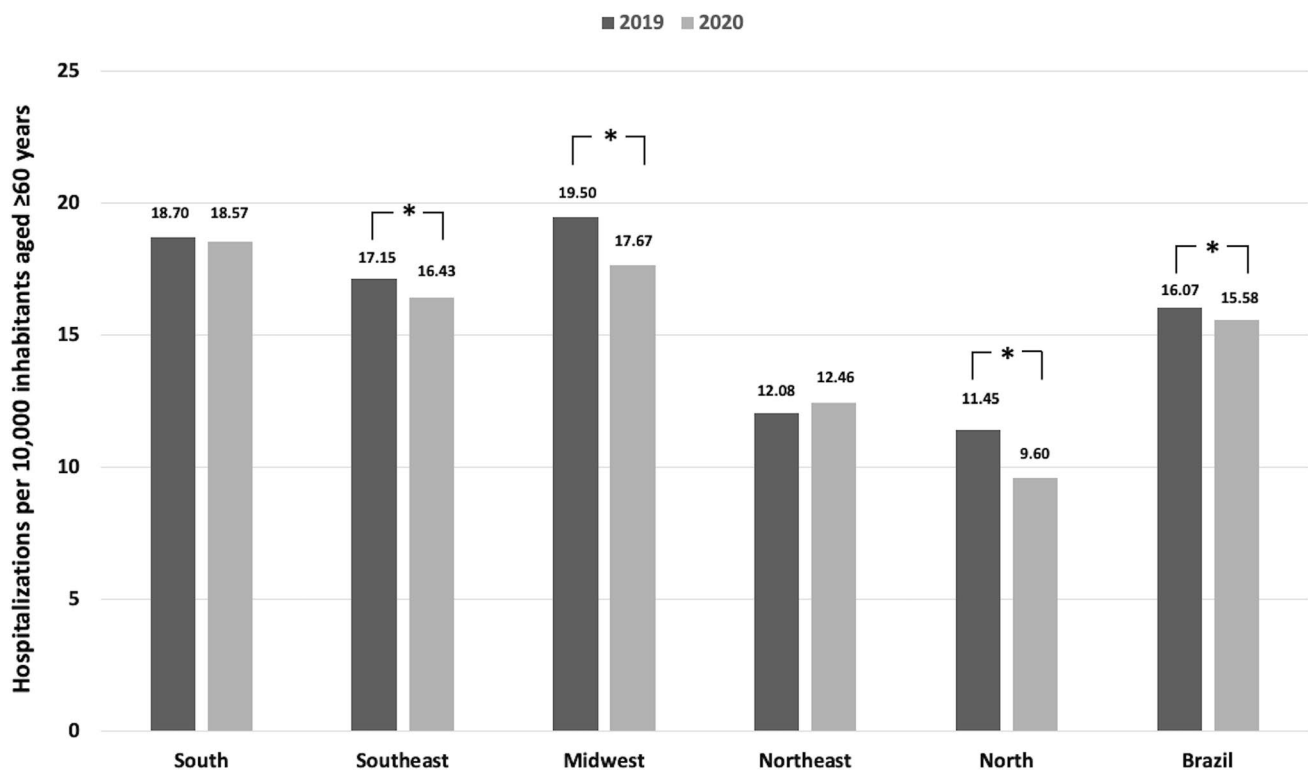


Fig. 1 Incidence of hip fracture per 10,000 inhabitants in the overall country and in each Brazilian region in 2019 and 2020. * $P < 0.05$

Table 2 Average length of hospital stay in Brazil and across Brazilian regions

Length of hospital stay (days)	2020	2019	<i>P</i> value
	Mean ± SD	Mean ± SD	
Brazil	8.35 ± 0.14	7.33 ± 0.44	< 0.005
By age (years)			
60 to 69	8.15 ± 0.25	7.26 ± 0.50	< 0.005
70 to 79	8.45 ± 0.28	7.34 ± 0.53	< 0.005
≥ 80	8.40 ± 0.15	7.34 ± 0.45	< 0.005
By sex			
Women	8.34 ± 0.16	7.29 ± 0.46	< 0.005
Men	8.42 ± 0.24	7.40 ± 0.49	< 0.005
Brazilian regions			
South	7.83 ± 0.26	6.75 ± 0.39	< 0.005
Southeast	8.08 ± 0.17	7.17 ± 0.35	< 0.005
Midwest	7.29 ± 0.76	7.04 ± 0.80	0.483
Northeast	9.71 ± 0.30	8.37 ± 0.80	< 0.005
North	10.89 ± 1.08	8.00 ± 1.23	< 0.005

SD standard deviation

were excluded because the full article was inaccessible, two were excluded for not reporting the number of hip fractures in 2019 and 2020, and one was excluded for comparing the year 2020 with 2018 and not including 2019.

Most remaining articles described a decrease in the hip fractures rates, while only two studies showed an increase in fracture rates from 2019 to 2020. Table 5 shows the variation in the hip fracture rate from 2019 to 2020 in the 16 articles selected for review.

Discussion

The rate of hospitalizations due to hip fractures covered by the Brazilian public health care system decreased during the COVID-19 pandemic in 2020 compared with the corresponding period before the pandemic in 2019. This was probably related to the various restrictive actions adopted since March 2020 to reduce viral transmission and prevent overloading of the health care system in the country. The recommendations for social isolation varied in terms of duration and intensity of restriction across the country's states and municipalities, mainly due to political divergences. However, the elderly population, in general, was encouraged to stay home [1]. A Brazilian study including 9173 elderly individuals found that only 12.2% of them failed to adhere to the social distancing recommendations, while 88% were totally or intensely social distancing [18]. The decrease in hip fracture rates observed in the present study was surprising, considering that hip fractures in individuals

Table 3 Mortality and lethality after hip fracture in 2019 and 2020

Mortality	2019 Per 100,000 (<i>n</i>)	2020 Per 100,000 (<i>n</i>)	RR 95% IC	<i>P</i> value
Brazil	8.45 (2379)	8.10 (2374)	0.96 (0.91–1.02)	0.15
By age (years)				
60 to 69	1.35 (216)	1.22 (202)	0.90 (0.74–1.09)	0.29
70 to 79	6.10 (502)	6.05 (522)	0.99 (0.88–1.12)	0.92
≥ 80	41.93 (1661)	39.94 (1650)	0.95 (0.89–1.02)	0.16
By sex				
Women	10.06 (1576)	9.52 (1552)	0.99 (0.92–1.06)	0.67
Men	6.43 (803)	6.32 (822)	0.98 (0.89–1.08)	0.73
Brazilian regions				
South	9.63 (456)	9.96 (491)	1.03 (0.91–1.17)	0.61
Southeast	10.48 (1410)	9.46 (1325)	0.90 (0.84–0.97)	<0.005
Midwest	7.80 (144)	7.47 (145)	0.96 (0.76–1.21)	0.72
Northeast	4.79 (317)	5.14 (352)	1.07 (0.92–1.25)	0.37
North	3.49 (52)	3.91 (61)	1.12 (0.77–1.62)	0.55
Lethality	%	%	RR (95% IC)	<i>P</i> value
Brazil	5.26	5.20	0.99 (0.94–1.05)	0.70
By age (years)				
60 to 69	2.37	2.17	0.92 (0.76–1.11)	0.37
70 to 79	3.58	3.66	1.02 (0.91–1.15)	0.72
≥ 80	7.51	7.47	0.99 (0.93–1.06)	0.86
By sex				
Women	5.11	5.03	0.99 (0.92–1.05)	0.66
Men	5.58	5.56	1.00 (0.91–1.10)	0.94
Brazilian regions				
South	5.15	5.36	1.04 (0.92–1.18)	0.55
Southeast	6.11	5.76	0.94 (0.88–1.02)	0.13
Midwest	4.00	4.23	1.06 (0.84–1.32)	0.64
Northeast	3.96	4.12	1.04 (0.90–1.21)	0.62
North	3.05	4.07	1.32 (0.91–1.90)	0.13

Table 4 Average reimbursement of hospitalization (in US dollars) for hip fracture in Brazil and regions in 2019 and 2020

Amount reim- bursed (US dollars)	2019 Mean ± SD	2020 Mean ± SD	<i>P</i> value
Brazil	648.35 ± 6.87	494.54 ± 8.85	0.291
By age (years)			
60 to 69	613.06 ± 5.86	472.16 ± 5.45	0.641
70 to 79	652.86 ± 8.78	503.85 ± 7.12	0.854
≥ 80	655.63 ± 6.29	510.10 ± 7.48	0.574
By sex			
Women	646.33 ± 4.90	500.48 ± 6.85	0.896
Men	646.12 ± 9.25	500.20 ± 6.11	0.924
Brazilian regions			
South	715.36 ± 11.73	548.47 ± 10.74	0.567
Southeast	648.49 ± 6.95	496.95 ± 5.94	0.335
Midwest	578.20 ± 18.30	449.14 ± 10.55	0.839
Northeast	592.06 ± 14.36	473.46 ± 7.71	0.048
North	654.01 ± 15.36	529.40 ± 18.18	0.086

SD standard deviation.

aged 60 years and older occur more often in the domestic environment [3].

Social isolation, associated with the periodic lockdown of supermarkets and services, led to decreased circulation of elderly individuals and reduced rates of accidents occurring outside the home. However, despite these individuals remaining for longer periods at home, injuries from accidents in this environment also decreased. According to a multicenter study carried out in 15 Italian trauma units, the COVID-19 pandemic was associated with a 50% reduction in intra-household trauma [19]. This reduced frequency of traumas at home was also likely to have occurred in Brazil due to greater care of elderly individuals and their families in preventing accidents for fear of contamination by the COVID-19 virus in hospitals and longer time of family members at home, reducing the exposure of elderly individuals to risky situations.

Fragility fractures occur mainly in-home (72.7%), while those occurring outside the home are much less frequent (7.1%); hip fractures correspond to 58.3% of these fragility

Table 5 Variation in rates of hip fracture from 2019 to 2020 in the current literature

Study	Country	Scope	Variation in hip fracture rates from 2019 to 2020 (during the COVID-19 pandemic)	P value	Observations
Silva et al	Brazil	National and regional	↓	0.005	In one region the rate had no significant change
Ben-Haim et al	Israel	Local	↓	0.04	-
Benazzo et al	Italy	National	→	NA	-
Egol et al	US	Regional	↑	NA	They described 138 hip fractures in 2020, compared to 115 in 2019
Esteban et al	Spain	Local	↓	0.03	-
Haskel et al	US	Local	→	NA	-
Maniscalco et al	Italy	Local	↓	NA	121 hip fractures in 2020, compared to 169 in 2019
Minarro et al	Spain	Local	↓	NA	32 hip fractures in 2020, compared to 63 in 2019
Mitkovic et al	Serbia	Local	↓	0.03	-
Narang et al	UK	Regional	↑	NA	682 hip fractures in 2020, compared to 664 in 2019
Núñez et al	Spain	Regional	↓	0.06	-
Ogliari et al	UK	Local	→	NA	-
Sephton et al	UK	Regional	↓	0.005	-
Slullitel et al	Argentina	Local	↓	NA	74 hip fractures in 2020, compared to 86 in 2019
Thakrar et al	UK	Local	→	0.349	-
Wignall et al	UK	Regional	↓	NA	276 hip fractures in 2020, compared to 304 in 2019

US United States of America; UK United Kingdom; NA not available; ↓ = decrease; → = unchanged; ↑ = increase.

fractures [20]. Thus, a reduction in the number of domestic accidents argues in favor of a reduction in the incidence of this type of fracture. As shown in Table 5, there was a decrease in the number of hip fractures described in studies from four European [7] [11] [21] [22] [23–25], one Asian [26], and one South American [16] country from 2019 to 2020. Only two studies [14] [27] indicated an increase in hip fracture incidence. Importantly, there was a reduction in the total number of other types of fractures during the COVID-19 pandemic in other studies [17, 19, 23, 28].

The incidence of hip fractures in the Southeast, Midwest, and North regions followed that of the country. The Southeast region, according to the IBGE, concentrates the largest population of elderly individuals in Brazil, which could have resulted in a greater influence of this region in the country's total results. On the other hand, the increase in the number of cases in men and in the age group between 70 and 79 years in the Northeast region contradicts data reported in the literature. According to a survey carried out by the Inloco platform [29] mapping the social isolation in Brazil based on the location of cell phones and smartphones, the Northeast region had one of the highest rates of social isolation in the country, reaching an average rate close to 50% in one its states, which does not explain the increased incidence observed [30]. Information about general characteristics and

differences in health care between Brazilian regions is available in supplementary table 1. It is important to emphasize the social and health care differences between Brazilian regions that may influence the results obtained. The Southeast has the largest urban area and the highest income among all regions, while the Northeast region has the smallest urban area and the lowest income. This has a direct influence on the habits and quality of life of the population and its exposure to risk factors for osteoporosis and fragility fractures. The percentage of the elderly population of each region also has a direct impact on the number of femur fractures. The south and southeast regions are the regions with the highest percentage of elderly (16.89% and 16.35%, respectively), whereas the northern region has the lowest percentage of elderly (8.7%). Regions with a higher percentage of the population linked to private health plans (South and Southeast) will have lower demand for hospital care through the SUS, despite having free access to it even with the private health plan. This also influences the number of hip fractures treated by the Brazilian public health system.

The decrease in the observed average length of hospital stay corroborates the findings reported in the current literature [7–12] and reflects the need for available hospital beds for patients with COVID-19. Additionally, several studies have shown that a longer hospital stay significantly increases

the chance of COVID-19 infection by exposing the patient to the virus [8, 10, 14, 15]. The nonsignificant reduction in mortality and lethality observed in the present study is aligned with findings from other studies from Spain [31] and UK [32], and the shorter hospital stay could be associated with that.

Several studies have shown that the association of COVID-19 infection and hip fracture significantly increases the patients' morbidity and mortality [8, 13–15, 30]. A prospective, multicenter study in the UK also found a higher mortality rate with associated COVID-19 infection and hip fracture. Interestingly, the mortality rate was similar when the pandemic period of 2020 was compared with the corresponding period in 2019 [27], suggesting that COVID-19 infection was an independent risk factor for increased hip fracture mortality. However, patients who suffered a hip fracture in 2020 without becoming infected with the virus did not seem to have had a different outcome than those who presented with this fracture in the previous year. These data indicated that the quality of hospital care remained even during the COVID-19 pandemic, and that the hospital infection rates among patients with hip fracture were not large enough to impact the mortality and lethality associated with this fracture in the overall population.

The significant reduction in mortality rate in the Southeast could be a consequence of the decreased incidence of hip fractures observed in this region, associated with the facts that the elderly population in this region is comprised mostly of women [33–35] and that the incidence of hip fractures significantly decreased in women from 2019 to 2020.

The average reimbursement of hospitalization for hip fracture treatment in the health care system in Brazil was comparable before and during the pandemic, which is aligned with reports from the literature [36–38]. However, we were unable to find a plausible reason for that or for the variations found in the average hospitalization reimbursement by region. In fact, the amount was expected to decrease, considering the lower hospitalization duration [8, 10, 14, 15].

The fact that we did not capture patients with hip fractures covered by the private health care system may have interfered with the rates found in our study. However, the Brazilian population relies heavily on public health care; indeed, 69.9% of the elderly have no access to private health care [39], and our study covered most of this population. Also of note is the fact that the DATASUS data are constantly updated by the states and municipalities. Other limitations of this study included the lack of a confirmed osteoporotic etiology for the fractures since the only information provided in the DATASUS database is about a generic diagnosis of "hip fracture." However, considering that the highest incidence of fractures due to osteoporosis occurs in older ages, we could infer that osteoporosis was the main cause of fractures in the

study population when accidents of any kind were excluded. Also, the different demographics between regions may have influenced the incidence of hip fractures.

As far as we are aware, this is the first analysis of the impact of the COVID-19 pandemic on the incidence of hip fractures in Brazil, which is a major strength of this study. Since Brazil has an extensive and diversified territory, the separated analysis by regions, age, and sex allowed a more complete understanding of the different epidemiological characteristics of the impact of the pandemic on hip fractures in each region.

From these results, we can conclude that hip fractures significantly reduced in Brazil in 2020 compared with 2019 at the expense of the reductions observed in older populations and women, while the lethality associated with hip fractures had no significant change with the pandemic. We also observed a reduced average length of hospital stay, mainly due to a possible need to reallocate beds for patients hospitalized with COVID-19 or prevent further contamination with the virus.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11657-022-01078-w>.

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Availability of data and material The datasets used and/or analyzed during the current study will be made available by the corresponding author upon reasonable request.

Code availability Not applicable.

Declarations

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Trial Registration (Plataforma Brasil): CAAE number 44105321.0.0000.0096, approval number 4.708.220.

Informed consent Not applicable.

Conflicts of interest None.

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