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Research

An interrupted time series study using administrative health data to examine the impact of the COVID-19 pandemic on alternate care level acute hospitalizations in Ontario, Canada

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Abstract

Background: Many health systems struggle with delayed discharges (known as alternate level of care [ALC] in Canada). Our objectives were to describe and compare patient and hospitalization characteristics by ALC status, and to examine the impact of the initial period of the COVID-19 pandemic on ALC rates in Ontario, Canada.

Methods: We conducted an interrupted time series using linked administrative data for acute care hospital discharges in Ontario between Feb. 28, 2018, and Nov. 30, 2020. We measured the monthly ALC rate among discharges before and after the onset of the COVID-19 pandemic (Mar. 1, 2020). We used interrupted time series regressions to examine the association between the onset of the pandemic and average ALC monthly rates.

Results: We identified no meaningful differences in patient and admission characteristics, irrespective of time; however, differences were identified by ALC status. The overall average monthly rate of ALC discharges before the COVID-19 pandemic was 4.9% and after the onset of the pandemic was 5.0%. These discharges dropped to 4.3% (n = 3558) in March 2020 but then rebounded to their peak of 5.8% (n = 3915). There was no significant change in the average level of ALC rates per month after the onset of the pandemic (increase of 0.36% average per month, 95% confidence interval [CI] –0.11% to 0.83%) or monthly rate of change (slope) after the onset of the pandemic (–0.08%, 95% CI –0.15 to 0).

Interpretation: We identified a continued high rate of hospital discharges with an ALC component despite the considerable efforts in hospital to reduce hospital occupancy during the COVID-19 pandemic. Future research should examine why ALC rates remain high despite hospital efforts.

The COVID-19 pandemic radically altered the way in which health care was delivered. During the initial waves of COVID-19 in Canada, hospitals across the country quickly adopted measures to reduce in-patient occupancy in anticipation of a pending influx of patients with COVID-19. These anticipatory changes had a dramatic impact on which patients were hospitalized and discharged, and why and when. In particular, between March and June 2020, many hospitals in Ontario, Canada, reported drastic reductions in occupancy, from over 100% (before the pandemic) to as low as 50% (in preparations for anticipated COVID-19 surges).[1–4] Although reductions in occupancy were, in part, due to cancelled surgeries and procedures, they were also related to patient occupancy and flow as patients were quickly transitioned out of hospital to other care settings, including interim care spaces in the community.[2,5]

Before the COVID-19 pandemic, many health systems have struggled with the long-standing issues related to patient flow and, more specifically, delayed discharges (known as alternate level of care [ALC] in Canada).[6–15] An ALC status is designated by a physician or a delegate when a patient occupies a bed and no longer needs the intensity of services provided in the care setting.[16] The Canadian Institute for Health Information (CIHI) reports that approximately 5.4% of hospital stays have ALC days.[17,18] Delays occur when a patient has completed their medical treatment but remains in the hospital, often because their next point of care is not available (e.g., rehabilitation bed, long-term care bed, home care). Medical care usually decreases as individuals wait.[19] Identifying and implementing solutions to address these delays, sometimes referred to as "hallway health care,"[20] has been a major priority in Canada and particularly within Ontario for decades,[15,20,21] but unfortunately the problem persists.

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Patients with a delay in discharge were likely most affected by the sudden pandemic-related changes to service delivery and policy. Understanding the potential impact of these hospital policy changes on ALC rates (as described above) and who experienced ALC during the pandemic will provide important insights into the extent to which hospital admission and discharge policies may alleviate a long-standing policy ALC issue. As such, there is a unique opportunity to investigate how these policy changes may have affected overall rates of ALC (for the better or worse) and the characteristics of patients with ALC status compared with others hospitalized during the COVID-19 pandemic.

In this context, the objectives of the present study were to describe and compare the characteristics of individuals hospitalized by ALC status and admission characteristics before and during the onset of the pandemic in Ontario, and to examine whether there was an impact of the COVID-19 pandemic on hospital ALC rates across Ontario, using administrative health data. We expected that patients with ALC status would have more medical complexity, and unplanned and medical admissions during the pandemic, with increased likelihood of hospital harm due to policies restricting informal (e.g., family and friends) caregivers. We also anticipated differences in ALC rates because of the pandemic, specifically, reduced ALC rates due to efforts in discharging patients to settings other than the hospital.

Methods

We conducted an interrupted time series using linked administrative data from ICES (https://www.ices.on.ca). ICES is an independent, nonprofit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. With a population of 14.8 million, Ontario is Canada's most populous province. Guided by the *Canada Health Act*, Ontario provides publicly funded medical coverage to residents for medically necessary services, including emergency department, inpatient and outpatient hospital, and physician services.[22] An interrupted time series was chosen as it allows for multiple observations before and after the pandemic onset while integrating time.[23,24] Our study period was February 2018 to November 2020. The Strengthening the Reporting of Observational Studies in Epidemiology checklist with the Reporting of Studies Conducted Using Observational Routinely-collected Data extension was used as a guide to report the results.

Population and data sources

The population for this study included all people discharged from an acute hospital (inpatient care for necessary treatment designed for a short period of time) in Ontario between Feb. 28, 2018, and Nov. 30, 2020. Data sets were linked using unique encoded identifiers and analyzed at ICES (a prescribed entity under the Ontario *Personal Health Information Protection Act*), where repositories of all health care data for Ontario are deposited. These data are valid and reliable, as described by previous published studies.[25–27] We captured all records of hospitalizations as well as procedures and diagnoses that occurred in hospital using the CIHI Discharge Abstract Database. We identified records of emergency department visits using the National Ambulatory Care Reporting System and records of outpatient physician visits and physician specialty information using the Ontario Health Insurance Plan database. We identified chronic comorbidities using a multimorbidity macro that leverages several ICES-derived cohorts from various data sets, including the Ontario Asthma Data Set, Congestive Heart Failure Data Set, Chronic Obstructive Pulmonary Disease Data Set, Ontario Hypertension Data Set, Ontario Diabetes Data Set, Ontario Rheumatoid Arthritis Data Set and the Ontario Dementia Database. Demographic information (e.g., age and sex), and mortality were obtained from the Ontario Registered Persons Database.[28–34] The Ontario Drug Benefit Database (ODB) was used to capture prescription drug claims for those aged 65 years or older, receiving social assistance (Ontario Works, Ontario Disability Support Program), or coverage through the Trillium Drug Program (high-cost drug support).

Exposure

Our primary exposure was the documented onset of the COVID-19 pandemic in Ontario, defined as of Mar. 1, 2020. We had 2 defined periods, with the period before the pandemic set as June 1, 2019, to Feb. 29, 2020, and the period after the onset of the pandemic set as Mar. 1, 2020, to Nov. 30, 2020.

Outcome

Our main outcome of interest was a closed, monthly rate of discharges with an ALC component, calculated by the total number of discharges with an ALC status out of the total number of discharges per month multiplied by 100.[18] The calculation is based on an established performance indicator on ALC.[18]

Other variables of interest

Sociodemographic and geographic characteristics

We identified patient age and sex. Neighbourhood income quintiles were calculated using Statistics Canada census and corresponding postal code information. We determined urban and rural residential location using the Rurality Index for Ontario. This index ranges from 0 to 100 and considers population factors and distance to referral centres. Locations with a score of greater than or equal to 40 are considered rural.[35] These variables were identified from admission date.

Clinical characteristics before admission

Using a validated multimorbidity algorithm at ICES, comorbidities were classified by 16 possible conditions, which included acute myocardial infarction asthma, arthritis, depression, diabetes, cancer, chronic coronary syndrome, cardiac arrythmia, congestive heart failure, chronic obstructive pulmonary disease, dementia, hypertension,

renal failure, rheumatoid arthritis and stroke.[36] We used the ODB to capture records of prescription medications (based on unique drug name) dispensed to individuals insured through the provincial drug plan in the year before the admission. Individuals are eligible for drug coverage if they are aged 65 years or older, reside in long-term care homes, receive home care services, have high prescription medication costs in relation to their net household income, or receive social financial assistance through Ontario Works or Ontario Disability Support Program.

Admission characteristics

Hospital admission characteristics included the type of admission (planned, unplanned), clinical category (surgical, medical), frailty (decline in function in several organ systems)[37] and hospital harm.[38] Frailty was measured using a Hospital Frailty Risk Score (< 5 low risk, 5–15 moderate risk, > 15 high risk).[37] We identified hospital harm using CIHI's hospital harm methodology.[38] The Canadian Institute for Health Information defines hospital harm as a hospitalization in which at least 1 unintended occurrence of a potentially preventable event occurs. Monthly rates of hospital harm were calculated by the total number of admissions that were associated with an incident of hospital harm per total number of admissions multiplied by 100. The 4 major categories of harm were health care– or medication-associated conditions (e.g., pressure injuries, wrong medications), health care–associated infections (e.g., surgical site infections), patient accidents (e.g., falls) and procedure-associated conditions (e.g., postoperative bleeding).[38]

Statistical analysis

We used descriptive statistics to examine demographic, clinical and hospital admission characteristics of the population admitted before the onset of the COVID-19 pandemic and after. Standardized differences were used to compare the populations admitted before and after pandemic onset because the very large samples can result in statistical significance of trivial differences. We considered differences unimportant when below 10% (0.1).[39] The impact of the pandemic on hospital discharges started from Mar. 1, 2020. The association of the COVID-19 pandemic on ALC rates was examined using interrupted time series regression (Appendix 1, available at https://www.cmajopen.ca/content/11/4/E621/suppl/DC1), in which we assessed both the immediate change in the level of ALC in March 2020 and the subsequent change in trend over time.[40] Models were examined for autocorrelation by inspecting a plot of residuals by time and the Durbin–Watson statistic.[41] The seasonality was examined using the *F* test. We ran stratified models by type of admission and clinical category. All analyses were conducted at ICES using SAS Enterprise Guide 7.1 (SAS Institute Inc.).

Ethics approval

The use of the data in this project is authorized under section 45 of Ontario's *Personal Health Information Protection Act*[42] and does not require review by a research ethics board.

Results

The number of hospital discharges during the 34 months of observation between Feb. 28, 2018, and Nov. 30, 2020, was 3 132 409 (2 356 428 prepandemic discharges and 775 981 discharges after the onset of the COVID-19 pandemic). Overall, there were no meaningful differences of individuals with discharges by ALC status before the pandemic and after the onset of the pandemic, as standardized differences were less than 0.1. However, differences were seen when comparing characteristics by ALC status irrespective of the time periods. Patients with discharges of an ALC status were older in age, and had more drug claims in the year before hospitalization, multimorbidity with 5 or more conditions, and frailty, irrespective of the 2 time periods. More drug claims might reflect that patients with ALC status were older and the drug claims data available are limited to those who are eligible for the Ontario Drug Benefit plan (Table 1).

The overall rate of hospital harm during the observation window was 2.6% with no meaningful differences based on the onset of the COVID-19 pandemic. However, discharges with ALC status had higher rates of overall hospital harm compared with discharges with no ALC status in the periods before and after the onset of the pandemic (standardized differences > 0.1). There were more health care– and medication-associated conditions and health care–associated infections among ALC status hospitalizations compared with non-ALC status, with no meaningful differences on procedure-related harms and patient accidents.

During the prepandemic period, the average monthly rate of ALC discharges was 4.9%, and it had remained stable during this prepandemic period (changing 0.002% per month, 95% confidence interval [CI] –0.01% to 0.02%; Table 2). After the onset of the COVID-19 pandemic in March 2020, there was a nonsignificant change in the average level of ALC discharges per month (increase of 0.36% average per month, 95% CI –0.11% to 0.83%). After dropping to a low of 4.3% (n = 3558) in March 2020, the ALC rate rebounded to a peak level of 5.8% (n = 3915) by April 2020. Nonetheless, the effect of the pandemic onset on monthly rate of change (slope) in ALC rates was also nonsignificant (–0.08%, 95% CI –0.15 to 0).

The overall monthly ALC rates and by admission type (planned, unplanned) are shown in Figure 1. Figure 2 shows ALC rates by major clinical category (surgical, medical and overall). There was an initial level drop in the month of March 2020 for both surgical- and medical-related hospitalizations with ALC status. After the initial level drop, rates rebounded in April, then stabilized. After April 2020, the rates remained relatively unchanged by admission type (planned or unplanned) or major clinical category (surgical or medical).

No seasonality was detected. The p values for tests of stable seasonality (p = 0.2), moving seasonality (p = 0.1) and combined test for the presence of identifiable seasonality (p = 0.07) were greater than 0.05, indicating no seasonality effects were present. The Durbin–Watson test indicated that the autocorrelation was present (p = 0.046 at the first order).

Table 1 (part 1 of 2): Baseline characteristics of individuals discharged from inpatient acute care during the study period in Ontario, stratified by time period (before and after the onset of the COVID-19 pandemic)

Characteristic	Prepandemic hospitalization (June 1, 2019, to Feb. 29, 2020)		Std. diff. (ALC v. no ALC status pre-pandemic)	Post–pandemic onset hospitalization (Mar. 1, 2020, to Nov. 30, 2020)		Std. diff. (ALC v. no ALC status post–pandemic onset)	Std. diff. (pre- v. post-onset, ALC status)*	Std. diff. (pre- v. post-onset, no ALC status)*
	ALC status*	No ALC status*		ALC status*	No ALC status*			
No. of discharges	116 490	2 239 938		38 200	737 781			
Age, yr								
Mean ± SD	76.9 ± 14.6	48.7 ± 29.3	1.22	77.3 ± 14.3	48.1 ± 29.3	1.27	0.02	0.02
Median (IQR)	80 (70–87)	56 (28–73)		80 (70–88)	54 (28–73)			
Sex, no. (%)								
Female	63 059 (54.1)	1 249 285 (55.8)	0.04	20 729 (54.3)	411 799 (55.8)	0.03	0	0
Male	53 418 (45.9)	985 392 (44.0)		17 468 (45.7)	323 867 (43.9)			
Neighbourhood income, no. (%)								
1 (lowest)	33 223 (28.5)	524 392 (23.4)	0.12	11 080 (29.0)	171 589 (23.3)	0.13	0.01	0
2	26 051 (22.4)	462 455 (20.7)	0.04	8589 (22.5)	151 669 (20.6)	0.05	0	0
3	21 553 (18.5)	441 593 (19.7)	0.03	7016 (18.4)	145 546 (19.7)	0.04	0	0
4	18 120 (15.6)	413 747 (18.5)	0.08	5886 (15.4)	136 104 (18.5)	0.08	0	0
5 (highest)	16 752 (14.4)	379 049 (16.9)	0.07	5344 (14.0)	124 742 (16.9)	0.08	0.01	0
Rural, no. (%)								
No	103 115 (88.5)	1 939 265 (86.6)	0.06	33 873 (88.7)	638 610 (86.6)	0.06	0.01	0.01
Yes	12 614 (10.8)	283 004 (12.6)		4052 (10.6)	91 372 (12.4)			
Comorbidities, no. (%)								
0	1802 (1.6)	516 580 (23.1)	0.69	560 (1.5)	183 181 (24.8)	0.74	0.01	0
1	3645 (3.1)	241 640 (10.8)	0.30	1112 (2.9)	79 129 (10.7)	0.31	0.01	0
2	6828 (5.9)	257 164 (11.5)	0.20	2163 (5.7)	84 443 (11.5)	0.21	0.01	0
3	11 256 (9.7)	252 870 (11.3)	0.05	3543 (9.3)	82 317 (11.2)	0.06	0	0.01
4	14 885 (12.8)	235 582 (10.5)	0.07	4931 (12.9)	75 370 (10.2)	0.08	0.02	0.03
≥ 5	78 074 (67.0)	736 102 (32.9)	0.73	25 891 (67.8)	233 341 (31.6)	0.78	0.01	0.02
No. of unique drugs†								
Mean ± SD	10.3 ± 8.0	4.7 ± 7.5	0.72	10.4 ± 8.0	4.6 ± 7.4	0.76	0.01	0.02

Table 1 (part 2 of 2): Baseline characteristics of individuals discharged from inpatient acute care during the study period in Ontario, stratified by time period (before and after the onset of the COVID-19 pandemic)

Characteristic	Prepandemic hospitalization (June 1, 2019, to Feb. 29, 2020)		Std. diff. (ALC v. no ALC status pre-pandemic)	Post–pandemic onset hospitalization (Mar. 1, 2020, to Nov. 30, 2020)		Std. diff. (ALC v. no ALC status post–pandemic onset)	Std. diff. (pre- v. post-onset, ALC status)*	Std. diff. (pre- v. post-onset, no ALC status)*
	ALC status*	No ALC status*		ALC status*	No ALC status*			
Hospital harm,‡ no. (%)								
No. of harm admissions	13 179 (11.3)	62 241 (2.8)	0.34	2954 (7.7)	17 377 (2.4)	0.25	0.12	0.03
Health care or medications	7531 (6.5)	33 351 (1.5)	0.26	1650 (4.3)	9646 (1.3)	0.18	0.10	0.02
Infections	7148 (6.1)	18 986 (0.9)	0.29	1659 (4.3)	4932 (0.7)	0.24	0.08	0.02
Patient accidents	893 (0.8)	1797 (0.1)	0.11	200 (0.5)	512 (0.1)	0.08	0.03	0
Procedure	1509 (1.3)	19 851 (0.9)	0.04	303 (0.8)	5886 (0.8)	0	0.05	0.01
Hospital Frailty Score								
Mean ± SD	8.1 ± 5.2	1.6 ± 2.8	1.57	8.4 ± 5.3	1.7 ± 3.0	1.57	0.05	0.04
Low risk (< 5), no. (%)	37 535 (32.2)	2 008 347 (89.7)	1.46	11 448 (30.0)	651 866 (88.4)	1.48	0.05	0.04
Moderate risk (5–15), no. (%)	66 456 (57.1)	219 235 (9.8)	1.16	22 246 (58.2)	81 018 (11.0)	1.14	0.02	0.04
High risk (> 15), no. (%)	12 499 (10.7)	12 356 (0.6)	0.45	4506 (11.8)	4897 (0.7)	0.47	0.03	0.01
Type of admission, no. (%)								
Planned elective	12 721 (10.9)	661 301 (29.2)	0.48	4283 (11.2)	203 713 (27.6)	0.43	0.01	0.04
Unplanned	103 769 (89.1)	1 578 637 (70.5)		33 917 (88.8)	534 068 (72.4)			
Major clinical category, no. (%)								
Surgical	27 009 (23.2)	673 359 (30.1)	0.15	8163 (21.4)	212 304 (28.8)	0.17	0.04	0.03
Medical	89 481 (76.8)	1 566 579 (69.9)		30 037 (78.6)	525 477 (71.2)			

Note: ALC = alternate level of care, IQR = interquartile range, SD = standard deviation, Std. Diff. = standardized difference.
*Standardized differences comparing characteristics of those with ALC status pre– and post–pandemic onset, as well as among those with non-ALC status.
†Number of unique drugs in the year before observation window for those eligible in the Ontario Drug Benefit Program.
‡Hospital harm as per the Canadian Institute for Health Information Hospital Harm Index.

Interpretation

Improving hospital flow and reducing discharge delays has been a major focus of health care in Canada and particularly within Ontario for decades.[11,15,20] In this study, we identified that the ALC rate initially dropped, then rebounded, and remained relatively unchanged in the initial wave of the COVID-19 pandemic compared with the prepandemic period, despite substantial changes to hospital admission, procedure and discharge processes. Our findings have important implications for preventive care and cross-sector integrated care among those at risk for hospital admissions and, ultimately, at risk for ALC status.

First, our findings suggest that hospital-specific policies of reducing procedures and increasing efforts to discharge patients in a timely manner had minimal effect on ALC rates. The ALC rates remained consistent as a proportion of all discharges, thus highlighting the pressures hospitals experience in addressing this complicated challenge. Our data suggest that only focusing on 1 particular sector, such as hospital processes and policies, had minimal impact on overall ALC rates. This finding reinforces previous research that posits a need to focus across other sectors (e.g., primary care, home care, community services and long-term care) to address this complicated system flow issue.[11] The unchanged ALC rates may also have been in part due to changes in

Table 2: Interrupted time series model results summarizing the association of the COVID-19 pandemic onset with delayed acute hospital discharges

Model component	Parameter estimate	Standard error	95% confidence interval
Post–pandemic onset level change The change in level of ALC rates for the post–pandemic onset period*	0.36	0.24	–0.11 to 0.83
Prepandemic slope Change in ALC rates in the prepandemic period†	0.002	0.01	–0.01 to 0.02
Slope change The change in monthly slope post–pandemic onset	–0.08	0.04	–0.15 to 0

*Onset of the COVID-19 pandemic: Mar. 1, 2020, to Nov. 30, 2020.
†Prepandemic: June 1, 2019, to Feb. 29, 2020.

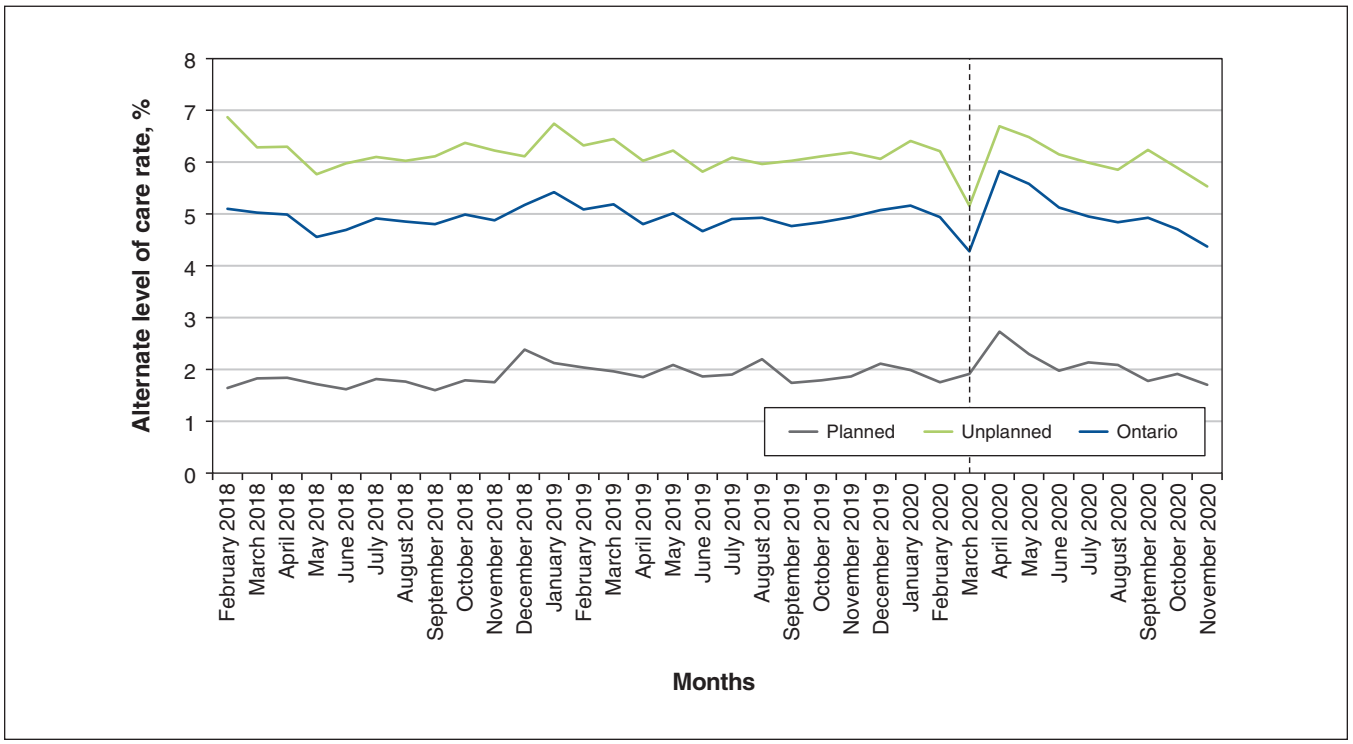

Figure 1: Monthly alternate level of care (ALC) rate (%) over the 18 months of observation (February 2018 to November 2020) in Ontario, overall and by admission type (planned, unplanned). The dotted vertical line indicates the onset of the COVID-19 pandemic in Ontario, as of Mar. 1, 2020. The monthly ALC rate was calculated by the total number of ALC patients who were discharged per the total number of discharges per month multiplied by 100.

long-term care admission policies during this period. In efforts to reduce SARS-CoV-2 transmission within long-term care facilities, new admissions were paused, creating a potential backlog in the acute hospitals.

In addition to the support of patients once they have been identified as having ALC status, upstream preventive efforts in the community, through more home care support, are required to substantially affect ALC rates with a focus on prevention and integrated care across sectors to minimize hospital-related avoidable admissions. Evidence supports integrated care, specifically multidisciplinary geriatric home care, for older adults with frailty.[43] Integrated care can reduce potentially avoidable hospital admissions.[43] Furthermore, a recent study in the United Kingdom identified a significant inverse association with home care supply and discharge delay, such that increased home care supply reduced rates of discharge delays.[44] In Ontario, timely access to home care remains a challenge, as substantial physical or cognitive impairments are required to be eligible for services.[45] Lack of timely access to appropriate community-based care can increase the risk of hospitalization.

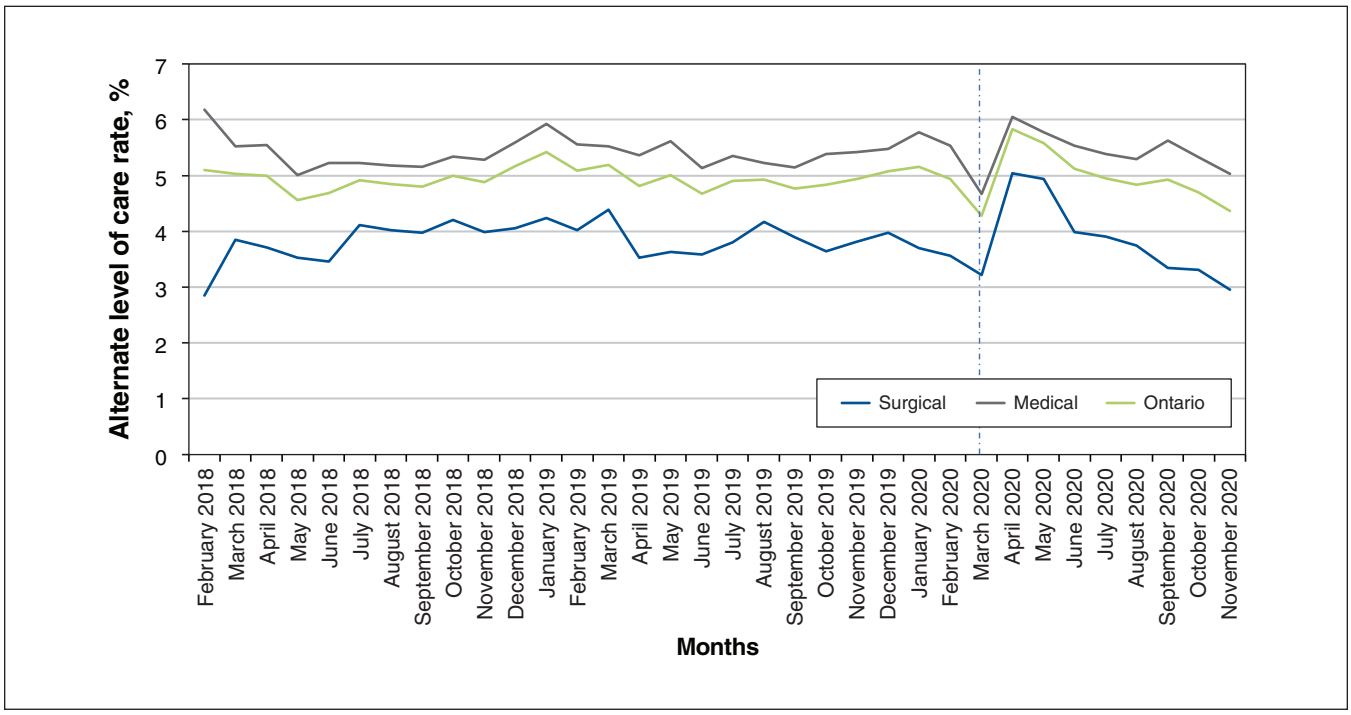

Figure 2: Monthly alternate level of care (ALC) rates (% cases) by major clinical category (surgical, medical, overall) over the 18 months of observation (February 2018 to November 2020) in Ontario. The dotted vertical line indicates the onset of the COVID-19 pandemic in Ontario, as of Mar. 1, 2020. The monthly ALC rate was calculated by the total number of ALC patients who were discharged per the total number of discharges per month multiplied by 100.

Second, we found that people with ALC status were overall more at risk for hospital-related harm with being older, and having more frailty and comorbidities, and higher prescription drug claims than people hospitalized without an ALC status. This finding is similar to results of other studies and reinforces the potential vulnerability of patients with ALC status, especially given the heightened risk of substantial functional and cognitive decline as they wait to leave hospital.[46] Inpatient therapy services, such as physical therapy or occupational therapy may decrease or stop altogether. The wait period combined with decreased therapeutic services often exacerbates an already heightened risk of functional decline and hospital-related harm (e.g., falls[47–51] and infection).[52] Hospitals implementing a no-visitor policy during the pandemic may have further exacerbated the risks of deconditioning among patients. Further research is warranted to examine the impact of the COVID-19 pandemic on patient and caregiver experiences, as well as health outcomes.

Limitations

Health systems evolved in response efforts with each wave of the pandemic, and as such, we cannot generalize that ALC rates remained consistent for subsequent waves. We were limited in our data at the time of analysis, and further follow-up is ongoing. The data represent rates within Ontario and cannot be generalized to other provinces or territories in Canada. Every province and territory had unique policies during the pandemic. Although interrupted time series estimate the change in outcome after an event or intervention within a population, it is possible that changes could be explained by unrelated temporal confounders. Also, since only descriptive unadjusted comparisons were made between patients who had ALC status and those who did not, we cannot assume observed differences such as hospital harm were caused by unnecessary hospital stays. Finally, the ODB database does not provide information on prescription drugs dispensed among all Ontarians; as such, more drugs dispensed among people with ALC status may be reflective of people being older and, thus, drugs dispensed being captured within the ODB database.

Conclusion

We identified relatively stable rates of delayed acute discharge throughout the early waves of the COVID-19 pandemic. Delayed discharge continues to be a recalcitrant issue that raises the importance of a cross-sector focus to mitigate the prevalence and negative impacts of delayed discharge.

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Data sharing: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at https://www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors on request, understanding that the computer programs may rely on coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

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