Single- versus shared-occupancy bedrooms in long-term care homes during the COVID-19 pandemic: A regional cohort study of 355 facilities in British Columbia, Canada

Brendan Buchanan Dee1* and Adam Rysanek1

1School of Architecture and Landscape Architecture, University of British Columbia, 2260 West Mall – Room 3131, Vancouver, BC, V6T 1Z4

Abstract. Long-term care homes (LTCHs) around the world have been severely impacted by COVID-19 outbreaks with exceptionally high case loads and fatalities relative to the general public. A growing body of researchers, policy makers, and advocates have raised concern that the design and operation of these specialized 24-hour eldercare facilities may be partly responsible for risk of infection from transmissible diseases. While by no means the only factor in healthcare associated infections (HAIs), bedroom occupancy has been suggested as a potential determinant due to the disparities of exposure in shared bedrooms with two or more residents when compared to the isolation provided by single-occupancy bedrooms. This cohort study examines the role of bedroom occupancy on resident attack rates (RAR) in LTCHs in British Columbia (BC), Canada, by linking public health data from the BC Centre for Disease Control (BCCDC) and administrative survey data from the BC Office of the Seniors Advocate (BCOSA). During the observation period which extended from March 5, 2020–February 9, 2022 (707 days), 333 outbreaks were reported at 200 of the 355 BCLTCHs (56.3%). A total of 2,519 staff cases, 4,367 resident cases, and 960 resident deaths were reported (22.0% case fatality rate). Correlation analyses show that single-occupancy bedrooms had a weak, inverse correlation with COVID-19 infections among residents, whereas number of staff cases and highest RAR of any encountered outbreak were strongly correlated with resident infections. Counter to the perception that LTCH residents of shared bedrooms were at far greater risk, these observations suggest the bedroom occupancy was a minor factor contributing to the spread of COVID-19 in BCLTCHs.

1 Introduction

Highly infectious and deadly outbreaks of COVID-19 have disproportionately impacted long-term care homes (LTCHs)—the specialized 24-hour healthcare facilities that primarily house and care for elderly persons who need assistance with their activities of daily living (ADLs) [1–4]. LTCHs are especially vulnerable to infectious diseases to the high prevalence of comorbidities in their communities including chronic illness, cognitive impairment, and frailty which predispose individuals to poorer health outcomes [1].

Although global LTCHs largely share a demographic focus on geriatric care, the design and operation of facilities varies between jurisdictions and individual sites, raising concern that institutional differences may be influencing risk of healthcare associated infections (HAIs). In an international study of 22 countries, Comas-Herrera et al. determined that as of February 2021, LTCH residents represented an average of 41% of COVID-19 related deaths while only accounting for 0.73% of average national populations [5]. The same study observed that Canada had the second highest rate of LTCH resident deaths as a percentage of its national total at 59% (11,114/18,974 Canadian COVID-19 related deaths), while having the greatest proportion of nationals living in LTCHs at 1.13% of the Canadian population [5].

Among the numerous variables that may contribute to disease transmission, building design has been suggested as an environmental factor impacting HAIs. LTCH residents typically live in congregate settings with communal areas such as dining rooms, lounges, and bathing facilities which raise the potential for exposure to infected persons and contact with contaminated spaces [6,7]. Bedrooms—where residents spend much of their time—have come under increased scrutiny in the wake of COVID-19 due to the disparity in isolation capacities afforded by single- and shared-occupancy bedrooms [8]. Throughout the pandemic, bedrooms played an outsized role as many LTCHs restricted use of common areas and confined residents to their bedrooms in the effort to curb transmission [9]. For LTCH residents with single-person bedrooms, the pandemic was typified by physical and social isolation, whereas for residents in shared rooms, the pandemic entailed extensive periods with one or more roommates with beds perhaps only separated by a curtain [6].

Since the crisis of COVID-19 outbreaks in LTCHs arose, shared bedrooms have been openly criticized in the media and retrospective outbreak reports [10–13]. In Canada, there have been growing calls for the abolition...
2 Literature Review

2.1 COVID-19 and Long-Term Care Homes

Cross-jurisdictional comparisons of the impact of COVID-19 on LTCH systems have been limited due to lack of international standards in data collection and reporting of metrics, including incongruent definitions and testing procedures of suspected cases and deaths [16]. Several studies have compared nationally reported data, mostly from high income countries (HICs), which observed that the impact of COVID-19 on LTCHs has been unevenly distributed and fluctuated over time [1,5,17]. Yet across these studies, Canada has emerged as an outlier in COVID-19 cases and fatalities represented by its LTCH residents [1,5,17].

According to eldercare experts and advocates, the status quo of Canadian LTCHs was in a state of crisis prior to the pandemic due to chronic understaffing, underfunding, and bed shortages that left Canadian LTCHs ill-prepared for incursions of infectious disease [6,15]. In the early months of the pandemic between March to August 2020, Canadian LTCH residents represented up to 81% of national COVID-19 related deaths—the greatest proportion among HICs in the Organization for Economic Co-operation and Development (OECD) [1,2,17]. Despite Canada’s staggering national aggregate, the Canadian Institute for Health Information found that in May 2020, the proportion of COVID-19 related deaths across the Canada’s thirteen provinces and territories was “greater than variation among OECD countries” [2].

Canada’s approach to the provision of healthcare and operation of LTCHs is multifaceted, with provincial responsibilities for healthcare enshrined in the federal Canada Health Act (1984), while the LTCH sector is segmented by publicly funded, private non-profit, and private for-profit facilities [6,18]. Armstrong et al. point out that access to LTCHs is not universally provided nor protected by the Canada Health Act, and characterized the present-day arrangement of provincially and territorially orchestrated healthcare systems as “disparate and piece-meal” [6]. The institutional mosaic of Canadian LTCHs has led to speculation that systemic differences between provincial healthcare models and their pandemic responses may be partly responsible for variations in cases and mortalities [19].

In lieu of robust international data, regional cohort studies present an alternative approach to public health monitoring of COVID-19 in LTCHs. Regional cohort studies typically rely on data from within a single jurisdiction with the expectation of greater uniformity within an administrative region. Cohort studies of COVID-19 and LTCHs have been deployed by several research groups to assess potential determinants of outbreak occurrence and transmission including Burton et al. in the Lothian region of Scotland, UK [20]; Ibrahim et al. in the state of Victoria, Australia [21]; Stall et al. and Brown et al. in Ontario [21,22]; Vijh et al. in BC [23]; and Liu et al. who compared the cases of Ontario and BC [19].

2.2 British Columbia’s Long-Term Care Homes

During the early months of the pandemic, BC was praised by public health officials and policy analysts for its rapid response to COVID-19, in particular, its early deployment of infection prevention and control (IPAC) procedures such as the single-site order (SSO) policy that restricted LTCH staff to a single workplace [6]. The effectiveness of the SSO, followed by its adoption in other provinces and countries cemented the notion that BC performed better than other jurisdictions at controlling outbreaks of COVID-19 [6,19]. Between March 2020 to September 10, 2020, Ontario reported 436 outbreaks and 1,817 deaths in its LTCHs, while BC had only 72 outbreaks and 156 deaths [19].

The narrative of BC’s successful response to COVID-19 took hold, however, an analysis by the BC Office of the Seniors Advocate (BCOSA) found that vulnerabilities remained after IPAC measures were in place, stating: “BC did much better than Ontario in Wave 1, but achieved more similar results to Ontario in Wave 2 (when Ontario had more fully implemented the long-term care control measures BC brought into effect earlier in Wave 1)” [12].

While staffing issues were ultimately the major focus of recommendations listed in the BCOSA’s Review of COVID-19 Outbreaks in Care Homes in British Columbia, there was also a call for the elimination of shared bedrooms, asserting that “the spread of infectious disease overall and in particular COVID-19 was amplified in sites with shared rooms” [12].
2.3 Single- versus Multi-Occupancy Bedrooms

Residents of BCLTCHs may reside in several types of bedroom accommodations, including single-person rooms (also referred to as private rooms, although not to be confused with ‘privately funded’ rooms); semi-private rooms which are house two individuals; and multi-person rooms that have three or four residents. For the purposes of this study, the term shared rooms is used in reference to bedrooms with two or more people, which is inclusive of BC’s definitions for semi-private and multi-person rooms. A distinction must also be made between the reporting of metrics as the number of single-person or shared bedrooms versus the number of residents. Whereas the breakdown by bedroom type in BCLTCHs is 89% single-occupancy, 8% semi-private, and 3.5% multi-person according to the BCOSA, Liu et al. determined that overall, 24% of BCLTCH residents share a room with at least one other person [12,19]. The crisis of COVID-19 in LTCHs has sparked calls for the elimination of shared bedrooms based on their unfavourable public perception and purported association with higher risk of infections [14]. Shared bedrooms have been the subject of ongoing debates between the ethics and economics of healthcare, spatial efficiencies, and financing [24]. In their pre-pandemic assessment of bedroom occupancy, Calkins and Cassella identified a 1996 study by the American Association of Retired Persons which reported a preference of 20-to-1 (82% to 4%) in favour of single-person bedrooms [15,16]. Proponents of single-person bedrooms insist that they afford greater dignity and privacy for residents [24,25].

Despite personal preferences, shared bedrooms with up to four people remain in operation within Canadian LTCHs due to their lower cost and greater efficiency in staffing, although their prevalence varies throughout the country [8]. In Canada, the proportion of shared bedrooms in LTCHs has fallen over time as single-occupancy bedrooms have gained popularity and are the predominant arrangement of new buildings, however, older facilities built according to earlier design specifications remain in operation [6]. In a comparison of BC and Ontario’s LTCH systems, Liu et al. found that while 24% of BCLTCH residents reside in a shared bedroom, 63% of Ontario’s LTCH residents have at least one roommate [19]. Brown et al. further explored the composition of Ontario’s LTCHs and determined that 48.9% were constructed before the introduction of a 1999 design standard which permitted the construction of four-person bedrooms [8]. In their examination of COVID-19 in Ontario’s LTCHs, Brown et al. reported that “residents of highly crowded homes were more than twice as likely to develop infection with and die of COVID-19” based on models of nursing home crowding index, a metric they defined “as the mean number of occupants per room and bathroom across an entire home according to the equation: Nresidents ÷ (½Nbedrooms + ½Nbathrooms)” [8]. The Brown et al. findings were congruent with a pre-pandemic systematic review by Stiller et al. which found that “the risk of a respiratory infection in occupants of 2-bed rooms was double that of those in a single-occupancy room” [8]. Stiller et al. pooled nine studies in a meta-analysis which found a risk reduction of roughly a half for patients in single rooms (RR: 0.55, 95% CI: 0.41—0.74) [26]. However, the generalizability of the Stiller et al. review to the conditions of LTCHs is limited as the included studies consisted of intensive care units (ICUs) including pediatric, surgical, general, neonatal, and burn center, each of which have different patient demographics and care requirements when compared to the mostly geriatric residents of LTCHs [26].

Among studies of BCLTCHs and COVID-19, Vijh et al. conducted a retrospective cohort study for the observation period of March 1, 2020—January 10, 2021 [23]. Vijh et al. determined that the “proportion of single rooms in the LTCF, despite being marginally significant in the descriptive analysis, was not associated with attack rates after controlling for other factors” [23]. Overall, there is a paucity of research examining the impact of bedroom occupancy on HAIs, especially in LTCH settings, as hospitals and clinical environments tend to garner greater attention and resources [9].

3 Methods

3.1 Data Sources and Procedures

This study linked administrative survey data from the BCOSA with COVID-19 outbreak reports from the BC Centre for Disease Control (BCCDC) [27,28].

According to the BCOSA there was a total of 355 BCLTCHs at the onset of this study, however, detailed facilities and population data including bedroom occupancy were only available for 291 BTCLTHs that were either publicly funded or had private non-profit status [12,29]. Facility and population data were obtained via annual survey conducted by the BCOSA and published in the Long-Term Care Quick Facts Directory [29].

Outbreak data was acquired from the Weekly COVID-19 Long Term Care, Assisted Living & Other Residential Outbreak Report published by the BCCDC since January 2021 and back dated to March 2020 [28]. The BCCDC reports included data from publicly funded and private non-profit BCLTCHs, in addition to private for-profit LTCHs when COVID-19 outbreaks occurred. Figure 1 illustrates the composition of the datasets, which revealed outbreaks at 31 private for-profit LTCHs.

The BCLTCH database used in this study was created by linking of BCCDC and BCOSA datasets, and expanded through the collection of architectural data from satellite images and Google Streetview remote site visits which enabled the counting of building storeys, courtyards, forecourts, and porte-cochères/vehicular drop-offs.

The individual entries for ‘Facility’ and ‘Community/Facility’ in the BCCDC and BCOSA may refer to an individual building or a cluster of buildings that operate together as part of a healthcare complex. In several cases, floor numbers, wings, or individual buildings were referenced in BCCDC outbreak reports, denoting the possible containment of an outbreak to a
sub-population of LTCH, however, these infrequent situations were subsequently grouped in this study.

Figure 1. Identification of 355 BCLTCHs, with 200 unique facilities reporting at least one COVID-19 outbreak during the observation period.

3.2 Ethics Statement

This study did not require an ethics review as the BCOSA and BCCDC datasets are publicly available and intended for public health surveillance. No individual or identifiable patient data was gathered for this analysis.

3.3 Primary Outcomes

The primary outcomes of this study are resident attack rates (RARs) and the number of outbreaks at any given BCLTCH. RAR is the measure of the peak number of residents infected by COVID-19 divided by total resident population during an outbreak. The number of resident infections was acquired from the BCCDC data using the total number of infected residents that was reported once an outbreak had been declared over. The staff attack rate could not be obtained as the total number of staff at a given facility is not reported in the BCOSA Quick Facts dataset. The RAR could not be calculated for the 31 private for-profit BCLTCHs with at least one outbreak as the resident population size remains unreported in the BCOSA data.

3.4 Visual and Statistical Analysis

The graphic representation of the BCLTCHs in this study builds on an earlier COVID-19 outbreak timeline produced by Burton et al. for their study of 189 LTCHs in the Lothian region of Scotland, which represented each LTCH as a separate row that were sorted chronologically according to the date of the first known COVID-19 case [20].

Observable correlations between reported metrics in the assembled BCLTCH database are assessed using the Kendall-\( \tau \) statistic.

4 Results and Discussion

4.1 Cohort

During the observation period, a total of 333 outbreaks were reported and declared over, while 46 active outbreaks remained as of February 9, 2022 [28]. Among the outbreaks declared over, a total of 4,367 LTCH residents tested positive for COVID-19 and 960 resident mortalities were reported (22.0% case fatality rate). There were 2,519 staff/other persons associated with BCLTCHs that contracted COVID-19 according to BCCDC reports but there were no staff fatalities. Of the 355 BCLTCHs, a total 200 LTCHs had at least one outbreak (56.3%). 94/200 BCLTCHs had two outbreaks (47.0%), 34/200 had three outbreaks (17.0%), and 5/200 had four outbreaks (2.5%).

4.2 Data Graphs and Timelines

COVID-19 outbreaks and LTCH resident population data are represented in Figures 2 & 3, that arrange the 355 BCLTCHs according to the highest recorded outbreak and the legislation they are subject to, respectively. Each row represents a unique BCLTCH site, pairing their demographic data with a timeline of associated COVID-19 outbreaks. On the left side of Figures 2 & 3, the resident population is represented in mirrored bar graphs corresponding with bedroom occupancy and total COVID-19 mortalities. The light and dark grey stacked bars depict resident population broken down by bedroom occupancy illustrating the proportion of residents living in single-person bedrooms (light grey) and those residing in shared bedrooms (dark grey). The red bars indicating the cumulative number of deaths is shown separately from the bedroom occupancy data because the BCCDC does not publicly report whether an infection or death occurred in a single-person or shared bedroom.

On the right side of Figures 2 & 3 is a timeline of the study observation period. The horizontal bars in this section mark the duration of a COVID-19 outbreak which are coloured by the associated RAR. The vertical dotted lines on the timeline are approximate boundaries of successive waves of the virus. Gaps in the population data that appear blank are instances of private for-profit BCLTCHs where resident population size remains unreported in the BCOSA data.

4.3 Bedrooms and Resident Attack Rates

In Figure 2, BCLTCHs have been sorted by order of highest RAR. The most infectious outbreaks (highest RAR) in BCLTCHs occurred in 2020 before the arrival of vaccines that were first being administered to the elderly in mid-December 2020 [30]. The occurrence of high RARs generally corresponds with higher case mortalities, which declined with lower rates of residents contracting the virus. Vijh et al. described an attack rate of >35% as ‘very high’, which in Figure 2 roughly corresponds with RAR tones of yellow, orange, and red.
Fig. 2. BC Long-Term Care Homes by Highest Outbreak Attack Rates. March 05, 2020–February 9, 2022.
Fig. 3. BC Long-Term Care Homes by Legislation. Community Care and Assisted Living Act (2002) and Hospital Act (1996).
in the horizontal bars of the timeline. During the observation period a total of 34 LTCHs reported at least one outbreak that exceeded this threshold. In observation of Figure 2, one can see that outbreaks with very high RARs occurred in BCLTCHs with single-occupancy and shared bedrooms alike. The most infectious outbreak in BC, with the highest RAR during any given COVID-19 outbreak, occurred in a BCLTCH with 50 residents, all living in single-person rooms, during which 47 residents contracted COVID-19 infected (94%) with 9 deaths (19% case fatality rate).

4.4 Bedroom Occupancy and Legislation

BCLTCHs are governed by either the Community Care & Assisted Living Act (CC&ALA, 2002), the Hospital Act (HA, 1996), or both which establish building requirements and standards of care for facilities under their authority. In Figure 3, the BCLTCHs have been grouped according to their respective legislative acts and then ordered by population size. In Figure 3, one can observe that the population of residents living in single-person rooms is much lower in BCLTCHs governed by the HA (1996) at 50.1%, whereas 91.4% of residents in CC&ALA (2002) sites and 76.8% of residents in facilities under both regulations do not share a room.

While HA (1996) buildings have more residents in shared rooms, highly infectious and deadly outbreaks of COVID-19 also occurred in BCLTCHs under the CC&ALA (2002) with mostly single-person rooms. This finding runs counter to the prevailing belief that shared bedrooms were much worse at preventing COVID-19 transmission in LTCHs. A subset of CC&ALA (2002) site had cumulative COVID-19 deaths that exceeding all others in BC, including five BCLTCHs where over 25 COVID-19 deaths during the observation period. Buildings constructed with mostly single-person bedrooms were still vulnerable to severe outbreaks of COVID-19, including the deadliest outbreak in BC with 99 resident cases and 41 deaths (41.4% case fatality rate), which occurred in a 117-bed facility with all bedrooms were much worse at preventing COVID-19 transmission. One does not see in the correlation analysis that counter conventional wisdom and pose new questions. One does not see in the correlation analysis evidence to suggest there were associations between COVID-19 outcomes in a LTCH and the percent of single-occupancy rooms. The same applies to the age of the LTCH and the regulatory act it was designed under.

The total population size of a LTCH was one of few discernible design metrics of the LTCH to be correlated with COVID-19 outcomes. Specifically, it is observed that the size of a given LTCH was weakly correlated with the presence and duration of a second COVID-19 outbreak occurring within the facility.

4.5 Statistical Analysis

The results of the correlation analysis are depicted in the heatmap diagram in Figure 4. The correlation analysis appears to confirm known insights regarding the state of BCLTCHs and reinforce visual observations made above. For example, when the Hospital Act came into existence in BC in 1996, it ruled out - or significantly reduced - the number of shared rooms in LTCHs built afterwards. In the Kendall- \( \tau_b \) correlation analysis, we see Percent Single Occupancy, a measure of the percentage of single rooms in a LTCH, inversely correlated with the presiding Regulatory Act at Construction (in this analysis, each Regulatory Act was represented ordinally by the age of each Act’s implementation, with pre-Hospital Act facilities assigned the highest value). Other observed relationships are intuitive. The number of storeys of any LTCH has some correlation with the LTCH population size, and this may have some impact on the architectural design of these LTCHs vis-a-vis the presence of porte-cochère/vehicular drop-offs.

Likewise, we see rational correlations between metrics of COVID-19 outcomes in BCLTCHs. The RAR of any declared COVID-19 outbreak was strongly or very strongly correlated with the outbreak’s duration. Both factors were also strongly or very strongly correlated to the infection fatality rate of the outbreak.

The correlation analysis does yield observations that counter conventional wisdom and pose new questions. One does not see in the correlation analysis evidence to suggest there were associations between COVID-19 outcomes in a LTCH and the percent of single-occupancy rooms. The same applies to the age of the LTCH and the regulatory act it was designed under.

The total population size of a LTCH was one of few discernible design metrics of the LTCH to be correlated with COVID-19 outcomes. Specifically, it is observed that the size of a given LTCH was weakly correlated with the presence and duration of a second COVID-19 outbreak occurring within the facility.
mortality of LTC residents across the dataset’s reporting period were the total number of staff cases and highest attack rate of any encountered COVID-19 outbreak. While there appears to be some indication, albeit weak, that total COVID-19 mortality may have had an inverse relationship to the percent of single occupied rooms in each LTCH, the statistical significance of this observation remains low.

5 Conclusion
This study provided an initial visual and statistical analysis of publicly-available data concerning the design of LTCHs in BC and the impacts of the COVID-19 pandemic. Throughout the pandemic, a common view held in BC’s public discourse on LTCHs was the increased risk of housing residents in shared bedrooms [12,13]. While this study may lend some element of a LTCH’s design or management policy.

References