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A Longitudinal Examination of Post-COVID-19 Mortality in Residents in Long-Term Care Homes

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Abstract

The most adverse outcomes of the COVID-19 pandemic include high post-infection mortality among long-term care (LTC) home residents. Research about mortality over a longer period after contracting COVID-19 and in different pandemic years is limited. In the current study, we examined outcomes for 1,596 LTC residents from the day of a positive COVID-19 test until January 31, 2023. We reported all-cause mortality 30 days after contracting COVID-19 and monthly throughout the follow-up, up to 35 months after the pandemic start. We also examined mortality among 2,724 residents residing in the same LTC homes, with no history of COVID-19 during the same period. The results underscored a large number of deaths in the first month post-infection, with 30-day mortality substantially decreasing over the years—from 28% (95% CI [24.3, 31.8]) among residents contracting COVID-19 in 2020, to 8.3% (95% CI [7.4, 9.2]) in the 2022 cohort. Observed over longer periods, monthly mortality among residents with a COVID-19 history was similar to mortality in the No-COVID residents, and no evidence was found of increased mortality risk in the COVID group beyond the first post-infection month. We discuss mortality in LTC during the pandemic and a continuing need to reduce mortality in the acute phase of COVID-19.

Keywords

long-term care, nursing homes, mortality, post-COVID-19, survival analysis

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Among the most adverse outcomes of the COVID-19 pandemic, worldwide, was the high mortality documented in long-term care (LTC) home residents (Akhtar-Danesh et al., 2022; Ballin et al., 2021; Levin et al., 2022; Mas Romero et al., 2020; Sepulveda et al., 2020). Mortality among LTC residents who contracted COVID-19 was closely followed during the pandemic in an effort to reduce and prevent this most adverse outcome. Post-infection mortality was commonly reported for the period immediately following the infection (e.g., 30-day mortality). However, in the context of concerns about possible long-term effects of contracting COVID-19 and post-acute sequelae of the infection, questions have been raised about the outcomes and mortality in longer follow-up periods after the infection (Sorensen et al., 2022; Weerahandi et al., 2022). As evidence is lacking, a possibility of increased mortality risk over a longer time after contracting COVID-19, along with other possible consequences of COVID-19, needs to be examined in the vulnerable LTC population.

Additionally, there were changes in mortality in LTC residents in different pandemic periods. Beside the individual-level factors relevant for COVID-19 infection outcome (Panagiotou et al., 2021), dynamic contextual factors in effect during the COVID-19 pandemic were relevant—including the changing nature of the virus itself and changes in treatments/care over time (Betini et al., 2021; Brown et al., 2021). While a decrease in post-COVID-19 mortality over the course of the pandemic has been evident across populations (Horita & Fukumoto, 2023), more specific information is needed about the changes in mortality in LTC in different pandemic periods (Levin et al., 2022; Thibon et al., 2023). Finally, factors unrelated to the COVID-19 infection itself, yet relevant for all LTC residents during the pandemic time, impacted residents' outcomes—including

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changes to health systems and various measures implemented to curb the spread of the virus and prevent outbreaks (Beaney et al., 2020; Betini et al., 2021; Levere et al., 2021). Therefore, investigations about mortality in LTC residents who contracted COVID-19 should also inform about mortality among residents who did not contract COVID-19 in the same LTC settings and COVID-19 pandemic circumstances.

In Canada, high numbers of COVID-19 deaths in LTC were reported in the early phases of the pandemic (Betini et al., 2021; Canadian Institute for Health Information, 2021). Information about mortality in residents who contracted COVID-19 and those who did not was reported by Akhtar-Danesh et al. (2022). Information was limited to the earliest pandemic period, in wave 1 and wave 2 in 2020.

The Current Study

In the current study, in the Canadian context, we examine mortality among LTC home residents from various perspectives—short-term after contracting COVID-19 and over a longer period post-infection, in different pandemic years, and in residents with and without a history of COVID-19—with the goal to build a more comprehensive picture of mortality in LTC residents during the pandemic. The specific study goals were: (a) to examine mortality in LTC home residents with a history of COVID-19 in the period immediately following infection (e.g., 30-day mortality); (b) to explore morality over a longer post-infection follow-up (up to 35 months from the pandemic start); (c) to examine and compare mortality in subgroups of residents who contracted COVID-19 in different pandemic years (i.e., in year 2020, 2021, and 2022); and (d) to explore mortality over time in residents with no history of COVID-19—those who resided in the same LTC homes during the same period as residents with a history of COVID-19.

Method

Participants and Data Sources

The study participants were residents in 19 LTC homes at any time in the period from March 1, 2020 to April 30, 2022 (n=4,320). The LTC homes are affiliated with Fraser Health Authority (FHA), British Columbia (BC), Canada. Information was available for publicly funded residents in these homes. Out of all residents, 1,596 residents had a positive COVID-19 test during the period from March 1, 2020 to April 30, 2022 (COVID group), and 2,724 residents did not have a positive COVID-19 test during this time (No-COVID group). Background characteristics of the study participants are provided in Supplemental materials Table 1 and 2. Participation was limited to residents in LTC homes (i.e., nursing homes, providing 24-hr professional service to meet residents' complex care needs), with other assisted living facilities not included.

Study data were collected retrospectively from the FHA data sources. Information about COVID-19 testing and the test results was obtained from BC Population and Public Health in FHA. Mortality data, and information about resident characteristics (i.e., age, sex, and functional status) were obtained from FHA administrative databases linked to the BC Vital Statistics Agency, and from the Resident Assessment Instrument—Minimum Data Set 2.0 (RAI-MDS 2.0). Ethical approval for the study was received from the FHA Research Ethics Board.

Outcome and Procedure

"All-cause" mortality was reported in the study (e.g., in residents with a history of COVID-19, mortality from any cause was reported as opposed to mortality directly resulting from the COVID-19 infection). The outcome for each resident with a history of COVID-19 was examined from the day of a positive COVID-19 test until January 31, 2023 (the date when mortality/survival information was obtained, chosen to ensure at least 9 months of follow-up for the residents who had a positive test toward the end of the study inclusion period, i.e., in April 2022). Length of time from the positive COVID-19 test until January 31, 2023 ranged from 9.1 to 34.5 months (M=18 months; SD=7.3).

Monthly mortality rates were reported for the No-COVID group—the outcome for each of these residents was also examined until January 31, 2023 (or, if they contracted COVID-19 after the study inclusion period, the outcome was examined until the date of the positive COVID-19 test[1]). Among No-COVID residents, we distinguished between two groups. One group (No-COVID_1) was residents residing in the LTC homes at the start of the study period (start of the pandemic), on March 1, 2020 (n=1,536)—for this group, monthly mortality was examined starting from March 1, 2020, with the mean length of time until the study end date of 34.5 months (range from 25.9 to 35 months). The second group of No-COVID residents (No-COVID_2, n=1,188) included residents admitted to the LTC homes after the pandemic start (after March 1, 2020) and within the study inclusion period. These residents were followed from their LTC home admission date—the mean length of time from admission until the end of the study was 20.8 months, ranging from 0.5 to 35 months. Distinguishing between these two cohorts was needed for establishing a meaningful follow-up start date.

Data Analysis

We described the background characteristics of the residents and compared the characteristics in the different groups by using chi-square test, t-test, or ANOVA, depending on what variables and groups were of interest in the analysis. To explore post-COVID-19 mortality over the follow-up period, non-parametric and

semi-parametric survival analyses were conducted. We used Kaplan-Maier analysis to plot survival curve in the COVID group and explore the survival probabilities in residents who contracted COVID-19 in the different years (three COVID-group cohorts). To assess the relations between resident characteristics and mortality over the follow-up, we used multivariate Cox regression (adjusted coefficients reported). To assess the relation between year of contracting COVID-19 and mortality at 30 days post-infection, while adjusting for the resident characteristics, we used multivariate logistic regression (there were no cases lost to follow-up during this time).

Monthly mortality hazard rates from survival analysis life tables were reported in the groups of residents with and without a history of COVID-19 over the follow-up period. In comparing different groups, as opposed to statistical comparisons of the survival curves, exploratory analysis of monthly mortality over time was deemed more appropriate and informative in the current context. In the case of residents with a history of COVID-19, their follow-up period and mortality reporting started from the day they contracted COVID-19 (a major health event) while in the No-COVID group, the follow-up start date was chosen arbitrarily, as suitable in the study context. Proportional hazard ratio assumption for statistical curves comparisons was not met in such a context (hazard was not independent of time); therefore, exploratory analysis of monthly mortality over time was deemed appropriate.

Results

Resident Characteristics

Out of the 4,320 residents in the LTC homes, 1,596 residents (37%) contracted COVID-19 in the period from March 1, 2020 to April 30, 2022. On the day of a positive COVID-19 test, the residents' mean age was 84.7 years ($SD = 9.97$), and 57% of the residents were female. Among these residents, 799 contracted COVID-19 in the year 2022 (50.1%), followed with 35.1% of residents in 2020, and 14.7% residents in 2021 (missing $n = 2$). The characteristics of residents who contracted COVID-19 in 2020, 2021, and 2022[2] are presented in Supplemental materials Table 1. The three groups were similar in terms of sex, age, and functional status (Activities of daily living [ADL] score) with no statistically significant differences found (all p-values $> .05$).

A greater heterogeneity was revealed within the No-COVID group; specifically, between residents residing in the LTC at the start of the pandemic and residents admitted later, during the pandemic (Supplemental materials Table 2). Differences in sex, age, and ADL scores between these two No-COVID subgroups were all statistically significant (all p-values $< .01$, Table 2). That is, residents admitted to LTC during the pandemic versus before the pandemic were slightly younger, there were more males in this group, and they had a higher ADL function. Therefore, the study outcome was investigated and reported separately in these two groups of No-COVID residents. An overall comparison of COVID and No-COVID residents did not reveal significant differences between the groups in terms of sex, χ^2 (2, 4316) = 2.67, $p = .26$, and age, t (4316) = 1.29, $p = .20$. A difference in ADL function (as indicated in the last assessment conducted before the follow-up start) was statistically significant, t (3609) = 2.5, $p = .01$; however, the difference was very small (less than one point on a 28-point scale).

Mortality in Residents With a History of COVID-19

The survival curve for the COVID group is presented in Figure 1a. The curve depicts high mortality in the first month after contracting COVID-19, and a substantial decrease in mortality in the following months. In the first 30 days after contracting COVID-19, mortality was 16.9% (95% CI [15, 18.7]). At 12 months post-infection, estimated cumulative mortality in this group was 36.6% [34.2, 39]; and at 24 months, it was 54.9% [51.6, 58.2]. Regarding the relations between resident characteristics and mortality—residents' age, sex, and ADL score were related to 30-day mortality and mortality over the follow-up period. According to the results of the multivariate logistic regression, the risk of mortality at 30 days increased with age, $OR = 1.05$ (95% CI [1.04, 1.07]), in male residents, $OR = 2.17$ [1.62, 2.9], and with increase in the ADL score (i.e., worsening functional status), $OR = 1.05$ [1.03, 1.07]; all p-values $< .001$. Over the follow-up, the results of the Cox regression analysis indicated the mortality risk as follows: age, $HR = 1.05$ (95% CI [1.04, 1.06]), males, $HR = 1.71$ [1.5, 2.0], and ADL score increase, $HR = 1.04$ [1.03, 1.05]; all p-values $< .01$. Monthly mortality rates in the months during the follow-up period are detailed in Figure 2a.

Among residents who contracted COVID-19 in each of the three different years (i.e., in year 2020, 2021, and 2022), 30-day mortality in the group contracting COVID-19 in 2020 was 28% (95% CI [24.3, 31.8]), decreasing in the groups of residents who contacted infection in the subsequent years: in year 2021, 30-day mortality was 19.6% [17.5, 21.7] and in year 2022, it was 8.3% [7.4, 9.2]. After adjusting for age, sex, and ADL score, the results of the logistic regression analysis confirmed a statistically significant relation between the year of contracting COVID-19 and 30-day mortality, $b = -0.85$, $p < .001$, $OR = 0.43$ (95% CI [0.36, 0.51]). Survival curves for the three groups, over the 12-month period, are presented in Figure 1b, and monthly mortality hazard rates are presented in Figure 2b–d. In these three groups, mortality was reported for the first 12 months after contracting COVID-19, as no information beyond this length of time was available for residents in the subgroup with the shortest follow-up window (i.e., residents that contracted COVID-19 in

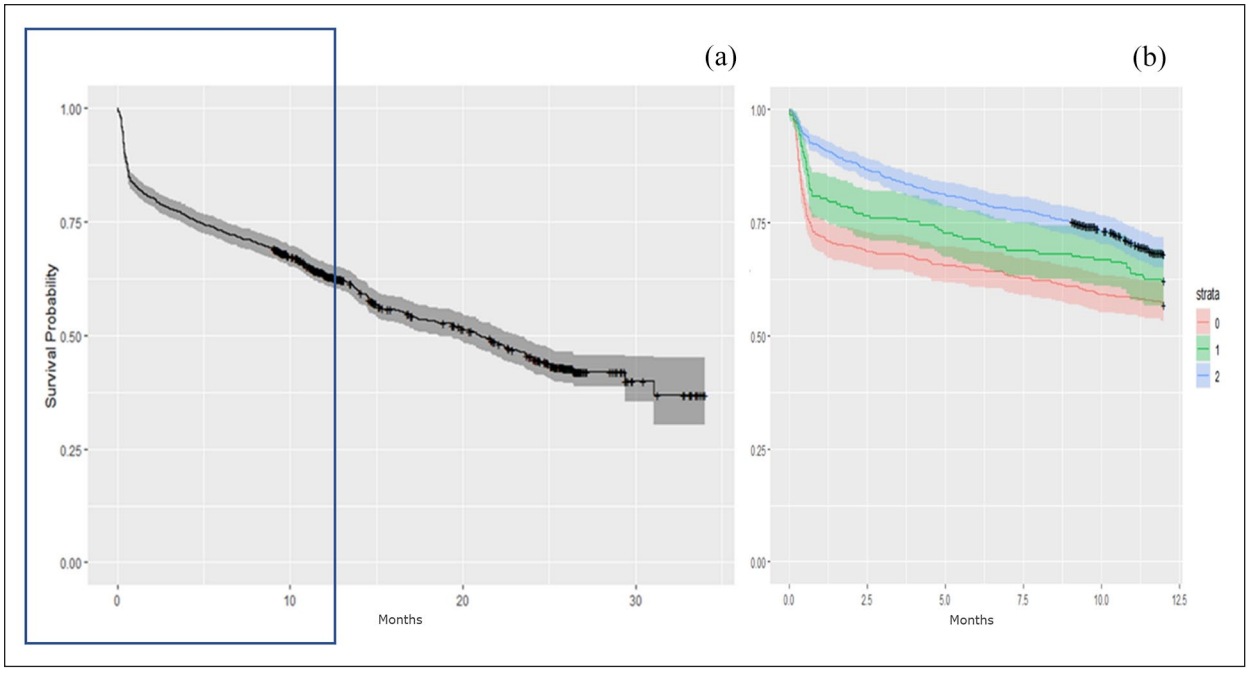

Figure 1. Survival curve with 95% confidence intervals plotted for residents with a history of COVID-19. On the *X* axis, zero-time is the date of positive COVID-19 test. (a) All residents with a history of COVID-19 ($n = 1{,}594$, missing $n = 2$). The insert depicts the first 12 months, corresponding to the time interval in Figure1b; (b) Residents who contracted COVID-19 in 2020 (pink line, $n = 560$), 2021 (green line, $n = 235$), and 2022 (blue line, $n = 799$). Only the first 12 months after infection were plotted, as no information beyond 12 months was available for 2022 cohort.

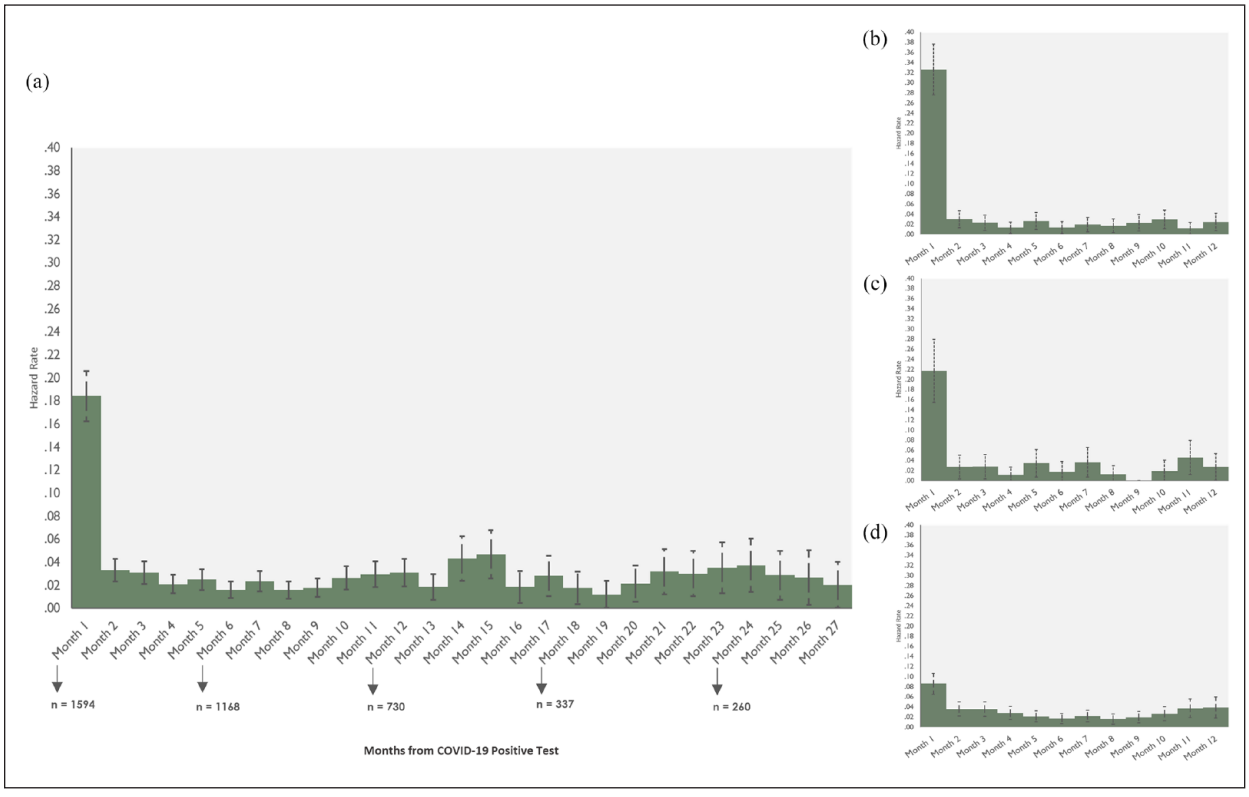

Figure 2. Mortality hazard rates with 95% confidence intervals for residents with a history of COVID-19. On the *X* axis, zero-time is the date of COVID-19 positive test. (a) All residents with a history of COVID-19 ($n = 1{,}594$); mortality rates are shown for 27 months after the infection—in the subsequent time intervals, the number of residents became small (i.e., 50 or less residents); (b) Mortality hazard rates for residents who contracted COVID-19 in 2020 ($n = 560$); (c) Mortality hazard rates for residents who contracted COVID-19 in 2021 ($n = 235$); (d) Mortality hazard for residents who contracted COVID-19 in 2022 ($n = 799$).

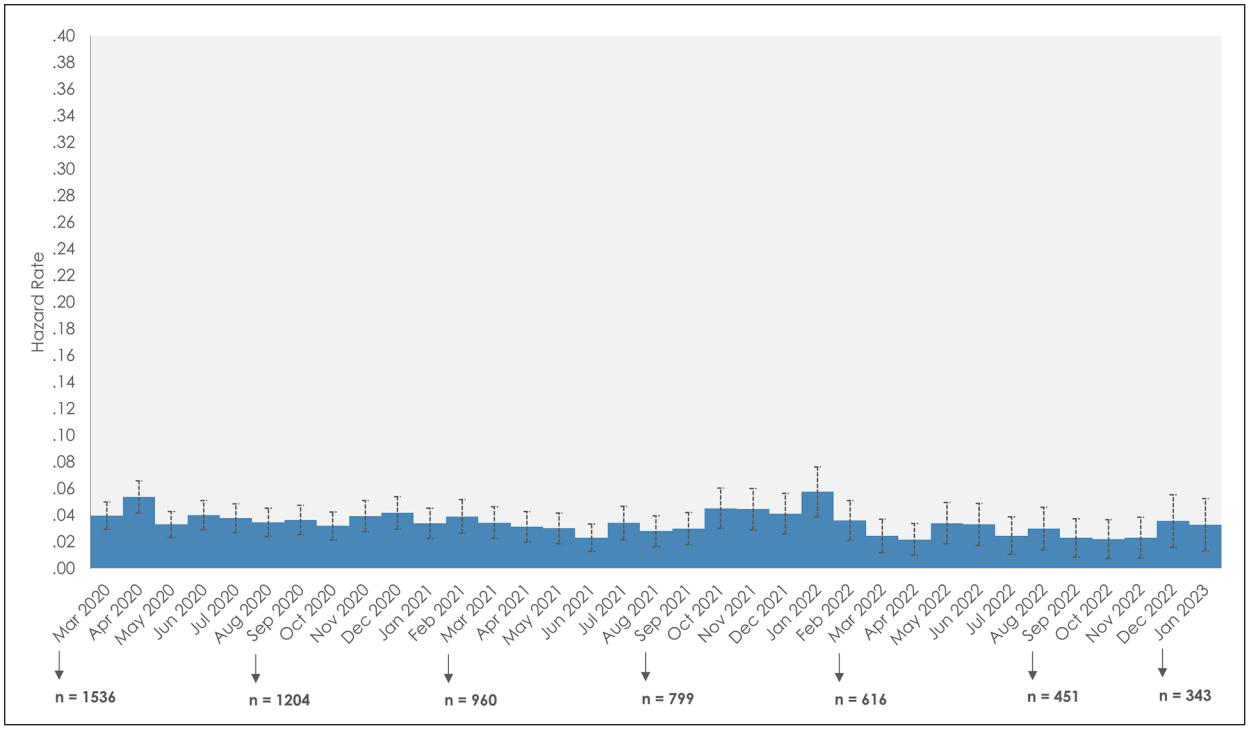

Figure 3. Mortality hazard rates with 95% confidence intervals plotted for No-COVID_I group. No-COVID_I are residents without a history of COVID-19 residing in LTC on March 1, 2020 (i.e., admitted to the LTC homes before the start of the pandemic) and followed from March 1, 2020 until January 2023. Monthly intervals correspond to the same calendar months in all residents.

2022). In the months after the first post-COVID-19 month (i.e., beyond 30-day mortality), no substantial differences were noted in mortality rates in the three cohorts (Figure 2b–d).

Mortality in Residents Without a History of COVID-19

In the No-COVID residents, monthly mortality rates over the follow-up period are presented in Figures 3 and 4. For those residing in LTC on March 1, 2020 and followed from that date, the monthly mortality rates ranged from 2.2% (95% CI [1.0, 3.4]) to 5.9% [4.1, 7.8]. For the group of residents admitted to LTC during the pandemic (i.e., after March 1, 2020), the monthly mortality rate range was from 1.7% (95% CI [0.5, 3.0]) to 6.8% [5.3, 8.3]. A summary of the distribution of the monthly mortality rates and the outlying points in the two No-COVID groups, along with the COVID group, is presented in Figure 5.

The same factors that were related to mortality over time among residents with COVID-19 (i.e., age, sex, and ADL function) were related to mortality among residents with no history of COVID-19. Specifically, the results of the multivariate Cox regression indicate that resident mortality risk over time was increasing with age, $HR = 1.04$ (95% CI [1.03, 1.04]); in males, $HR = 1.52$ [1.37, 1.69]; and with increase in ADL score (i.e., worsening functional status), $HR = 1.04$ [1.03, 1.05]; all p-values $< .01$ (the same predictors were statistically significant in both No-COVID cohorts).

Discussion

The current study provides more information on post-COVID-19 mortality in LTC residents, short- and long-term after contracting COVID-19 infection, and in different pandemic years (2020–2022). Residents in 19 LTC homes who had a positive COVID-19 test in the study inclusion period were followed longitudinally from the day of the positive test until January 2023. To provide the relevant context, mortality in residents in the same LTC homes, who did not contract COVID-19 during the same period, was also investigated.

The results revealed a large number of deaths in the first month after a positive COVID-19 test—the highest 30-day mortality was recorded among LTC residents who contracted COVID-19 in 2020, when 28% of the residents died within the first month post-infection. Thirty-day mortality decreased to 8.3% in 2022. After adjusting for relevant individual-level predictors (age, sex, and ADL function), there was a strong relation between year of contracting COVID-19 and 30-day mortality. In the early phases of the pandemic, the high all-cause 30-day mortality was reported in LTC homes in Canada and worldwide (Brown et al., 2021; Lee et al., 2021; Levin et al., 2022; Sepulveda et al., 2020). The trend of decrease in deaths over the pandemic years

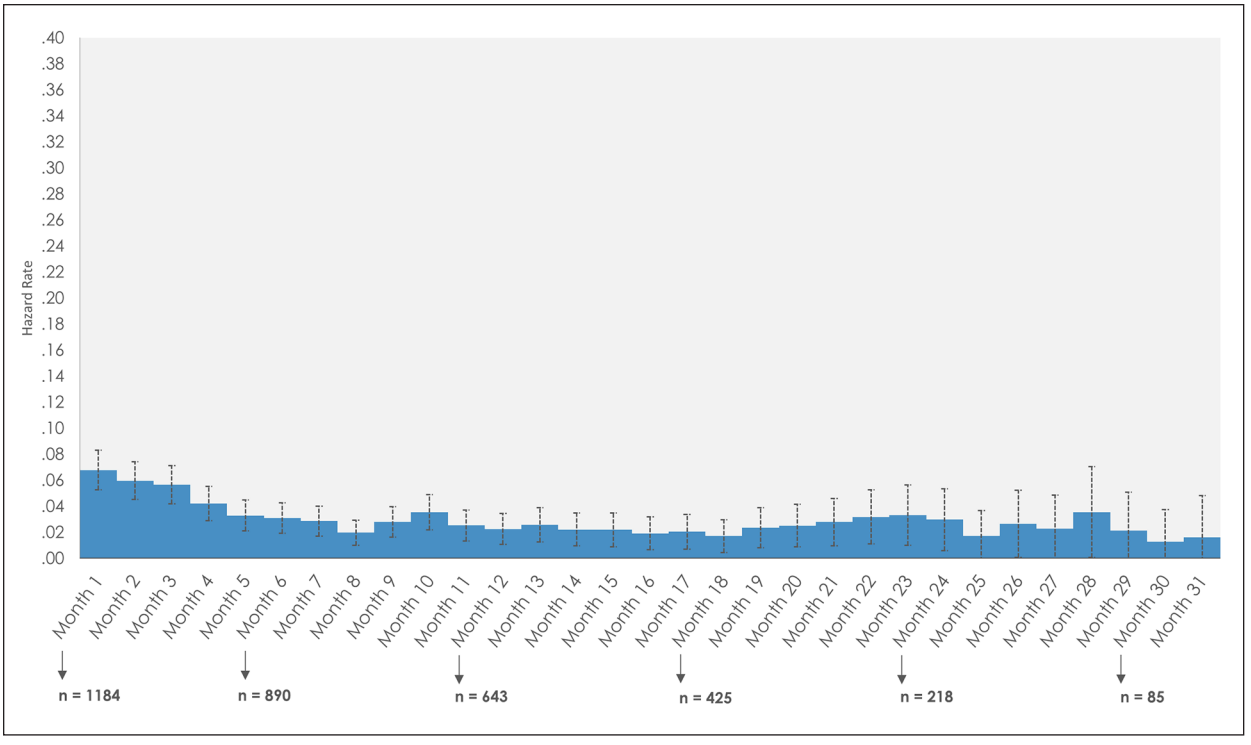

Figure 4. Mortality hazard rates with 95% confidence intervals plotted for the No-COVID_2 group. No-COVID_2 are residents without a history of COVID-19 who were admitted to the LTC homes after March 1, 2020 and during the study inclusion period (i.e., until April 30, 2022). On *X* axis, zero-time is the date of admission to the LTC home for each resident; the months subsequent to that date are plotted up to 31 months (i.e., until the number of residents entering the time interval became very small).

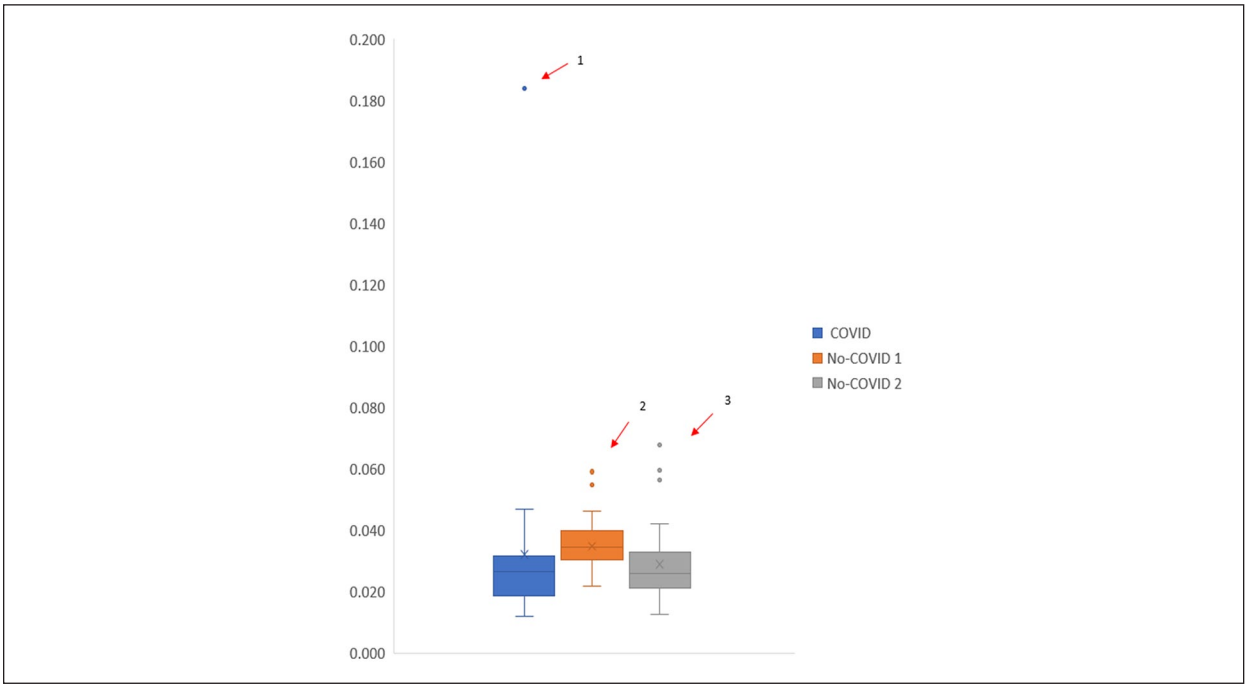

Figure 5. Distribution summary of monthly mortality hazard rate in the three groups (COVID, No-COVID_1, and No-COVID_2), with outlying points presented: 1—the first month after contracting COVID-19 in the COVID group; 2—two months with the highest mortality in No-COVID_1 group (April 2020 and January 2022); 3—three months with the highest mortality in No-COVID_2 group (the first 3 months following admission to the LTC home).

followed, with several factors noted as contributing to this trend. Early in the pandemic, information about high mortality in LTC homes initiated widespread efforts and mobilization of substantial resources in an attempt to deal with the problem and mitigate the consequences of the pandemic in the LTC settings (Brown et al., 2021; Levin et al., 2022; Telford et al., 2020). Factors such as increasing knowledge about how to deal with the virus and the adverse pandemic circumstances, improving COVID-19 disease treatments, improved immunity due to vaccination and natural immunity, and the changing nature of the virus itself were contributing to the decrease in deaths after contracting COVID-19 over the years (Brown et al., 2021; Kananen et al., 2023; Rivasi et al., 2022; Telford et al., 2020).

Over longer periods after the acute phase of COVID-19 infection, monthly mortality in residents with a history of COVID-19 decreased substantially. In contrast to 16.9% mortality in the COVID group in the first 30 days post-infection, monthly mortality in the subsequent 8 months was 3.3%, 3.0%, 2.1%, 2.5%, 1.6%, 2.3%, 1.6%, and 1.8%, respectively.[3] In the groups of residents who contracted COVID-19 in 2020, 2021, and 2022, monthly mortality rates were in similar range and no substantial differences were noted in the months following the first 30 days post-infection.

When examining mortality over time in the groups of residents who contracted COVID-19 and those who did not, the observed differences were driven by a large number of deaths in the first post-infection month in the COVID group. In the following months, over the follow-up period, no increased mortality risk in the COVID group was noted. For example, the highest monthly mortality rate in the COVID group, in the months after the first post-COVID-19 month, was 4.7% (95% CI [2.6, 6.8]), whereas in the No-COVID residents, the monthly mortality ranged from the 1.7% [0.5, 3.0] to 6.8% [5.3, 8.3]. Over the follow-up, the same individual-level predictors that were relevant for mortality risk in residents with a history of COVID (i.e., age, sex, and ADL score) were relevant for No-COVID residents.

In relation to the consequences of COVID-19 over the longer period post-infection, evidence about outcomes such as ADL function, cognitive function, and different health outcomes emerged in recent research (Cortés Zamora et al., 2022; Pérez-Rodríguez et al., 2021; Rajlic et al., 2024; van der Krogt et al., 2022). This study provided more evidence about the mortality outcome. Although variability in monthly mortality rates was present in the both COVID and No-COVID group in the months beyond the first month post-infection, monthly mortality in the COVID group was comparable and not exceeding mortality in the No-COVID group. In some monthly intervals, moreover, the mortality rate in the No-COVID group was substantially higher than in the COVID group. This finding likely reflects the impact of COVID-19 on the most vulnerable; notably, the frailest among the residents who contracted COVID-19 died first while more resilient residents survived, resulting in the smaller than expected monthly mortality in the following months (i.e., lower mortality in the COVID than in No-COVID group). Variations in the ratio of mortality risk in the group of residents with COVID and No-COVID were noted in some cross-sectional design reports. For example, Akhtar-Danesh et al. (2022) reported a substantial increase in monthly mortality among residents with a positive COVID-19 test in the months corresponding to the peak of the wave 1 and wave 2 in 2020; in the other pandemic months in 2020, however, a decrease in mortality was noted in the test positive as compared to the test negative residents.

Among residents with no history of COVID-19, specifically those admitted to LTC during the pandemic, the highest mortality was noted in the first 3 months after admission to the LTC home. This is consistent with what has been known in the field about the increased risk for mortality in the initial period following LTC admission (Hirdes et al., 2019). Among the No-COVID group who resided in the homes at the start of the pandemic, a slightly increased mortality was noted in some months (e.g., in April 2020), which may indicate that some of these residents, even though undiagnosed with COVID-19 at the time, might have been infected by COVID-19. Alternatively, the increase in mortality may have been a result of the healthcare system changes in the early pandemic months, or the increased pressure on the health system (e.g., in January 2022 another spike in mortality was noted, when the highly transmissible Omicron variant was in effect).

Limitations of the current study included challenges in establishing COVID-19 status based on the record of a positive COVID-19 test only. Due to shortcomings related to the testing process (especially in the early phase of the pandemic when COVID-19 testing was not implemented as reliably as it was later on) and the limited accuracy of the test results (Levin et al., 2022), some residents classified in the No-COVID group could have been infected with the virus. The undetected COVID-19 infections could have impacted the mortality results in the two groups. However, mortality rates found in the current study closely approximated those reported in other studies (Akhtar-Danesh et al., 2022; Lee et al., 2021; Panagiotou et al., 2021). Mortality information was limited to BC, and out of province moves and deaths may have been uncaptured—the number of such cases was expected to be very small. Finally, study limitations include the lack of reliable information about other relevant factors, including comorbidities and health status of residents before follow-up, as well as information about the severity of the COVID-19 disease. We did not have complete information about the relevant moderators such as vaccination uptake and COVID-19 re-infections (i.e., only first infection was considered)—these effects should be examined in future research in LTC settings.

Conclusion

In summary, the current study provides more details to the picture of mortality after contracting COVID-19 in the population of LTC residents. The study results underscore a large number of deaths in the first month after a positive COVID-19 test, with 30-day mortality significantly decreasing over the years. Thirty-day mortality in 2022, however, was still substantial and concerning (8.3%; 95% CI [7.4, 9.2]). After surviving the acute phase of the disease, in the months following the first post-infection month, monthly mortality in residents with COVID-19 was comparable to mortality in No-COVID residents, and no evidence of increased mortality risk was observed.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical approval

Ethical approval for the study was received from the Fraser Health Authority Research Ethics Board. It has been deemed that individual participant informed consent to participate would be impossible or impracticable to obtain and it has been waived by the Ethics Board.

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Supplemental Material

Supplemental material for this article is available online.

Notes

1. Some No-COVID residents ($n=371$), who fulfilled the study inclusion criteria, contracted COVID-19 after April 30, 2022 and during the follow-up period, before January 31, 2023. For these residents, we ended their follow-up at the date of their positive COVID-19 test (resulting in the shortening of the follow-up time for some of the residents) and retained their information up to that point. Some in the No-COVID group, therefore, had less than 9 months of follow-up.
2. The first positive result for any SARS-CoV-2 microbiological test recorded by BC Population and Public Health.
3. All COVID-group residents were followed for a minimum of 9 months, after that time, right-hand censoring due to loss to follow-up was present (estimates from survival analysis accounting for censoring were reported there).

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