Introduction

Long-term care facilities provide housing, support and nursing care to frail elders no longer able to function independently. Due to the nature of care provided, and the close contact between staff and residents, these facilities are at higher risk for the spread of infections. (1) During the early months of the coronavirus disease 2019 (COVID-19) pandemic of 2020, long-term care facilities proved to be sites of major outbreaks in British Columbia (2) and across Canada (3, 4). The impact on long-term care facilities and their residents highlighted the need to better understand the risk factors for COVID-19 outbreaks in this setting.

Long-term care facilities in British Columbia are publicly funded except for a small number of private pay facilities in larger cities. There are five regional health authorities in British Columbia that deliver the province's publicly funded health services. Of these publicly funded facilities, approximately one third are owned and operated by the provincial health authorities (publicly-owned). The remaining facilities are owned and operated by independent (non-government) non-profit societies or for-profit owned corporations. In addition to ownership differences between facilities, there is also substantial variation in staffing levels (5) and staff mix, human resources practices (sub-contracting the workforce and/or services) (6, 7), facility characteristics (number of beds, number of rooms with shared beds, facility age) (8), and resident case mix distribution (8).

Past research has demonstrated that differences among long-term care facilities should be considered when examining health outcomes. (9) Research from the US found a number of facility characteristics to be predictive of COVID-19 outbreaks, including for-profit ownership (10), lower total nurse staffing and registered nurse staffing levels (11), and larger facility size (11, 12). One study set in Ontario, Canada, reported that facility size and older design standards

but not ownership were associated with odds of an outbreak, although for-profit ownership was associated with the extent of outbreaks and death rates when compared to non-profit societies and municipal government-owned facilities. (13) However, that study did not include staffing data - an important potential confounder when examining ownership due to the association of for-profit ownership with both lower staffing levels (14) and greater risk of COVID-19 infection (10). Aside from the Ontario study, there has been little published Canadian research on this topic. Our study aimed to assess whether facility ownership and staffing characteristics (staffing levels and sub-contracting out practices) were associated with COVID-19 facility outbreaks among publicly funded long-term care facilities, after controlling for other factors.

Methods

Setting and Study Design

This retrospective observational study included all COVID-19 outbreaks in long-term care facilities in British Columbia, during the first and second waves of the pandemic between March 1, 2020 and January 31, 2021. The study included all publicly funded long-term care homes in the five health regions in British Columbia. It excluded assisted living facilities, supportive housing, group homes, palliative and hospice homes, acute care facilities, and private pay-facilities. Facilities with less than five beds (n=3) were also excluded since publicly available COVID-19 outbreak data was not available for these facilities.

Data sources

Long-term care facility data were obtained from the Office of the Seniors Advocate BC Long-Term Care Facilities Quick Facts Directory 2019/2020 (8), a publicly available data source containing information from the Ministry of Health, health authorities, the Canadian Institute for Health, the British Columbia Centre for Disease Control, and the facilities themselves. Outbreak

data and community prevalence data were obtained from publicly available British Columbia Centre for Disease Control data: Weekly COVID-19 Outbreak Reports for Long-Term Care, Assisted Living and Independent Living Facilities (15); and the COVID-19 Dashboard Case Details database (16). COVID-19 cases included in the study were identified according to the British Columbia Centre for Disease Control case definitions. (17) Daily community incidence for each of British Columbia's five health authorities was computed using the British Columbia Centre for Disease Control case data (16) for each day of the study period (March 1, 2020 to January 31, 2021) and health authority population counts from Statistics Canada (18). A decision to end the study on January 31, 2021 was made since by that time virtually all residents and a high number of long-term care staff had been fully vaccinated.

Outcome and explanatory variables

Our main outcome variable was occurrence of a COVID-19 outbreak. An outbreak was declared when "one or more clients (residents) and/or staff of a long-term care facility was identified by a laboratory-confirmed COVID-19 diagnosis." (17) Explanatory variables of interest included facility ownership (for-profit, non-profit, or health authority owned and operated), staffing levels (total direct, nursing, and allied care hours per resident day), and sub-contracted out services (professional and non-regulated nursing, and food services). A time-varying covariate for community-level incidence of COVID-19 was created by calculating a rolling 14-day incidence per 1000 population for each day, by health authority location of the facility. Other covariates included facility age, size, facilities with shared beds, and the proportion of rooms in shared accommodation. Covariates for facility distribution of resident mean age, proportion male, and mean case mix index were also included.

Statistical analysis

We calculated descriptive statistics related to COVID-19 outbreaks in long-term care facilities, including the type of outbreak – whether it involved residents versus staff, length of outbreak, and descriptive summary statistics on the number of cases and deaths. We conducted bivariate analyses of facilities with and without a COVID-19 outbreak on ownership, staffing, community incidence, and facility and resident characteristics.

Cox proportional hazards analyses were conducted to explore the association between ownership, staffing, community, facility and resident characteristics, and risk of a COVID-19 outbreak. Facilities were deemed at risk of an outbreak throughout the duration of the study (March 1, 2020 to January 31, 2021) except when experiencing a declared outbreak. In addition to ownership, explanatory variables for the Cox proportional hazards analyses were determined by their significance in the bivariate analysis. If there were several variables in the same category of characteristics, only one significant variable was considered for the multi-variable analysis. For example, initially three staffing variables that measured care hours were reported but only the most significant one was considered in the model. The analysis utilized the time-varying variable for community incidence. The analyses included a robust sandwich estimator for the covariance matrix to account for correlation among observations between health authorities and subsequent outbreaks at the same facility. Univariate models were generated first to explore the association of explanatory variables with the risk of an outbreak. Models were then generated that included the main ownership explanatory variable while adjusting for other characteristics in distinct blocks that reflected the following categories: staffing, community, facility, and resident characteristics. All variables that were significant in their respective category model, or were determined to be an important outcome predictor a priori, were then included together in the final model. Unadjusted and adjusted hazard ratios (HR) with 95% confidence intervals (CI) are

reported for these analyses, and the proportional hazards assumptions were tested. Sensitivity analyses were conducted to test the robustness of the final model results, by re-running the models to exclude outlier facilities, and health authorities with proportionally fewer outbreaks.

Statistical analyses were conducted using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Ethics Approval

Ethics approval was obtained from the University of British Columbia Behavioural Research Ethics Board.

Results

COVID-19 outbreaks, cases, and deaths

From March 1, 2020 to January 31, 2021, there was 164 COVID-19 outbreaks in 112 out of 293 unique facilities. Just over one fifth of the outbreaks took place in wave 1 of the pandemic (March 1 to July 31, 2020) while the majority were part of the second wave (August 1, 2020 to January 31, 2021). Over one half of outbreaks involved at least one resident case, and one third of those outbreaks resulted in a resident death. (Table 1)

Long-term care facility characteristics

Among the 293 facilities included in this study, 35.6% were for-profit-owned, 28.0% were non-profit, and the remainder (36.2%) were owned and operated by a health authority. The mean total direct care and total nursing/care aide hours across all facilities were 3.29 and 2.98 hours per resident day respectively. Approximately one quarter of the facilities sub-contracted out professional nursing services and a similar proportion sub-contracted non-regulated services. The mean age of all facilities was 30.3 years and the mean number of beds per facility was

approximately 100 beds. Almost two thirds of facilities had some beds in shared occupancy rooms. Missing data for all variables was very minimal. (Table 2)

Characteristics by outbreak status

Comparisons of facilities with an outbreak versus those with no outbreak over the study period are presented. There were significant differences in ownership characteristics between the two groups. Among those facilities with an outbreak, 42.9% were for-profit, 36.6% were non-profit and 20.5% were health authority owned and operated. Facilities with outbreaks had significantly lower mean total nursing/care aide hours compared to facilities with an outbreak (2.90 versus 3.03hours). Likewise, a significantly higher proportion of facilities with an outbreak sub-contracted out professional nursing non-regulated nursing, and food services. (Table 2)

Other characteristics that were significantly different between those with an outbreak versus those without included higher mean COVID-19 community incidence, larger facility size, and facilities with beds in shared rooms. There was no significant difference between the two groups for mean facility age or larger proportion of beds in shared rooms. (Table 2)

Associations with risk of outbreak

In the multi-variable regression model, the following variables were associated with a higher risk of COVID-19 outbreak: for-profit and non-profit ownership compared to health authority owned and operated facilities (adjusted HR 1.50 (95% CI 1.02, 2.20) and 1.67 (95% CI 1.11, 2.50) respectively), regional incidence of COVID-19 (adjusted HR 1.008 (95% CI 1.004, 1.011) and higher number of beds in a facility (adjusted HR 1.14 (95% CI 1.10, 1.19) per 25 beds). Higher total nursing/care aide hours per resident day was inversely but non-significantly associated with risk of outbreak (adjusted HR 0.69 (95% CI 0.33, 1.43). No violations of the proportional hazards assumptions were observed. Facilities with shared rooms were not at higher

outbreak risk compared to those with no shared rooms. Sensitivity analyses with facility outliers removed, and data restricted to health authorities with higher community incidence of COVID-19 did not change the results of the final model. (Table 3)

Interpretation

Summary of results

This study set out to assess the association of ownership and staffing characteristics with COVID-19 facility outbreaks. We included 293 long-term care homes and found that ownership by a health authority was protective of a COVID-19 outbreak compared to both for-profit and non-profit facilities. We also found that community incidence rates and larger facilities were significantly associated with outbreak risk but found no association with shared rooms or facility age. Our study is part of the growing body of research examining facility characteristics and risk of COVID-19 outbreak. More specifically, it adds to the US studies and scant Canadian research by demonstrating that ownership status has a significant association with risk of COVID-19 even after adjusting for staffing and other potential confounding factors. (13, 19)

Explanation of findings

The significant protective effect of health authority ownership on outbreak occurrence differs from an Ontario study that found ownership was not associated with COVID-19 outbreak risk. (13) One explanation for this might be that, whereas public ownership in Ontario is through municipal governments, public ownership in British Columbia is through an integrated health system of health authorities delivering acute and community health services to the population in their respective regions. This health system integration, by health authority owned and operated long-term care facilities, may afford a number of advantages. (20) For example, research from British Columbia also suggests that health authority facilities, at least earlier on in the pandemic,

had greater access to Infection Prevention and Control support, and personal protective equipment (2), both of which are key strategies for outbreak prevention.

Unlike one US research study that found a protective effect of both non-profit and government-owned facilities (19) on outbreak risk, our study did not see the protective effect of ownership extend to non-profit ownership. Prior British Columbia research has demonstrated a similarly protective effect of publicly-owned (health authority owned and operated) facilities compared to both for-profit and non-profit facilities for other measures of quality including higher staffing levels (5), greater access to other direct care resources (21, 22), and lower emergency department (21, 22) and hospital admission rates (23). These findings are consistent with the protective effect of health authority ownership on outbreak risk seen in the current study.

US literature similarly supports some but not all of the other findings explored by this study. A number of US studies report higher staffing levels associated with lower odds of facility infection. (10, 11) Our study found that higher hours of nursing/care aide hours per resident day were protective in the univariate model, although this lost significance in the multi-variable model. Our study found no association between facility age or shared room accommodation with outbreak risk, and differs from Ontario research in this regard. (13) However, our research supports the literature that the cumulative incidence of COVID-19 (13, 24), and facility size are significantly associated with odds of an outbreak. (4, 11-13)

Future directions

Future research should examine facility consistency of personal protective equipment practices, the proportion of facility funding allocated to staffing, timely implementation of single site orders, infection control and prevention policies, team cohesion, other measures of facility

leadership such as staff trust, and directors of care length of employment as potential contributors to outbreak risk. Further research from other provinces is also needed to examine the association of facility ownership and other characteristics with outbreak severity and mortality.

Limitations

This study had several limitations. First, since British Columbia had relatively few outbreaks during the first wave of the pandemic, this may have limited the overall power of the study to detect statistically significant differences in the regression models. Second, since the study only utilized British Columbia data and definitions of outbreak can vary across studies, the generalizability of results to other provinces or jurisdictions may be limited. This study was also limited by the cross sectional survey data source utilized. Therefore, it was not able to consider additional measures outside of the survey questions, or account for other changes that occurred at facilities over the study period as a direct result of the pandemic, such as staffing levels. Third, the community incidence rates were for entire health authorities instead of more localized geographies that may better explain each facility's risk. Despite these limitations, our study is the first Canadian study to examine outbreak risk by ownership, staffing, and a number of other facility characteristics.

Conclusion

The study findings suggest that health authority ownership of long-term care facilities in British Columbia was protective of COVID-19 outbreaks, and that the factors behind this are likely multidimensional. Further study to unpack the influence of facility ownership and other

characteristics on COVID-19 outbreaks will help inform decisions on the development of new long-term care models.

Data sharing

The datasets utilized and analyzed during the current study are available from the corresponding author upon reasonable request.

List of abbreviations

HR – hazard ratio

CI – confidence interval

COVID-19 – coronavirus disease 2019

IQR – interquartile range

SD – standard deviation

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Table 1: Description of long-term care facility COVID-19 outbreaks declared between March 1, 2020 and January 31, 2021 in British Columbia

COVID-19 outbreaks	**No. (%) of all COVID-19 outbreaks**
Total outbreaks (one or more residents or staff)	n=164
Wave 1* of pandemic Wave 2* of pandemic	29 (17.7%) 135 (82.3%)
Outbreak involving 1 or more residents 1 or more staff members only At least one death	 94 (57.3%) 70 (42.7%) 75 (45.7%)
Mean days of outbreak per outbreak (SD) Minimum – maximum	33.8 (21.6) 5.0 – 106.0
Unique long-term care facilities	**No. (%) of all long-term care facilities**
Total facilities	n=293
Unique facilities with outbreak(s)	112 (38.2%)
No outbreak(s) 1 outbreak 2 outbreaks 3 or more outbreaks	181 (61.8%) 71 (24.2%) 32 (10.9%) 9 (3.1%)
COVID-19 cases	**No. (%) of COVID-19 cases**
Total resident and staff cases	n=3947
Resident cases (resident cases/total cases) Median (IQR) resident cases per facility	2379 (60.3%) 8.0 (40.0)
Resident deaths due to COVID-19 (resident deaths/resident cases)	749 (31.5%)
Community COVID-19 rates	**COVID-19 infections/ population**
Health Authority daily incidence* (infections/1 000 000 population) Vancouver Coastal Health Fraser Health Interior Health Island Health Northern Health	 41.4 67.5 25.2 7.6 42.0

SD – standard deviation; IQR – interquartile range
*Wave 1: March 1, 2020 – July 31, 2020; Wave 2: August 1, 2020 to January 31, 2021

[†]Average daily incidence (March 1, 2020-January 31, 2021) calculated from laboratory-diagnosed or episode-linked case tallies by health authority in British Columbia

Table 2. Characteristics of long-term care facilities in British Columbia by presence of a COVID-19 outbreak declared between March 1 2020 and January 31 2021

	No. (%) of all facilities	No. (%) of unique facilities with outbreak	No. (%) of facilities with no outbreak	p-value*
Total facilities	n=293	n=112	n=181	
Total beds	29 095	13 641	15 454	
Ownership characteristics				
For-profit	105 (35.8%)	48 (42.9%)	57 (31.5%)	**<.001**
Non-profit	82 (28.0%)	41 (36.6%)	41 (22.7%)	**<.001**
Health authority owned and operated (reference)	106 (36.2%)	23 (20.5%)	83 (45.9%)	-
For-profit/non-profit (contract)	187 (63.8%)	89 (79.5%)	98 (54.1%)	**<.001**
Health authority owned and operated (reference)	106 (36.2%)	23 (20.5%)	83 (45.9%)	-
For-profit chain	90 (30.7%)	41 (36.6%)	49 (27.1%)	**<.001**
For-profit non-chain	15 (5.1%)	7 (6.3%)	8 (4.4%)	**0.036**
Non-profit multi-site	32 (10.9%)	14 (12.5%)	18 (9.9%)	**0.014**
Non-profit single site	50 (17.1%)	27 (24.1%)	23 (12.7%)	**<.001**
Health authority owned and operated (reference)	106 (36.2%)	23 (20.5%)	83 (45.9%)	-
Staffing characteristics				
Mean total direct care hours (SD)	3.29 (0.36)	3.22 (0.23)	3.34 (0.41)	**0.001**
Mean total nursing/care aide hours (SD)	2.98 (0.35)	2.90 (0.19)	3.03 (0.42)	**<.001**
Mean total allied health hours (SD)	0.32 (0.10)	0.32 (0.07)	0.32 (0.11)	0.922
Missing	1	0	1	

Professional nursing services sub-contracted Non-regulated services (care aides) sub-contracted Any food services provided by outside contractor Missing	69 (23.6%) 69 (23.6%) 109 (37.9%) 5	38 (33.9%) 36 (32.1%) 56 (50.5%) 1	31 (17.1%) 33 (18.2%) 53 (29.9%) 4	**0.001** **0.006** **<.001**
Community characteristics				
Mean facility weighted[†] COVID-19 community incidence[§] (infections/1 000 000) (SD)	39.8 (22.4)	52.3 (17.9)	28.8 (20.0)	**<.001**
Facility characteristics				
Mean age of facility (SD)	30.3 (16.3)	31.0 (17.2)	29.8 (15.7)	0.549
Mean beds per facility (SD)	99.3 (56.1)	121.8 (59.0)	85.4 (49.5)	**<.001**
Facilities with beds in shared rooms	174 (59.4%)	75 (67.0%)	99 (54.7%)	**0.038**
Large proportion of beds in shared rooms** (versus small proportion or none)	88 (30.0%)	38 (33.9%)	50 (27.6%)	0.253
Resident characteristics				
Mean facility weighted[§] age of population (in years) (SD) Missing	83.8 (3.2) 3	84.1 (2.8) 0	83.5 (3.6) 3	0.104
Mean facility weighted[§] proportion male (SD) Missing	0.36 (0.10) 3	0.36 (0.11) 0	0.35 (0.10) 3	0.484
Mean facility weighted[§] case mix index (SD) Missing	0.58 (0.04) 4	0.58 (0.03) 1	0.58 (0.04) 3	0.544

SD – standard deviation; IQR – interquartile range;

*Tests of comparison include: Two independent samples t-test; Wilcoxon-Mann-Whitney test; Chi-square test.

†Variable is weighted by size of facility

§Infections per million population; Average daily incidence (March 1, 2020-January 31, 2021) calculated from laboratory-diagnosed or episode-linked case tallies by health authority in British Columbia

**Large proportion of beds in shared rooms = greater than 20% of total beds are in shared rooms

Table 3. Cox proportional hazards modelling, ownership and staffing characteristics associated with COVID-19 outbreaks in long-term care facilities in British Columbia, March 1 2020 to January 31 2021

Characteristics	Univariate models (unadjusted) HR (95% CI)	Ownership model adjusted for staffing characteristics Adjusted HR (95% CI)	Ownership model adjusted for community characteristics Adjusted HR (95% CI)	Ownership model adjusted for facility characteristics Adjusted HR (95% CI)	Final Model*: Ownership model adjusted for all characteristics Adjusted HR (95% CI)
Main explanatory variable					
For-profit	**1.70 (1.19, 2.43)**	1.34 (0.89, 2.00)	**1.69 (1.11, 2.57)**	**1.63 (1.19, 2.22)**	**1.50 (1.02, 2.20)**
Non-profit	**2.00 (1.41, 2.85)**	**1.68 (1.15, 2.46)**	**2.09 (1.38, 3.16)**	**1.86 (1.37, 2.54)**	**1.67 (1.11, 2.50)**
Health authority owned and operated (reference)					
Staffing characteristics					
Higher total nursing/care aide hours per resident day	**0.34 (0.16, 0.70)**	0.55 (0.28, 1.08)			0.69 (0.33, 1.43)
Professional nursing sub-contracted	**1.36 (1.10, 1.70)**	1.22 (0.98, 1.53)			
Community characteristics					
Time-varying COVID-19 incidence	**1.009 (1.006, 1.013)**		**1.009 (1.006, 1.013)**		**1.008 (1.004, 1.011)**
Facility characteristics					
Higher no. of beds per facility (per 25 beds)	**1.15 (1.11, 1.19)**			**1.13 (1.09, 1.17)**	**1.14 (1.10, 1.19)**
Facilities with beds in shared rooms versus none	1.27 (0.98, 1.64)			1.18 (0.93, 1.49)	

HR – hazard ratio; CI – confidence interval

*Model was initially adjusted for case mix index; however, it was non significant and did not change the results, and therefore was removed from the final model.