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Long-term care facilities for older people and the COVID-19 pandemic: epidemiological data and preventive measures

Instituições de longa permanência para idosos e a pandemia de COVID-19: dados epidemiológicos e medidas preventivas

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Abstract

Objectives: The COVID-19 pandemic has challenged society, especially residents of long-term care facilities (LTCF). This study investigated rates of infection, hospitalization, and death due to COVID-19 among LTCF residents and staff in Minas Gerais, Brazil and identified strategies to control the spread of the disease.

Methods: This cross-sectional study collected data from 164 LTCF (6017 older adults). The owners or managers were invited to answer an electronic questionnaire. The questionnaire included 55 items, divided into 3 sections.

Results: Of the participating LTCF, 48.7%, 39.6%, and 32.3% reported COVID-19 infections, hospitalizations, and deaths, respectively, among residents, while 68.9%, 7.3%, and 1.2% reported COVID-19 infections, hospitalizations, and deaths, respectively, among staff. Preventive measures were identified and classified as organizational, infrastructural, hygiene items/personal protective equipment, and staff training.

Conclusion: The strategies used in the daily routines of LTCF during the pandemic were classified. The challenges experienced in Brazilian facilities were similar to those observed worldwide. The results highlight the importance of continuity and the need to improve protective measures for LTCF residents, especially in low- and middle-income countries.

Keywords: SARS-CoV-2; nursing home; mortality; long-term care facility.

Resumo

Objetivos: A pandemia da COVID-19 tem sido desafiadora para a sociedade, principalmente para aqueles que residem em Instituições de Longa Permanência (ILPI). Este estudo teve como objetivo descrever as taxas de infecção, hospitalização e óbito por COVID-19 entre idosos e funcionários de ILPI de Minas Gerais/Brasil e identificar estratégias de prevenção e controle da disseminação da doença.

Metodologia: Este estudo transversal foi realizado com 164 ILPI (6.017 idosos). Os gestores ou proprietários foram convidados a responder ao questionário eletrônico. O questionário incluiu 55 itens, divididos em três seções.

Resultados: Entre as ILPI estudadas, 48,7% confirmaram a infecção por COVID-19 em idosos, resultando em 39,6% de internação e 32,3% de óbito entre os infectados. Além disso, 68,9% das ILPI confirmaram infecção por COVID-19 na equipe, com 7,3% de internação e 1,2% de óbito. As medidas preventivas foram identificadas e classificadas como organizacionais, infraestrutura, itens de higiene e equipamentos de proteção individual e treinamento de pessoal contra a COVID-19.

Conclusão: Essas medidas revelaram estratégias e barreiras vivenciadas no cotidiano das ILPI durante a pandemia. As ILPI no Brasil passaram por desafios semelhantes aos observados mundialmente. Os resultados destacaram a importância da continuidade e melhoria das medidas de proteção para idosos em ILPI, especialmente em países de baixa e média renda.

Palavras-chave: SARS-CoV-2; casa de repouso; mortalidade; Instituição de Longa Permanência para Idosos.

INTRODUCTION

Between January 2020 and May 2023, the COVID-19 pandemic was declared an international public health emergency, and immediate strategies were needed to control infection and preserve life. The high prevalence of pre-existing comorbidities among older adults increased care requirements in different contexts and countries.¹ In Brazil, the life expectancy for people aged ≥ 65 years decreased by 0.9 years in 2020, regressing to the 2012 level.²

COVID-19 was especially problematic for long-term care facilities (LTCF), mainly due to the vulnerability of older residents, the collective housing context, and staff exposure during a period of high community transmission, increasing the risk of exposure among residents.³ Comas-Herrera et al.¹ analyzed data from 22 countries in Europe, Asia, Africa, America, and Oceania, determining that 41% of all deaths from COVID-19 occurred among LTCF residents, which indicates the need for greater support for residents and staff. COVID-19 transmission reached 60% in LTCF and increased the death rate in this population.³ Based on World Health Organization recommendations, the Brazilian Ministry of Health and Social Development published urgent health care measures to prevent and control COVID-19 in LTCF.⁴

A 2021 study identified 7029 LTCF in Brazil, mainly in the southeastern (60.21%) and southern (26.66%) regions, which is a considerable increase from the 2010 total of 3548.⁵ Although long-term institutional care is available through public and private systems, Brazilian LTCF have insufficient governmental and financial support, which impairs management and care.⁶ Some Brazilian studies have indicated the scarcity and low methodological quality of data on Brazilian LTCF residents.^{7,8} Da Mata et al.⁸ also reported a lack of data about the pandemic's impact on LTCF and the extent to which COVID-19 prevention and control measures reached these institutions in Brazil. Although official data are not yet available, it is estimated that 107,528 deaths due to COVID-19 occurred in Brazilian LTCF, with 12,093 occurring in the state of Minas Gerais alone.⁹

Data on the rates of infection, hospitalization, and death from COVID-19 and preventive measures in Brazilian LTCF are essential for identifying obstacles to fighting the pandemic. Such data could also help focus actions to improve daily living in LTCF, despite the lack of resources.¹⁰ Considering that the pandemic has ended, determining which variables must be considered in new health emergencies will help equip LTCF for future epidemics. Despite a wave of pandemic denialism in Brazil, civil society was promptly mobilized in support of LTCF, which may have helped reduce infection, hospitalization, and death rates in Brazilian institutions

compared to other countries. Nevertheless, facilities in the non-profit sector face a series of difficulties, including financial issues, that could have impeded operations during the pandemic. Another aggravating factor was the large number of residents in some LTCF, resulting in overcrowding. Thus, this study aimed to describe rates of infection, hospitalization, and death from COVID-19 among residents and staff of LTCF in a state in southeastern Brazil, identifying the strategies used to control infection and exploring the relationship between epidemiological data and LTCF size and sector (non-profit or for-profit).

METHODS

This cross-sectional study used non-probability sampling of LTCF from Minas Gerais, Brazil. The results are reported according to STROBE guidelines.

Statewide, we identified 1116 LTCF in the state's 10 regions, mainly the central region (38.42%), using data from the State Department of Justice, the State Secretariat for Social Development, and the National Front for Strengthening LTCF. Of these facilities, a telephone number or e-mail could be found for 911, and they were invited to participate in the study. The owners or managers were invited to answer an electronic questionnaire. To ensure a high response rate, all institutions were invited to participate via e-mail, after which all institutions were contacted by telephone up to 3 times. After 3 unsuccessful attempts, a new round of e-mails was sent. Invitations were also published on the websites and social networks of the Department of Justice and the National Front for Strengthening LTCF.

The authors developed a self-applied electronic questionnaire in Google Forms based on federal recommendations about LTCF regarding technicians, managers, owners, and staff working as caregivers or administrators of these facilities between January 4 and July 1, 2021. The questionnaire included 55 items, divided into 3 sections: identification and characterization of the institution and respondent; the prevalence of COVID-19 cases, hospitalization, and deaths among residents and staff; and COVID-19 control measures, including organizational changes, infrastructural changes, availability of personal protective equipment (PPE) and hygiene items, and staff training. To ensure the accuracy of data on the number of COVID-19 infections, hospitalizations, and deaths, the respondents were asked to only consider cases confirmed by RT-PCR or serological tests.

The data were transferred to an Excel 10.0 spreadsheet (Microsoft, Redmond, WA, USA) and were analyzed in IBM SPSS Statistics 21.0 (IBM, Armonk, NY, USA). Data on

participant characteristics, the occurrence of cases, hospitalizations, and deaths and the main preventive measures were presented as absolute and relative frequencies. The Spearman correlation was used to determine the association between LTCF sector (non-profit or for-profit) and the number of cases, hospitalizations, and deaths among residents and staff. The Pearson correlation was used to determine the association between LTCF size (number of residents) and the number of COVID-19 cases, hospitalizations and deaths among residents and staff.

The study complied with National Health Council Resolution 466/12 and the Declaration of Helsinki and was approved by the Pontifical Catholic University of Minas Gerais Research Ethics Committee (no. 4427965/2020). Because the data could not be used to directly identify residents, only the owners or managers were required to provide written informed consent. This study received funding from the Pontifical Catholic University of Minas Gerais through its Research Incentive Fund (FIP-2020/24734-1S)

RESULTS

At the time of data collection, there were 6017 residents in the participating LTCF. The number of available vacancies was 7108, indicating an occupancy rate of 84.60% during the study. Of these LTCF, 120 were non-profit (73.17%) and 44 were for-profit (26.83%). Of the 1116 LTCF in the state, 164 agreed to participate in the study, a 14.69% response rate. However, good regional representativity of the population was achieved (Table 1), with 37.19% ($n = 61$) of the LTCF being from the central region.

The results were divided into 3 sections:

1. Prevalence of COVID-19 cases, hospitalizations, and deaths among LTCF residents and staff;
2. Pandemic control measures in LTCF; and

3. The association between COVID 19 cases, hospitalizations, and deaths among residents and staff and LTCF size and sector.

Prevalence of COVID-19 cases, hospitalizations, and deaths among long-term care facility residents and staff

COVID-19 infection among residents was reported by 48.7% of the LTCF. Of the 6017 LTCF residents, 1139 were infected, an 18.93% infection rate. Older residents from 39.63% ($n = 65$) of the LTCF were hospitalized, and the hospitalization rate was 34.80% among those infected by COVID-19. A total of 214 residents from 32.32% ($n = 53$) of the LTCF died from COVID-19, an 18.78% mortality rate. The overall mortality rate from COVID-19 among LTCF residents was 3.56%. The rate of cases, hospitalizations, and deaths from COVID-19 is shown in Figure 1.

Of the included LTCF, 68.90% reported COVID-19 cases among staff ($n = 113$), totaling 664 infected people. Infected staff were hospitalized in 7.32% of the LTCF ($n = 12$), with a hospitalization rate of 2.60% among the infected. Staff deaths were reported in 1.22% ($n = 2$) of the LTCF, a 0.32% mortality rate. The rate of cases, hospitalizations, and deaths from COVID-19 among LTCF staff is shown in Figure 2.

Pandemic control measures in long-term care facilities

Preventive measures were divided into organizational, infrastructural, hygiene items/PPE, and staff training to combat COVID-19.

Organizational control measures

A total of 96.95% ($n = 159$) of LTCF managers reported implementing an action plan to prevent and control COVID-19 infection. However, 22.56% ($n = 37$) of the LTCF did not have a contingency plan with municipal

TABLE 1. Participating long-term care facilities vs the overall number in Minas Gerais, Brazil, according to region.

State regions	Participating LTCF	% per region	Total number of LTCF	% per region
Central	61	37.19	449	40.23
South	25	15.24	172	15.41
Mata	22	13.41	135	12.10
Midwest	13	7.93	81	7.26
<i>Jequitinhonha/Mucuri</i>	12	7.32	42	3.76
<i>Alto Paranaíba</i>	7	4.27	37	3.32
<i>Rio Doce</i>	7	4.27	56	5.02
North	7	4.27	39	3.49
<i>Triângulo</i>	6	3.66	87	7.80
Northwest	4	2.44	18	1.61
Total	164	100.0	1116	100.0

LTCF: Long-term care facility.

health authorities to manage older adults with suspected or confirmed COVID-19 infection.

Most LTCF (98.17%, $n = 161$) reported higher frequencies of cleaning and surface/furniture disinfection, although 1.83% ($n = 3$) reported that adequate cleaning and disinfection were not possible. Similarly, 96.95% ($n = 159$) of the LTCF reported cleaning or quarantining food, vegetables, and fruits.

As a disease control measure, 82.32% ($n = 135$) of the LTCF offered COVID-19 testing for all staff and residents at least once. A total of 92.07% ($n = 151$) of the LTCF actively screened professionals and service providers for signs and symptoms of COVID-19.

Visits by family members and friends were suspended in 95.73% ($n = 157$) of the LTCF, and 89.63% ($n = 147$) also suspended socialization activities among residents.

Most LTCF (84.76%, $n = 139$) performed in-person medical consultations for suspected cases of COVID-19, and 94.50% reported cases to the Brazilian Unified Health System's epidemiological surveillance system, the Department of Justice, the Secretariat for Social Assistance, Older Adult Rights Council, and other authorities.

Residents from 4.29% ($n = 7$) of the LTCF were not registered with their local Basic Health Unit and had an outdated vaccination schedule according to National Immunization Program recommendations.

Infrastructural control measures

Collective living spaces and drinking fountains were not used by 40.85% ($n = 67$) and 44.51% ($n = 73$) of the LTCF, respectively; all LTCF maintained the highest environmental ventilation flow.

Specific entrance areas for professionals, staff, and service providers were available in 78.66% ($n = 129$) of the LTCF. Most (85.37%, $n = 140$) designated spaces to isolate suspected and confirmed cases of COVID-19; however, 14.63% ($n = 24$) of these isolation rooms did not have a bathroom.

Hygiene items and personal protective equipment

Not all participating institutions acquired the recommended PPE for COVID-19 protection (i.e., surgical, N95/PFF2, and fabric masks; disposable gloves; disposable aprons; boots; shoe covers; face shields; safety goggles; and surgical caps). Several LTCF managers reported a lack of PPE (Figure 3) and hygiene items (Figure 4).

Of the participating LTCF, 79.87% ($n = 131$) received guidance about managing suspected or confirmed COVID-19 cases. Most professionals (96.95%, $n = 159$) were trained in hand hygiene techniques, the proper use of PPE, and social distancing. LTCF training occurred monthly (60.97%, $n = 100$), fortnightly (7.32%, $n = 12$), weekly (18.29%, $n = 30$), or daily (13.41%, $n = 22$).

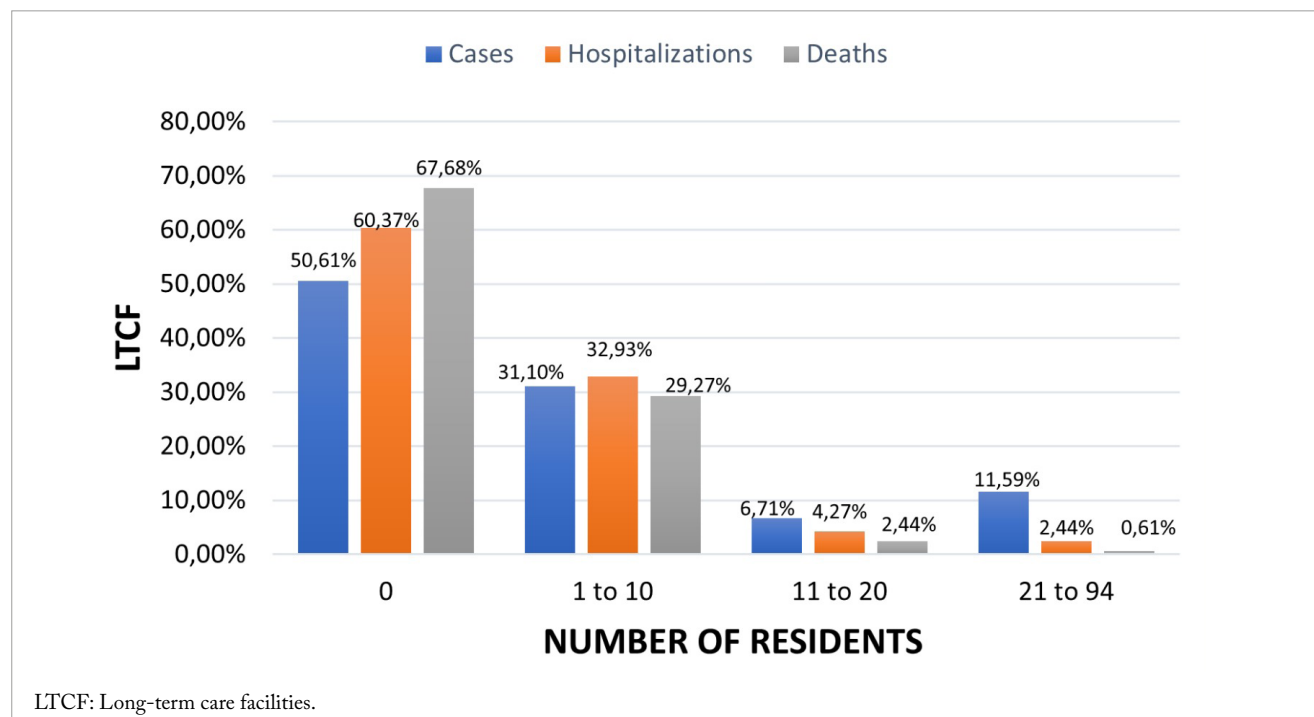


FIGURE 1. Rate of COVID-19 cases, hospitalizations, and deaths among residents of long-term care facilities of Minas Gerais, Brazil ($n = 164$).

The LTCF provided posters, booklets, and verbal guidance about correct safety techniques for residents, the importance of frequent hand hygiene (94.49%) and respiratory

etiquette (96.33%) and helped staff who had difficulties with hand hygiene procedures (98.22%). All of the LTCF instructed professionals, service providers, and delivery

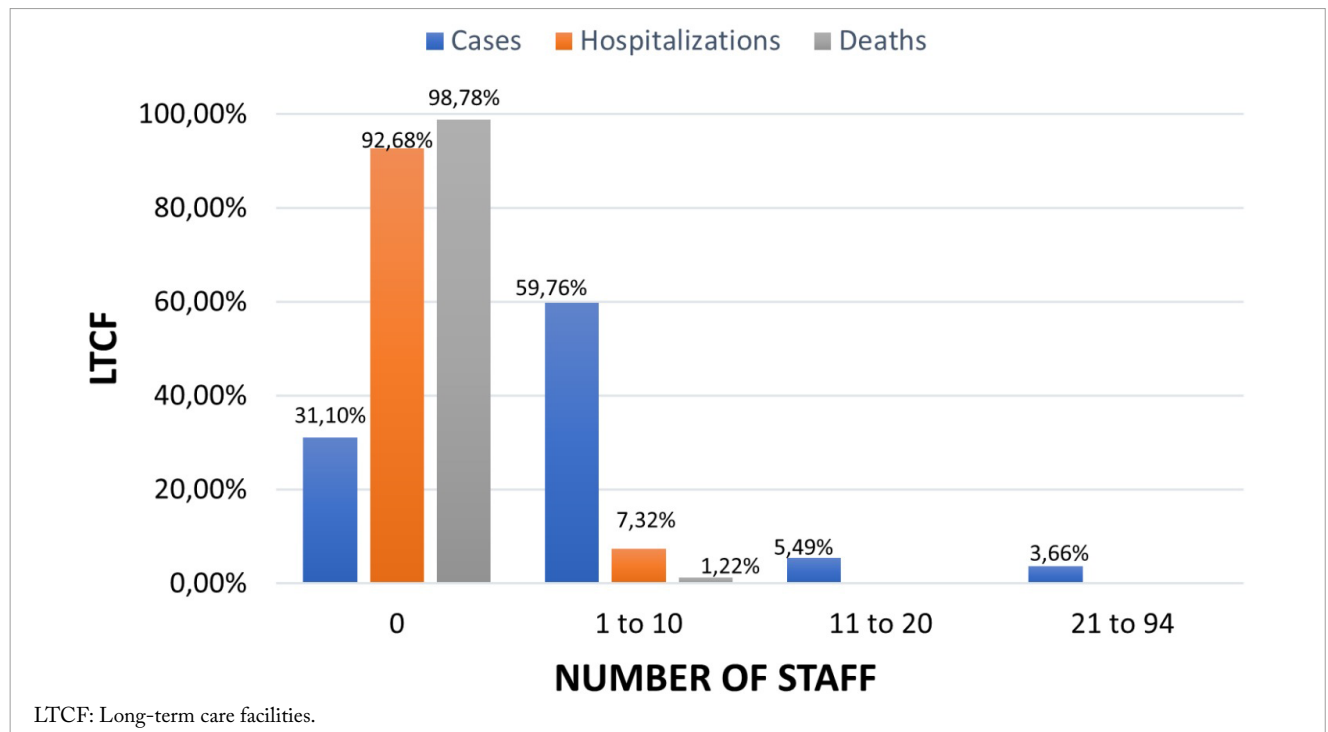


FIGURE 2. Number of cases, hospitalizations, and deaths among the staff of long-term care facilities. No COVID-19 infections were reported in 31.10% of the facilities and between 1 and 10 deaths were reported 1.22% (n = 164).

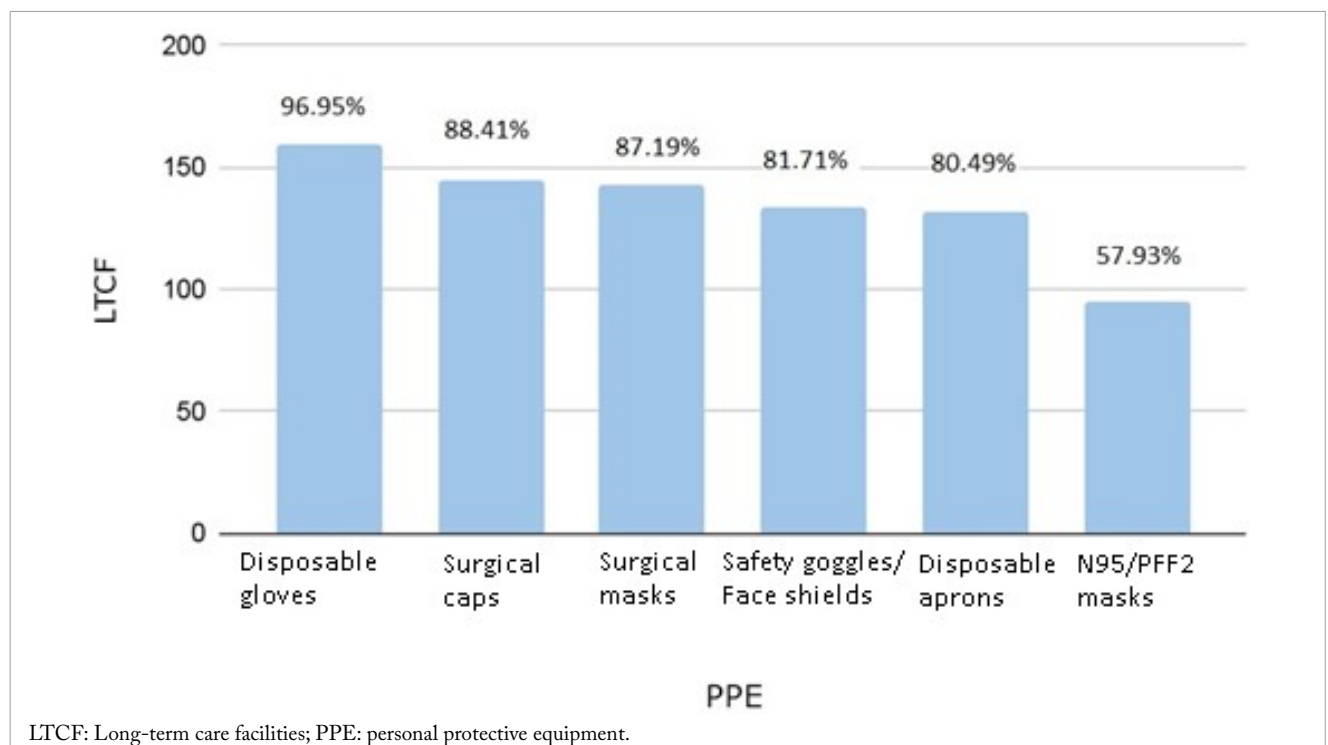


FIGURE 3. Personal protective equipment available in long-term care facilities (n = 164).

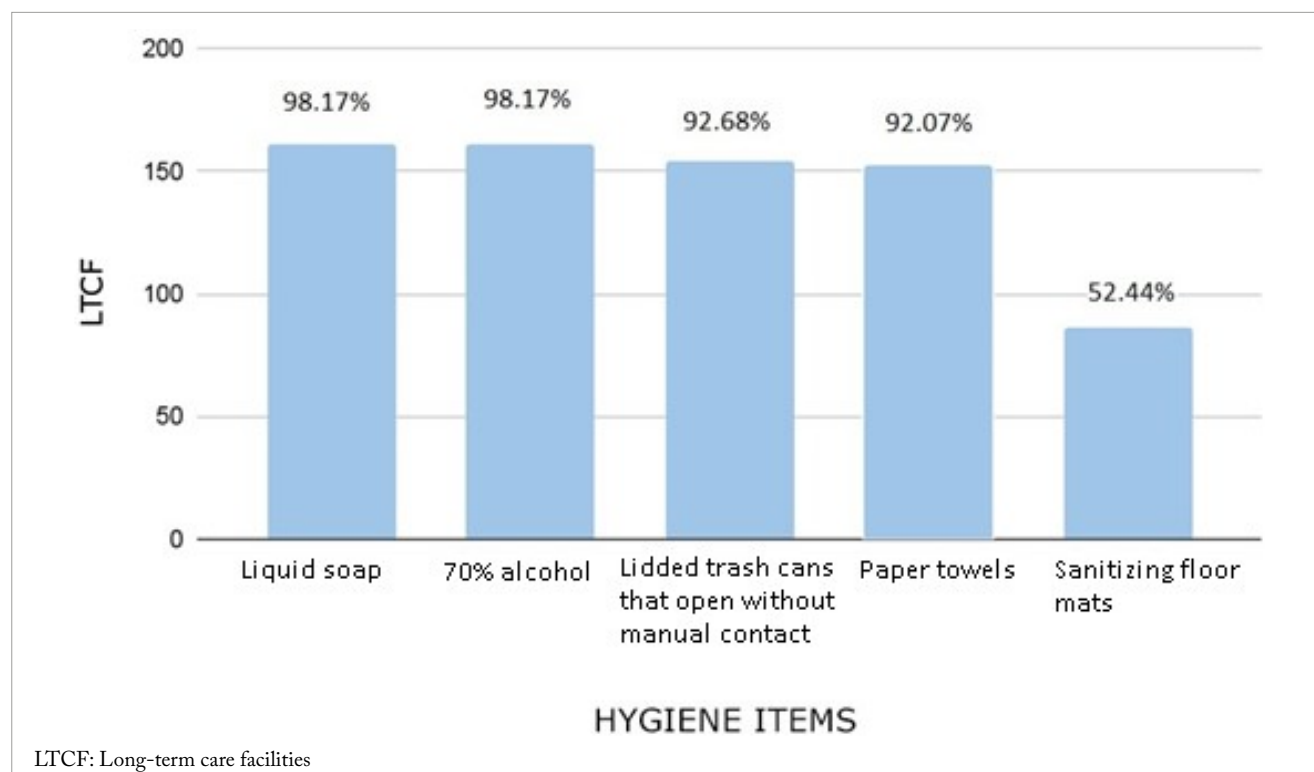


FIGURE 4. Hygiene items available in long-term care facilities. More than 150 LTCF (98.17%) had liquid soap, and 85 (52.44%) had a sanitizing mat ($n = 164$).

personnel to wash their hands with soap and water or alcohol before entering.

The association between COVID-19 cases, hospitalizations, and deaths among residents and staff and long-term care facility size and sector

There was no significant association between LTCF sector and the number of cases ($p = 0.79$), hospitalizations ($p = 0.38$) or deaths ($p = 0.62$) among residents or between the number of cases ($p = 0.06$), hospitalizations ($p = 0.88$) or deaths ($p = 0.39$) among staff. However, there was a significant but weak correlation between LTCF size and the number of cases ($r = 0.301$; $p = 0.00$), hospitalizations ($r = 0.23$; $p = 0.01$) and deaths ($r = 0.24$; $p = 0.01$) among residents and the number of cases ($r = 0.26$; $p = 0.01$), hospitalizations ($r = 0.06$; $p = 0.04$) and deaths ($r = 0.15$; $p = 0.04$) among staff.

DISCUSSION

This study presented data on rates of COVID-19 infection, hospitalization, and death among residents and staff of LTCF in Minas Gerais, Brazil, between January and July 2021, as well as the facilities' main preventive measures. Although electronic questionnaires are advantageous, they commonly achieve low

response rates. For instance, LTCF response rates in studies from China¹¹ and Ireland¹² were 48.0% and 62.2%, respectively. In contrast, Kariya et al.¹³ had a low response rate (16.9%) to questionnaires on infection prevention and control measures among LTCF. The daily problems of residents and staff during the pandemic may have also contributed to the low response rate.^{11,12} Response rate cut-off points are not recommended during rapidly developing scenarios, such as the COVID-19 pandemic, since studies with small samples may also provide important findings for further research.¹⁴ Nevertheless, selection bias must be considered when interpreting the results.

High variability in COVID-19 cases was observed among LTCF residents worldwide (4% to 77%, mean prevalence 37%).¹⁵ Much of this variability can be explained by methodological differences, and some, but not other, studies may have been conducted during more severe periods of the pandemic. Wachholz et al.¹⁶ found a 6.57% incidence of COVID-19 cases in 2154 Brazilian LTCF ($n = 59,878$ older adults). In the present study, 48.78% ($n = 80$) of LTCF reported COVID-19 cases among residents, a lower rate than in developed countries.¹ Studies from Ireland (28 LTCF) and Italy (57 LTCF) reported COVID-19 cases in 75% and 64.9% of their samples, respectively.^{12,17} Nevertheless, some factors may have influenced our findings, such as low rates of testing and high rates of underreporting.⁸

Residents were hospitalized for COVID-19 in 39.63% of the participating LTCF, reinforcing the frailty of this population. The COVID-19 hospitalization rate among LTCF residents was almost 4 times higher (34.80%) than that of older adults in the state's general population (8.8%).¹⁸

The present study reported a lower COVID-19 lethality rate among LTCF in Minas Gerais than in Ireland (27.6%), Australia (33.1%) and Canada (27.8%).^{12,19,20} At least 40% of all COVID-19 deaths in the United States were from older adults in LTCF.²¹ Wachholz et al.¹⁶ found mortality and lethality rates of approximately 1.47% and 22.44%, respectively, among LTCF residents in Brazil due to COVID-19; the mortality rate was 1.15% in this state.

A substantial risk to LTCF residents is contamination by staff.³ Staff may be exposed to COVID while commuting (eg, public transportation) or in other environments (eg, hospitals or other facilities).³ Only asymptomatic LTCF staff were allowed to work,¹⁵ and few cases of hospitalization or death occurred among them, reinforcing their low vulnerability due to fewer risk factors.

Of the participating LTCF, 77.44% did not develop contingency plans with health authorities. In contrast, 96.95% had internal institutional plans.

In-person visits from friends and family and collective activities continued in some LTCF, exposing residents to risk, since social distancing is essential to controlling SARS-CoV-2 transmission.³

Active screening (ie, monitoring COVID-19 signs and symptoms among residents, professionals, and visitors) allows early detection and isolation of suspected and confirmed cases in LTCF and is essential for effective control of COVID-19.²¹ Most LTCF offered testing for all residents and staff at least once during the study period. Immediately notifying epidemiological surveillance agencies is also necessary in suspected cases (ie, for symptoms of influenza or severe acute respiratory syndrome) to improve protection measures and develop adequate strategies against the virus.⁴

According to the Ministry of Health, LTCF are also responsible for training their staff to prevent and control COVID-19 transmission.³ Most LTCF staff (96.95%) only received training about COVID-19 prevention, including the correct use of PPE. Most training programs in Brazil were conducted online, especially those provided by the government.²² Nevertheless, considering that most populations have low socioeconomic and educational levels, dissemination of this information may have been insufficient.⁷ LTCF residents have different levels of dependence, which could also impair self-care and preventive measures against COVID-19.²³ In the present sample of LTCF, almost half used collective drinking fountains, and 40.85% had shared objects in their living

spaces. Most LTCF provided instructions about correct hand hygiene and respiratory etiquette to control infection among residents. Most LTCF expanded their daily cleaning routines and disinfected surfaces and furniture. However, most did not designate a specific entrance for employees and service providers, increasing the risk of contact with residents. Although most LTCF managers (85.37%) designated spaces to isolate suspected and confirmed COVID-19 cases, 14.63% of these had no bathroom. The lack of infrastructure in these LTCF hindered COVID-19 prevention⁸ and highlights the need for strategies to protect older people in other epidemic situations.

Dykgraaf et al.²⁴ suggested that non-pharmacological measures in LTCF could prevent COVID-19 infection and its consequences, and these findings were reinforced in a review²⁵.

There was a lack of PPE in the participating LTCF, such as N95/PFF2 masks and goggles. A Chinese study of 484 LTCF found that 72% lacked PPE.¹¹ These findings corroborate studies from other locations.^{7,26} Such results may reflect ineffective public policies regarding LTCF in a number countries.²⁷ Thus, efforts are needed to acquire PPE for LTCF staff, since they can be asymptomatic carriers of COVID-19.¹⁵

These multiple needs require a coordinated response between LTCF managers and the government. Based on the present data, the scenario experienced in Brazilian LTCF during the pandemic was better than that of other LTCF worldwide, especially regarding COVID-19 deaths among residents,¹ which confirmed this study's initial hypothesis. Civil society was mobilized even without effective public policies to protect LTCF,²² which may have helped minimize the number of cases, hospitalizations, and deaths from COVID-19. This mobilization began with public outcry over the state of LTCFs,²⁸ which led to a public hearing in Congress on April 7, 2020. Consequently, the National Front for Strengthening LTCF united hundreds of professionals and volunteers across Brazil to mitigate the effects of the COVID-19 pandemic on LTCF.²⁹ Experts in gerontology and public management also proposed strategies (such as the "coordination, identification, assessment, and work" approach) to support government actions against the pandemic and control the impact of COVID-19 on LTCF in developing countries.³⁰ Another hypothesis confirmed by this study was the significant association between an LTCF's infection, hospitalization and death rates among residents and staff and its number of residents. This shows that greater attention must be paid to LTCF with more residents, which is in line with World Health Organization recommendations on the need to increase preventive measures in environments with greater crowding. However, since there was no correlation between epidemiological data and LTCF sector, national prejudice against care quality in non-profit

LTCF is unjustified. Finally, it should be pointed out that our data imply association, and not causality, between the variables. Future studies may help clarify these associations.

Vaccines against COVID-19 were not available in Brazil when our questionnaire was being developed. We also point out that rates of infection, hospitalization, and death among residents and staff may have been impacted by vaccination, which coincided with the data collection period. Nevertheless, this study is not free from limitations. The growing demand for research on this topic, lack of time due to workload, and cultural habits may have contributed to a lower response rate than other international studies,^{10,11} although exhaustive methodological procedures were employed to reach the target population. Data on LTCF staff size were not collected, which prevented determining the COVID-19 prevalence and mortality rates among staff. Furthermore, since the questionnaire was answered by LTCF managers or owners, there is no way to guarantee the accuracy of the epidemiological data or the extent to which preventive measures were implemented. Finally, the study's aim was not to explore the association between preventive measures and epidemiological data. Since the data were collected at different points during the pandemic (January-July 2021), with some institutions answering the questionnaire during periods of outbreak and others during periods of relative calm, it was impossible to determine whether preventive measures had been intensified or relaxed overall.

This study presented data on rates of COVID-19 infection, hospitalization and death among residents and staff of LTCF in Minas Gerais, Brazil. Although undertesting and underreporting may have been factors, the COVID-19 infection and mortality rates among these facilities were lower than those observed in other countries. The lack of an association between LTCF sector and infection, hospitalization, and mortality rates may help remove prejudice against non-profit institutions. Furthermore, the main preventive measures were characterized, including organizational and infrastructural aspects, the availability of hygiene items and PPE, and staff training. These measures must be reinforced, especially in LTCF with larger populations. Despite knowing that prevention strategies, mainly infrastructural measures and PPE availability, could reduce infection among residents and staff, many LTCF could not comply with recommendations, which reveals the obstacles they face on a daily basis. The vulnerability of this population demonstrates the need for greater support from civil society and government agencies.

CONCLUSIONS

The COVID-19 pandemic severely affected LTCF, highlighting the need for protective actions due to the vulnerability of

this population. We determined the COVID-19 infection rate among residents and staff of LTCF in Minas Gerais, Brazil. COVID-19 mortality was higher among residents than staff. LTCF sector was not associated with the number of cases, hospitalizations, or deaths, but these were associated with LTCF population size. Prevention strategies, especially infrastructural measures and PPE availability, could have reduced infection among residents and staff, but many LTCF could not comply with recommendations.

These challenges to COVID-19 prevention indicate that public policy should focus on the daily struggles of LTCF. Our results emphasize the importance of continuity and more focused actions to protect LTCF residents and promote health education for LTCF managers and staff. Further studies to monitor the impact and challenges of the COVID-19 pandemic are also needed.

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Conflict of Interests

The authors declare no conflicts of interest.

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Author Contributions

TTBL: conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing – original draft, writing – review & editing, visualization, supervision, and project administration. MGA: formal analysis, writing – review & editing, visualization, and supervision. VNS: conceptualization, methodology, investigation, resources, data curation, writing – original draft, and visualization. LGDD: conceptualization, validation, investigation, resources, data curation, writing – original draft, and visualization. APRG: conceptualization, validation, investigation, resources, data curation, writing – original draft, and visualization. PFC: methodology, software, writing – review & editing, and visualization. NCH: conceptualization, formal analysis, investigation, resources, writing – review & editing, and visualization. MCMRS: conceptualization, formal analysis, resources, writing – review & editing, and visualization. LSMP: formal analysis, writing – review & editing, visualization, and supervision.

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