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Original Article

Evaluation of a multisectoral intervention to mitigate the risk of severe acute respiratory coronavirus virus 2 (SARS-CoV-2) transmission in long-term care facilities

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Abstract

Objective: A Canadian health authority implemented a multisectoral intervention designed to control severe acute respiratory coronavirus virus 2 (SARS-CoV-2) transmission during long-term care facility (LTCF) outbreaks. The primary objective was to evaluate the effectiveness of the intervention 14 days after implementation.

Design: Quasi-experimental, segmented regression analysis.

Intervention: A series of outbreak measures classified into 4 categories: case and contact management, proactive case detection, rigorous infection control practices and resource prioritization and stewardship.

Methods: A mixed-effects segmented Poisson regression model was fitted to the incidence rate of coronavirus disease 2019 (COVID-19), calculated every 2 days, within each facility and case type (staff vs residents). For each facility, the outbreak time period was segmented into an early outbreak period (within 14 days of the intervention) and postintervention period (beyond 14 days following the intervention). Model outputs quantified COVID-19 incidence trend and rate changes between these 2 periods. A secondary model was constructed to identify effect modification by case type.

Results: The significant upward trend in COVID-19 incidence rate during the early outbreak period (rate ratio [RR], 1.07; 95% confidence interval [CI], 1.03–1.11; $P < .001$) reversed during the postintervention period (RR, 0.73; 95% CI, 0.67–0.80; $P < .001$). The average trend did not differ by case type during the early outbreak period ($P > .05$) or the postintervention period ($P > .05$). However, staff had a 70% larger decrease in the average rate of COVID-19 during the postintervention period than residents (RR, 0.30; 95% CI, 0.10–0.88; $P < .05$).

Conclusions: Our study provides evidence for the effectiveness of this intervention to reduce the transmission of COVID-19 in LTCFs. This intervention can be adapted and utilized by other jurisdictions to protect the vulnerable individuals in LTCFs.

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Long-term care facilities (LTCFs) have been disproportionately affected by coronavirus disease 2019 (COVID-19). The high incidence and case fatality rate of LTCF residents highlights the vulnerability of frail individuals with numerous comorbidities in a congregate setting with a long duration of stay.[1,2] Across Canada and Europe, most COVID-19–related deaths have occurred in LTCFs.[1-3] In British Columbia, 59% of COVID-19–related deaths were in LTCFs, compared to 75% in Canada overall and 30%–60% across Europe.[3,4] In the United States, a single COVID-19 outbreak in an LTCF facility in Washington State resulted in 62% of the LTCF residents becoming infected, of whom 56.8% were subsequently hospitalized and 27.2% died.[5]

Many large COVID-19 outbreaks have been attributed to a failure in proactive surveillance and early recognition of potentially infected patients, as well as a failure to rapidly implement appropriate infection control measures.[3,5] A national Canadian military report of 5 LTCFs experiencing COVID-19 outbreaks highlighted serious concerns regarding infection control practices, frontline working conditions, limited supplies, and poor policies and procedures.[6] Additionally, increased crowding, use of communal spaces, low staffing ratios, and documented index infection in staff

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members all increase the risk of a COVID-19 outbreak in LTCFs.[7] Given the significant mortality among residents, proactive infection prevention measures, as well as effective outbreak management by public health, are necessary to reduce and/or prevent subsequent COVID-19 cases when they are detected in the facility.

The first Canadian LTCF COVID-19 outbreak and resident death occurred in British Columbia, within the Vancouver Costal Health (VCH) region.[8] As a result, mitigating the transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in LTCFs quickly became a top priority. A rapid, coordinated, and multistakeholder outbreak control response was developed to specifically support LTCFs. A multifaceted intervention containing a bundle of outbreak control measures was developed and immediately implemented following the initiation of each facility's outbreak response. This was accomplished through collaboration between LTCF leadership and regional residential care, infection prevention and control (IPAC), and public health programs.

The objectives of this study were (1) to provide a descriptive overview of LTCF COVID-19 outbreaks, (2) to evaluate the effectiveness of the intervention (a bundle of outbreak control measures) in terms of reducing subsequent transmission among residents and staff, and (3) to inform the ongoing public health approach to managing COVID-19 outbreaks in LTCFs.

Methods

Setting

In British Columbia, acute, community, residential care as well as public health are delivered by 5 geographically defined regional health authorities (RHA), one of which is VCH. A unique and important feature of public health in British Columbia involves the licensing and regulation of LTCFs.[9] Moreover, RHAs can also be responsible for directly operating or financially supporting many LTCFs within their region.

VCH is responsible for providing care to ~1.25 million people (25% of the BC population). There are 75 LTCFs located within the VCH region (19% of all facilities in the province), of which 21% and 57% are respectively owned or financially supported by VCH. As of May 2020, 35% (76 per 100,000 population) of all COVID-19 cases in the province were located in the VCH region. The study period of our analysis spanned February 28, 2020, through May 24, 2020.

Study population

All LTCFs with a documented exposure to a laboratory-confirmed case of COVID-19[10] among staff members or residents that resulted in <2 subsequent cases in the facility were excluded because there would not be enough data to carry out a segmented regression analysis. Asymptomatic cases (n = 19.6%) were excluded from the analysis because their incidence could not be clearly reliably attributed to the early outbreak period versus the postintervention period. Eligible facilities varied in size, ranging from 108 to 259 staff and from 107 to 210 residents (Appendix 1 online).

Data collection

All COVID-19 cases residing within VCH were contacted by public health staff for case management and contact tracing through a standardized data collection form.[11] Staff collected case information including demographics, symptom onset date, exposure details, association with high-risk settings, and high-risk contacts through patient and family interviews and medical chart review. Data were centrally compiled to form a master case list and an individual facility line list. Cross validation of data for each case was carried out between the master case list and individual facility line lists. Conflicting or missing values were reconciled and corrected through a review of these cases. Total resident and staff numbers within each LTCF during the outbreak period were obtained from licensing records (ie, staff and resident census lists).

Study intervention

A bundle of outbreak control measures were imposed by public health upon outbreak declaration and are summarized in Table 1.

Primary outcome

Our primary outcome of interest was the COVID-19 incidence rate within each facility, which was calculated for staff and residents using case counts over 2 days, divided by the total population in the facility at-risk (removing individuals who became cases in previous time periods). Symptom onset dates (instead of case report dates) were used as a marker for incidence because of the inherent delays between exposure and case identification.

Potential confounders

Staffing levels for IPAC were similar across facilities as it was delivered by an outreach team that would deploy immediately following declaration of a facility outbreak. A daily meeting between regional LTCF operation leads, public health representatives, and the LTCF administration ensured consistent resource allocation, maintenance of staffing levels, and adherence to consistent IPAC recommendations during each LTCF outbreak. Lastly, our model accounted for background community infection rates (Appendix 2 online).

Study design

The study was a quasi-experimental before-and-after study based on a segmented time-trend regression analysis of interrupted time-series data. Segmented regression analysis of time-series data is a widely used method to evaluate the effect of population-level interventions or policy changes implemented at a discrete point in time.[12] For these reasons, we used this method to evaluate the impact of this intervention on preventing further transmission and spread of severe acute respiratory coronavirus virus 2 (SARS-CoV-2) within LTCFs experiencing an outbreak.

Our expectation was that the effect of these measures on the rate of new cases would be fully apparent, 14 days after implementation since individuals could incubate up to 14 days from their exposure to SARS-CoV-2 before showing COVID-19 symptoms.[13]

Statistical analyses

COVID-19 case demographics (age and sex) and case status by case type (staff vs resident) within LTCFs were summarized. Attack rates and case fatality rates for each facility were calculated using public health and licensing data. These statistical analyses were carried out using Stata version 15 software.[14]

A mixed-effect segmented Poisson regression was fit to our facility-specific COVID-19 case data against time to assess the association between the intervention and the COVID-19 incidence rate. The model was built using a standard approach for segmented

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Table 1. Description of the Multisectoral Intervention Implemented in Long-Term Care Facilities

Intervention Category	Outbreak Measures	Details
Case and contact management	Notification of all long-term care staff members for assessment of symptoms and linkage to testing	All staff members were sent communication the day an outbreak was declared prompting all symptomatic individuals to call public health and be directed for testing.
	Rigorous case follow-up, contact tracing and exclusion of high-risk contacts (even if asymptomatic)	A standardized data collection form was utilized to carry out case and contact tracing. Review with long-term care administration team to identify additional contacts was conducted. Individuals that met our high-risk exposure criteria (ie, >15-minute contact, with inadequate personal protective equipment) were asked to isolate even if not symptomatic. Daily follow-up of all excluded contacts was conducted, and if symptomatic, they were directed to testing.
	Line listing of all new cases and proactive follow up of SARS-CoV-2 test results for all residents and staff tested the day prior	A standardized and updated list of COVID-19 cases was created for each facility outbreak to track all cases that were confirmed or under investigation.
Proactive case detection	Daily monitoring of staff and residents for symptoms	Staff had routine symptom and temperature checks at the start of their shift. Residents were assessed for signs and symptoms at least twice daily.
	Low threshold for SARS-CoV-2 testing (mild/atypical symptoms)	Individuals that presented with any symptoms (ie, deviation from baseline) were immediately swabbed or sent for testing. Universal testing (regardless of symptoms) was carried out in select facilities where exposures from contact investigations were widespread or difficult to determine.
Infection control practices[a]	Universal personal protective equipment (PPE) precautions for all facility staff	Long-term care staff were required to wear masks, eye protection, and gloves universally for all care provided. Details are provided in Appendix 9 (online).
	Contact and droplet precautions for confirmed, suspected or exposed cases of COVID-19; universal precautions implemented intermittently	All COVID-19 cases (asymptomatic or symptomatic), newly symptomatic residents, or residents with significant exposure were placed under contact and droplet precautions. Airborne precautions were used if an aerosol-generating medical procedure was carried out. Universal contact and droplet precautions for all residents were implemented in circumstances where a staff exposure was widespread and/or difficult to contact trace.
	Assessment, education, and ongoing support from a dedicated COVID-19 mobile IPAC team	A mobile IPAC team was deployed to outbreak sites to ensure the facility was trained and adhering to IPAC guidelines set out by our health region[a] (Appendix 9 online).
	Closure of facility to all admissions or community discharges	Admissions or transfer of residents back to the long-term care facility were stopped. Individuals were transferred out to higher acute-care settings if medically required and consistent with the goals of care. Transfer of COVID-19 cases to a designated COVID-19 facility was used in exceptional circumstances where only 1–2 cases were identified at the start of the outbreak.
	Restriction of residents to rooms with in-room dining	All residents were asked to isolate in their room. Communal dining was suspended.
	Cohorting of staff to specific floors, wards, or units	Where logistically feasible, separation of staff between COVID-19 and non–COVID-19 floors was carried out, as well as dedicated care staff to COVID-19–positive patients specifically.
	Cohorting of COVID-19 resident cases to specific floors, wards, units, or rooms	Where logistically feasible, new COVID-19 resident cases were moved to COVID-19–specific wards or single occupancy rooms. However, in cases where individuals could not be cohorted, universal contact and droplet precautions were applied to all residents in the room, irrespective of COVID-19 case or symptom status.
	Enhanced cleaning of the facility (ie, each room, common spaces and high-touch surfaces)	Strategic cleaning was also implemented with cleaning non–COVID-19 units, wards, or rooms first and COVID-19 units, floors, or rooms second.
Resource prioritization and stewardship	Proactive daily check-in with regional long-term care operation leads around staff and PPE levels	Each long-term care facility on outbreak provided daily updates on PPE supply and staffing levels to the regional long-term care operations lead. If shortages were encountered, immediate action was taken to provide resources and staff.
	Deployment of necessary resources (ie, additional staff) and PPE in a timely fashion	PPE was centralized in the health region and distributed based on a daily supply assessment. Hazard pay or additional staff were deployed to outbreak facilities with diminishing human resources.

(*Continued*)

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Table 1. (*Continued*)

Intervention Category	Outbreak Measures	Details
	Low barrier/preferential access to SARS-CoV-2 testing and rapid processing of test specimens	Regular communication between public health and regional laboratories, public health and long-term care administration allowed for rapid collection and processing of test specimens for both staff and residents.
Multisectoral collaboration	These outbreak measures were implemented and maintained by using a team-based approach.	This approach included: (1) a daily meeting between public health, the long-term care facility management and administration and regional long-term care operational leads to provide updates on new cases/contacts, discuss challenges with infection control, enhance case detection and address resource or staff shortages, (2) collaboration between public health and provincial and regional medical laboratories to prioritize processing of COVID-19 tests from outbreak facilities, and (3) deployment of a novel COVID-19 IPAC outreach team to provide support to facilities on outbreak.

Note. PPE, personal protective equipment.
[a]Additional details around infection control and outbreak control measures can be found in greater detail in the British Columbia Infection Prevention and Control Requirements for COVID-19 in Long-Term Care and Seniors' Assisted Living.[40]

regression of time series data[15] and the study followed the Outbreak Reports and Intervention Studies of Nosocomial Infection (ORION) reporting guidelines.[16] R version 3.6.2 software[17] was used to perform generalized linear mixed-effects regression and generate figures with the ggplot2 package.

For each facility, the outbreak period was segmented into an early outbreak period (from the first case until 14 days following implementation of measures) and the postintervention period (after 14 days from the implementation of measures). We estimated 4 standard components: (1) the early outbreak trend in COVID-19 rate, (2) the postintervention trend in COVID-19 rate, (3) the magnitude of change in trend from early outbreak to postintervention, and (4) the change in the average COVID-19 rate from early outbreak to postintervention (ie, level change). Random intercept models (using facility as a random effect) were used to account for variation by facility in COVID-19 rates and for the nonindependence of cases within a facility arising from the infectious spread of SARS-CoV-2. Relative effects in the form of rate ratios (RRs) were calculated through exponentiation of the relevant model coefficients. A second model was constructed to evaluate case type (staff vs resident) as an effect modifier. Two-sided tests at 5% significance levels were used to determine statistically significant differences.

A counterfactual trend during the postintervention period was generated by setting all model coefficients, except early outbreak trend, to zero and predicting the COVID-19 rate as if the intervention were not effective or were not implemented. Full details regarding the model specification and residuals examination can be found in Appendix 2 (online).

Ethics approval

Research ethics board review was not required because this study was part of routine public health operations for quality improvement and program evaluation. Data were deidentified and aggregated, and results were suppressed where counts were <5 individuals.

Results

Descriptive analyses

Between February 28, 2020, and May 30, 2020, 18 of 75 (24%) of all LTCFs in the VCH region had at least 1 documented exposure from a COVID-19 case. Among those, 10 of 18 (56%) had a single staff case of COVID-19 with no documented transmission to another staff member or resident. One facility experienced only 1 subsequent case. Among these 18 LTCFs, 7 experienced 2 or more subsequent cases and were included in the analysis.

In total, 275 COVID-19 cases (165 staff and 110 residents) were reported to public health from these 18 study facilities. Appendix 3.1 (online) shows case counts by symptom onset or episode dates for long-term care staff. Appendices 3.2 and 3.3 (online) summarize the characteristics of symptomatic and asymptomatic COVID-19 cases by facility. For all of the LTCFs, except facility C, most cases occurred among residents. The facility attack rates ranged from <4% to 25%. The case fatality rate for infected residents among individual facilities ranged from 22% to 50%.

Appendices 3.4 and 3.5 (online) outline characteristics of symptomatic and asymptomatic COVID-19 cases by case type for the study facilities, respectively. The case fatality rate was 34% among residents, and no deaths were recorded among staff. Figure 1 illustrates the size and duration of COVID-19 outbreaks by facility as well as the varied characteristics of each outbreak and non-LTCF cases in VCH.

Regression analyses

The results of the regression model are described in Table 2 and Appendix 4 (online). The segmented regression analyses are presented in Fig. 2 based on a model with the effect modification terms (model 2).

After adjusting for case type, there was a significant upward trend in the COVID-19 incidence rate during the early outbreak period (RR, 1.07; 95% CI, 1.03–1.11; $P < .001$). Following 14 days from implementation of the intervention bundle, a significant reversal in trend was identified (RR, 0.68; 95% CI, 0.62–0.75; $P < .001$). In particular, the postintervention trend demonstrated a 27% decrease in the COVID-19 incidence rate every 2 days (RR, 0.73; 95% CI, 0.67–0.80; $P < .001$). We detected a decrease (level change) in the overall average incidence rate following the early outbreak period (RR, 0.83; 95% CI, 0.52–1.36) that was not statistically significant ($P > .05$).

Effect modification by case type

The upward COVID-19 incidence trend during the early outbreak period did not differ significantly between staff and resident ($P > .05$). Neither the change in trend during the early outbreak period

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Table 2. Results of Segmented Regression Analysis to Evaluate the Impact of a Multisectoral COVID-19 Intervention

Variable	Model 1[a]	Model 2[b]		
	Overall RR (95% CI)	Resident RR (95% CI)	Staff RR (95% CI)	Effect Modification By Case Type[c] RR (95% CI)
Early outbreak trend in COVID-19 rate[d]	1.07 (1.03–1.11)***	1.07 (1.03–1.12)***	1.07 (1.03–1.12)**	1.00 (0.96–1.03)
Level change after intervention[e]	0.84 (0.51–1.36)	1.20 (0.69–2.10)	0.36 (0.14–0.93)*	0.30 (0.10–0.88)*
Trend change after intervention[f]	0.68 (0.62–0.75)***	0.67 (0.60–0.75)***	0.72 (0.60–0.85) ***	1.07 (0.88–1.31)
Postintervention trend in COVID-19 rate[g]	0.73 (0.67–0.80)****	0.72 (0.65–0.80)****	0.77 (0.65–0.90)**	1.07 (0.88–1.30)

Note. RR, Rate Ratios; CI, confidence interval; *$P < .05$; ** $P < .01$; ***$P < .001$; ****$P < .0001$.
[a]Model 1 adjusts for baseline trend, change in rate, change in trend and case type (resident vs staff), and allows a random baseline COVID-19 rate among facilities.
[b]Model 2 adjusts for the same covariates as model 1 as well as interactions between case type and baseline trend, change in rate, and change in trend. It also allows for a random baseline COVID-19 rate among facilities.
[c]Ratio of relative rate between staff and residents.
[d]Average 2-day (daily) change in the rate of COVID-19 during the early outbreak period (prior to public health measures, plus 14 days).
[e]Difference in the average COVID-19 rate between the early outbreak period and the postintervention period (ie, level shift).
[f]Change in slope from the early outbreak period to the postintervention period.
[g]Average daily change in the rate of COVID-19 during the postintervention period (starting 14 days after the intervention).

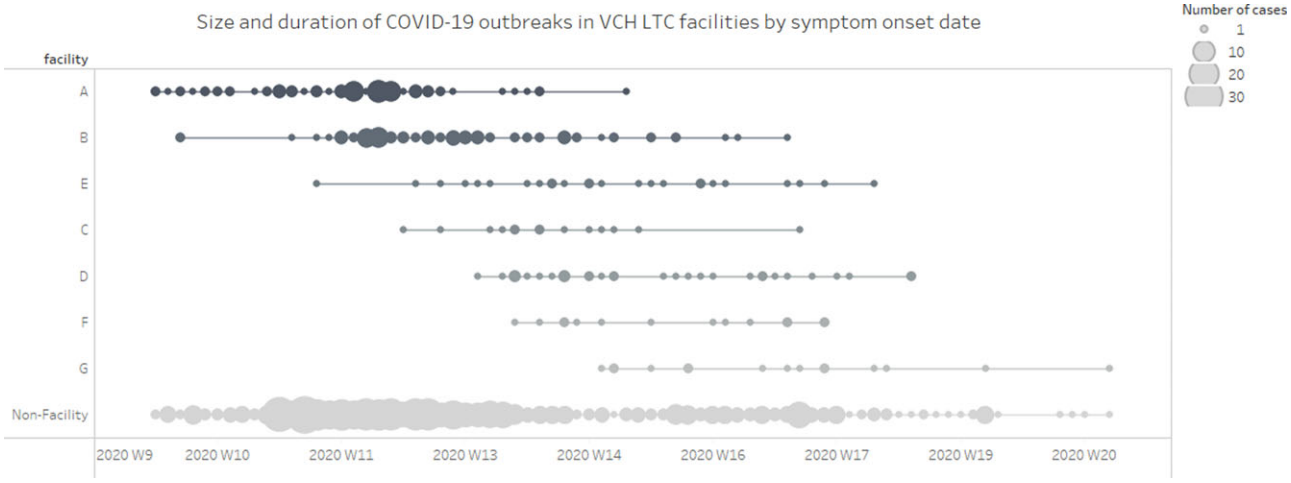

Fig. 1. Size and duration of COVID-19 outbreaks in study long-term care facilities by symptom onset date. Dots indicate cases and the dot size is proportional to the number of cases. Prior to April 8, 2020, testing was restricted to individuals that were either hospitalized, likely to be hospitalized, health care workers, residents of long-term care facilities or part of an investigation of a cluster/or outbreak (as decided by public health). Therefore, nonfacility cases were likely underestimated during that period.

versus postintervention period (RR, 1.07; 95% CI, 0.88–1.31), nor the downward postintervention trend (RR, 1.07; 95% CI, 0.88–1.30), varied significantly between staff and residents.

However, the level change from the early outbreak to postintervention period was significantly different between residents and staff. Specifically, staff had a 70% greater reduction in their average rate of COVID-19 compared to residents following the early outbreak period (RR, 0.30; 95% CI, 0.10–0.88; $P < .05$).

Discussion

Summary of findings

The results of our analysis provide an overview of the epidemiology of COVID-19 within LTCFs experiencing outbreaks in the VCH region. Most cases occurred among residents of these facilities, whereas only 1 facility had more COVID-19 cases among staff than residents. Our regression analysis demonstrated that the combination of outbreak control measures (Table 1) delivered through a collaborative approach were associated with a decrease in COVID-19 incidence rates 14 days from implementation in each LTCF. This change from an upward to downward trend in COVID-19 was consistently detected among both staff and residents and across facilities, regardless of the background rates of community transmission. In addition, the impact of the intervention varied between staff and residents, with a significantly greater decrease (level change) in the average rate of COVID-19 among staff compared to residents after the early outbreak period.

Explanation of findings

The pronounced effect of the intervention among staff cases may be attributable to the lower exposure risk experienced by staff because they spend less time in the facility and they use personal protective equipment daily. Also, many of the outbreak control

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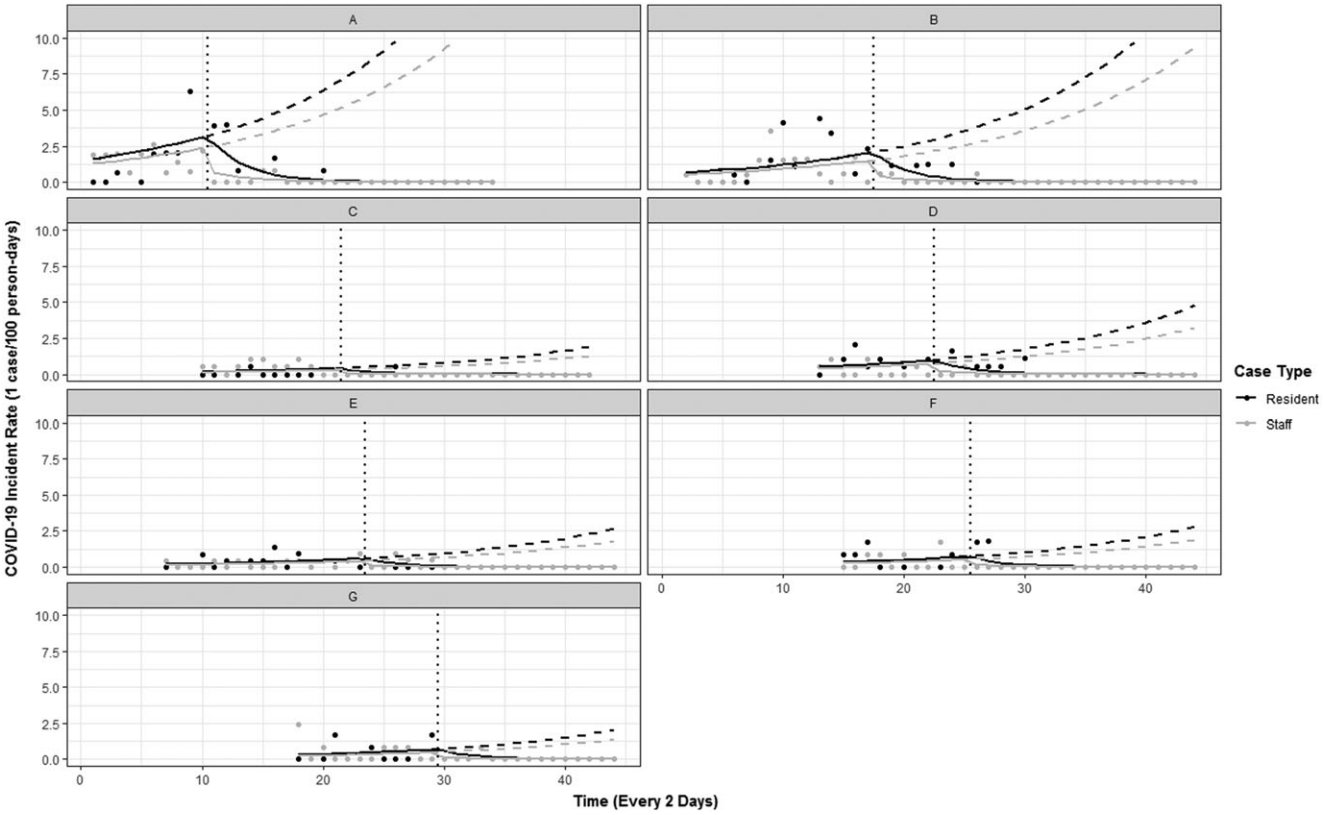

Fig. 2. Segmented regression result for all study facilities. Time is based on symptom onset date. Rates were calculated for every 2-day period. A counterfactual (dotted line) was constructed to visually represent that predicted rate of COVID-19 if public health measures were not implemented or were not effective. The results from model 2 are shown.

measures are largely focused on rapidly identifying and removing symptomatic staff from the work environment, thereby decreasing the frequency of new COVID-19 introductions into the facility. The gradual but persistent decline of new resident cases after the intervention can be explained by the increased exposure time in the facility as well as challenges with resident isolation (ie, wandering due to cognitive impairment). This pronounced effect among staff is particularly important given that documented infections among staff has been demonstrated to be a strong risk factor of long-term care resident mortality.[18]

Comparison of related studies in the literature

To the best of our knowledge, this is the first study to evaluate outbreak control measures to mitigate the transmission of COVID-19 in LTCF using a quasi-experimental design. Cheng et al[19] evaluated a regional infection control response to COVID-19 using descriptive epidemiological methods. Various studies using interrupted time series analysis and segmented regression analysis have evaluated the impact of broader interventions such as social distancing,[20] travel restrictions,[21] and lockdown policies[22] on COVID-19 incidence and mortality.

In addition, various outbreak summary reports, commentaries, and media articles have highlighted the challenges with managing COVID-19 outbreaks in LTCFs in other regions of Canada, United States, and Europe. Key barriers included poor communication and collaboration between key actors, limited access to personal protective equipment (PPE), inadequate early identification of symptomatic staff and resident cases, and challenges in infection control education and adherence.[3,5,6,23-26] In contrast, our intervention was administered through a collaborative team-based approach that fostered excellent communication between public health and LTCF operators. This approach also facilitated the implementation of public health directives and troubleshooting ongoing concerns with the facility. Working directly within a regional health authority structure, PPE levels were monitored daily and were prioritized to LTCFs facing shortages. Access to accurate resident and staff census lists (through public health licensing officials) allowed early notification, assessment, and exclusion of all symptomatic or significantly exposed staff. Prioritization and low-barrier access to SARS-CoV-2 testing allowed for timely case identification and public health action. Furthermore, our intervention included outbreak measures that have been implemented to curb transmission across the United States, such as cohorting[27] and routine symptom monitoring of staff and residents,[28] universal mask policies,[29] appropriate PPE use/ensuring no PPE shortages.[30] As a result, our analysis provides additional support for the effectiveness of outbreak measures not implemented in large LTCF COVID-19 outbreaks in other jurisdictions and are comparable to recommended approaches in the United States and Canada.[2,28,31-33]

However, important difference exists in our approach compared to what has been reported and recommended in the United States. First, the rapid creation and deployment of a government-funded COVID-19 IPAC outreach team was critical in providing effective standardized[28] education to staff, carrying out infection control audits, and diminishing a substantial burden on the LTCF IPAC educators and administrators. Also, we did not

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conduct weekly, biweekly or bimonthly testing of LTCF staff without symptoms, which is currently recommended[32,33] with reported effectiveness.[34] However, we enacted broad and stringent infection control precautions, which likely reduced the benefit of serial testing.[35] Lastly, during our study period universal facility-wide testing was not carried out following the first identified case but rather was determined by contact investigations. However, after the conclusion of our study period, the health region has adopted facility-wide testing to align with current evidence.[36,37]

Strengths and limitations

Time-based segmented regression analyses are one of the strongest quasi-experimental designs to evaluate the impact of population-level interventions targeting nosocomial infection rates.[38] A mixed-effect model also adds rigor to account for dependency (correlation) of observations within each facility. A major strength of a multigroup analysis is the ability to assess for comparability between groups on our observed covariates. Using multiple facilities also increased the number of time points, adding additional power to detect significant effects.[12] A time-based approach also allows for the control of overall secular trends in rates, which can provide an estimate of the true impact of the intervention. Our model demonstrated a consistent effect across facilities while accounting for varying COVID-19 incidence rates among facilities and across time. Lastly, LTCFs that experienced significant COVID-19 outbreaks (>2 cases) occurred unsystematically in our region, providing essentially a random sample of LTCFs for analysis.

However, with the study of any model, there are limitations. First, we assumed that the bundle of measures was imposed upon outbreak declaration; however, the actual implementation of each measure may have occurred over a few days, underestimating the true effect of the intervention. Second, although the model evaluates the bundle of measures, it cannot determine the contribution of individual measure to the overall effect nor whether the intervention improved across time as it became more cohesive and comprehensive. Third, our findings should only be generalized to LTCFs experiencing COVID-19 outbreaks (with >2 cases). Our intervention may not be easily implemented or generalizable in jurisdictions that do not utilize a regional health authority structure to deliver health services. Fourth, asymptomatic cases could not be reliably included potentially biasing our results; however, it is unlikely that these cases would significantly drive our final model due to their small size. A final limitation is the lack of a control group (ie, an LTCF where the intervention was not implemented) given that this would have been unethical. Nonetheless, the early outbreak intervention period serves as control for the post-intervention period, which still accounts for threats to internal validity and constitutes a methodologically acceptable study design for evaluating the impact of population-level intervention.[39]

In conclusion, our comprehensive, timely intervention leveraged regional partnerships to reduce the incidence of COVID-19 in LTCFs, underscoring the value and importance of collaborative approaches for effective infection control. The findings of this study can help to inform and prepare key policy makers such as public health, infection control practitioners, healthcare professionals, and LTCF operators for future COVID-19 outbreaks. We hope our intervention and its team-based approach can be adapted and utilized by other jurisdictions to effectively decrease SARS-CoV-2 transmission and protect the vulnerable populations in LTCFs.

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