Title: The Immunity of Delayed Acute Discharges to the COVID-19 Pandemic in Ontario, Canada: An Interrupted Time Series Study

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Abstract

BACKGROUND
During the initial waves of COVID-19 in Canada, hospitals quickly adopted measures to reduce in-patient occupancy. These anticipatory changes had a dramatic impact on who, why and when patients were admitted and discharged. Our objectives were to examine the impact of the initial period of COVID-19 pandemic on delay in discharge (also known as Alternate Level of Care; ALC) rates in Ontario, Canada; and to describe the characteristics of individuals experiencing ALC before and during the onset of the pandemic.

METHODS
We conducted an interrupted time series using linked administrative data for discharges in Ontario between February 28, 2018 and November 30, 2020. We measured the monthly ALC rate before and after the onset of COVID-19 (March 1, 2020). We used segmented regression analysis to examine the association between the onset of COVID-19 and ALC rates.

RESULTS
The overall average monthly rate of ALC pre-COVID was 4.9%, and post-COVID, it averaged 5.0%. On visual inspection of trends, there was an initial drop of delayed discharge rates to 4.3% during the month of March 2020 which quickly rebounded. Our interrupted time series model showed no significant level or slope changes on delayed discharge rates during the observation window [parameter estimate = 0.27; standard error = 0.34, p value > 0.05].

INTERPRETATION
We identified continued high ALC rates despite the substantial efforts in hospital to reduce hospital occupancy during COVID-19. Future research should examine patient outcomes of persons who were rapidly discharged during the pandemic, especially among those who were ALC.

Introduction

COVID-19 radically altered the way in which healthcare 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 pending influx of COVID-19 patients. These anticipatory changes had a dramatic impact on who, why and when patients were hospitalized and discharged. In particular, between March and June 2020, many hospitals in Ontario, Canada reported drastic reductions in occupancy, from over 100% (pre-COVID) to as low as 50% (in preparations for anticipated COVID surges).[1-4] While reductions in occupancy were, in part, due to cancelled surgeries and procedures, they were also related to patient flow as patients were quickly transitioned out of hospital to other care settings, including interim care spaces in the community.[2,5]

Prior to COVID-19, many health systems have struggled with the longstanding issues related to patient flow and more specifically, delayed discharges (known as Alternate Level of Care, ALC, in Canada).[6-15] The Canadian Institute for Health Information (CIHI) reports that, in most provinces, patients designated as ALC occupy more than 12% of hospital beds.[16] Delays occur when a patient has completed their medical treatment but remain in the hospital often because their next point of care is not available. Medical care usually decreases as individuals wait.[17] Identifying and implementing solutions to address these delays, sometimes referred to as 'hallway healthcare"[18] has been a major priority in Canada, and particularly within Ontario for decades[15,18,19] but unfortunately the problem persists.

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

In this context, the objectives of the present study were: 1) to examine whether there was an impact of COVID-19 pandemic on hospital ALC rates across Ontario, Canada using administrative health data; and 2) to describe and compare the characteristics of individuals hospitalized by ALC status before and during the onset of the pandemic in Ontario, Canada.

Methods

Study Design and Setting

We conducted an interrupted time series using linked administrative data from ICES (formerly the Institute for Clinical Evaluative Sciences), Toronto, Ontario (www.ices.on.ca). With a population of 14.8 million, Ontario is Canada's most populous province. As per the Canada Health Act, Ontario provides universal medical coverage to residents for medically necessary services, including emergency department, inpatient and outpatient hospital, physician, and homecare services.[20]

Population and Data Sources

The population for this study included all persons discharged from an acute hospital in Ontario, Canada between February 28, 2018 and November 30, 2020. Datasets were linked using unique encoded identifiers and analyzed at ICES (a prescribed entity under the Ontario

Personal Health Information Privacy and Protection Act) where repositories of all healthcare data for Ontario are deposited. These data are valid and reliable, as described by previous published studies.[21-23] We captured all records of hospitalizations as well as procedures and diagnoses that occurred in hospital using the Canadian Institute of Health Information (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 which leverages several ICES-derived cohorts from various datasets, including the Ontario Asthma Dataset, Congestive Heart Failure Dataset, Chronic Obstructive Pulmonary Disease Dataset, Ontario Hypertension Dataset, Ontario Diabetes Dataset, Ontario Rheumatoid Arthritis Dataset, and the Ontario Dementia Database. Demographic information (e.g., age and sex), and mortality were obtained from the Ontario Registered Persons Database.[24-30] The Ontario Drug Database was used to capture prescription drug claims for those 65 years or older, receiving social assistance (Ontario works, Ontario Disability Benefits), or Trillium drug coverage (high cost drug support).

Exposure

Our primary exposure was the documented first onset of COVID-19 in Ontario, Canada defined as of March 1, 2020.

Outcome

Our main outcome of interest was a monthly ALC rate, calculated by the total number of ALC patients per the total number of discharges per month multiplied by 100.

Other Variables of Interest

Other variables of interest included sociodemographic (age, sex), socioeconomic status (neighbourhood income), geography (urban and rural status) and clinical characteristics prior to admission (comorbidities and previous drug claims), and admission characteristics (planned/elective, or unplanned/urgent, medical or surgical, hospital harm, and frailty).

Sociodemographic, geography

Neighbourhood income quintiles were calculated using census and postal code information. We determined urban and rurality residential location using the Rurality Index of 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.[31]

Clinical characteristics prior to admission

Using 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.[32] We used the Ontario Drug Benefit Database to capture records of prescription medications dispensed to individuals insured through the provincial drug plan in the year prior to the admission. Individuals are eligible for drug coverage if they are 65 years of age or older, reside in long-term care homes, receive home care services, have high prescription medication costs compared to their net household income, receive social financial assistance through Ontario Works or Ontario Disability Benefits Plan.

Admission characteristics

Hospital admission characteristics included the type of admission (planned, unplanned), clinical category (surgical, medical), frailty (decline in function in several organ systems),[33] and hospital harm.[34] We identified hospital harm using CIHI's hospital harm methodology.[34] CIHI defines hospital harm as a hospitalization in which at least one unintended occurrence of 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 four major categories of harm included: 1) healthcare-/medication-associated conditions (e.g., pressure injuries, wrong medications); 2) healthcare-associated infections (e.g., surgical site infections); 3) patient accidents (e.g., falls); and 4) procedure-associated conditions (e.g., post-operative bleeding).[34] Frailty was measured using a Hospital Frailty Risk Score (<5 low risk, 5-15 moderate risk, >15 high risk).[33]

Statistical Analysis

We used descriptive statistics to examine demographic, clinical and hospital admission characteristics of the population admitted before the onset of COVID-19 and after. Standardized differences were used to compare the populations admitted before and after COVID-19 onset because the sample sizes are very large and statistical significance is assured. We used a threshold of greater than 10% (0.1) difference being important.[35] We used segmented regression analyses to examine the association of COVID-19 on ALC rates. Basic, no trend, intervention trend models were tested. For the no trend model, we used a bivariate regression to examine the intervention (f_COVID) effect. In the basic model, the overall trend was tested using a time series regression. The intervention trend model was evaluated using an interrupted time series regression. Models were examined for autocorrelation by inspecting a plot of residuals by time and the Durbin-Watson statistic. Full and balanced data (9 months before and after the onset of COVID-19) were examined on model fit, with models having smaller Schwartz's Bayesian information criterion (SBC) value and mean squared errors being preferred.[36] All analyses were conducted at ICES using SAS Enterprise Guide 7.1 (SAS Institute Inc., Cary, NC, USA).

Ethics Approval

As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use healthcare data for the purposes of health system analysis, evaluation, and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. The use of data was authorized under section 45 of Ontario's *Personal Health Information Protection Act,*[37] which does not require review by a Research Ethics Board.

Results

The number of hospitalizations during the 34 months of observation between February 28, 2018 and November 30th, 2020 was 3,132,409, with an overall average monthly ALC rate of 4.9%. We observed an initial reduction in March 2020 of ALC rates (4.3%), however the impact of COVID onset was non-significant on the overall ALC rate (parameter estimate [ß]=0.2691; standard error [standard error] = 0.34; p=0.44) for the balanced data.

The overall monthly trends in 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 drop in the month of March 2020 for both surgical and medical related hospitalizations with ALC status. After the initial drop, rates rebounded in April, then stabilized. After April 2020, the rates remaining relatively unchanged by admission type (planned or unplanned) or major clinical category (surgical or medical). Full data graphs are shown in the Supplemental File.

Overall there were no meaningful differences in sociodemographic or clinical characteristics before COVID-19 and after the onset of COVID-19 (Table 1). However, differences were seen when comparing by ALC status. Discharges with an ALC status had higher prevalence of frailty (n=9181; 11.3%) compared no ALC status (n=9531; 0.6%). There was a higher prevalence of frailty among those with ALC status irrespective of COVID-19 (10.8% before compared to 11.8% post COVID-onset). Relatedly, overall ALC discharges were associated with being older (median 80 years of age, IQR 70-87 for ALC, compared to 55 (IQR=29-74) for non-ALC), more drug claims in the year prior to hospitalization (mean 10.3 (SD=8.0); compared to 4.7 (SD=7.4) for non ALC;) and multimorbidity with 5+ conditions (67.4% compared to 32.3%), with relatively no changes over time. The overall rate of hospital harm during the observation window was 2.6% with no meaningful differences over time. However, discharges with ALC status had higher rates of overall hospital harm (n=6730; 8.3%) compared to discharges with no ALC status (n=37140; 2.4%). Rates of hospital harm remained high for those discharges with ALC pre COVID (8.7%) and during COVID onset although rates came down slightly for ALC related discharges (7.7%). Overall for ALC related discharges, there were more harms for healthcare-/medication-associated conditions (4.8%) and healthcare-associated infections (4.5%) compared to non-ALC admissions (1.3% and 0.7%, respectively); with no meaningful differences on procedure-related and patient accidents.

Interpretation

Of the 3 million Canadians admitted to acute care each year, approximately 20% have an ALC status.[38] Improving hospital flow and reducing discharge delays has been a major focus of healthcare in Canada and particularly within Ontario for decades.[11,15,18] In our time series analyses, we identified that the ALC rate initially dropped, then rebounded, and remained relatively unchanged in the initial wave of the COVID-19 pandemic despite substantial changes to hospital admission and procedure processes. Our findings have important implications for prevention and cross-sector integrated care among those at risk for hospital admissions, and ultimately at risk for ALC status.

Firstly, 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, thus highlighting the persistent pressure flow of individuals coming into the hospital at risk of ALC status. Our data suggests that only focusing on one 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 sectors such as primary care, homecare, community social supports, 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 long-term care admission policies during this time period. In efforts to reduce COVID-19 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 become ALC, upstream preventative efforts in the community, through homecare support, are required to substantially impact 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 homecare, for older adults with frailty can reduce potentially avoidable hospital admissions.[39] Furthermore, a recent study in the United Kingdom identified a significant inverse association with homecare supply and discharge delay, such that increased homecare supply reduced rates of discharge delays.[40] In Ontario, timely access to homecare remains a challenge as significant physical and/or cognitive impairments are required to be eligible for services.[41] Lack of timely access to appropriate community-based care can increase the risk of hospitalization.

Secondly, we identified individuals who were identified as ALC, were overall more at risk for hospital related harm with being older, higher frailty, more comorbidities, and higher prescription drug claims compared to persons hospitalized without an ALC status. This finding is similar to other studies, and reinforces the vulnerability of ALC patients especially given the heightened risk of significant functional and cognitive decline as they wait to leave hospital.[42] Inpatient therapy services, such as physical therapy or occupational therapy may decrease and/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[43-47] and infection).[48] 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 COVID-19 on patient and caregiver experiences as well as health outcomes.

Limitations

Health systems evolved in response efforts with each wave 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 also represents rates within Ontario, and cannot be generalized to other provinces or territories in Canada. Every province and territory had unique policies during the pandemic.

Conclusions

We identified relatively stable delayed acute discharge rates 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.

Data Sharing Statement

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

Word Count: 2491

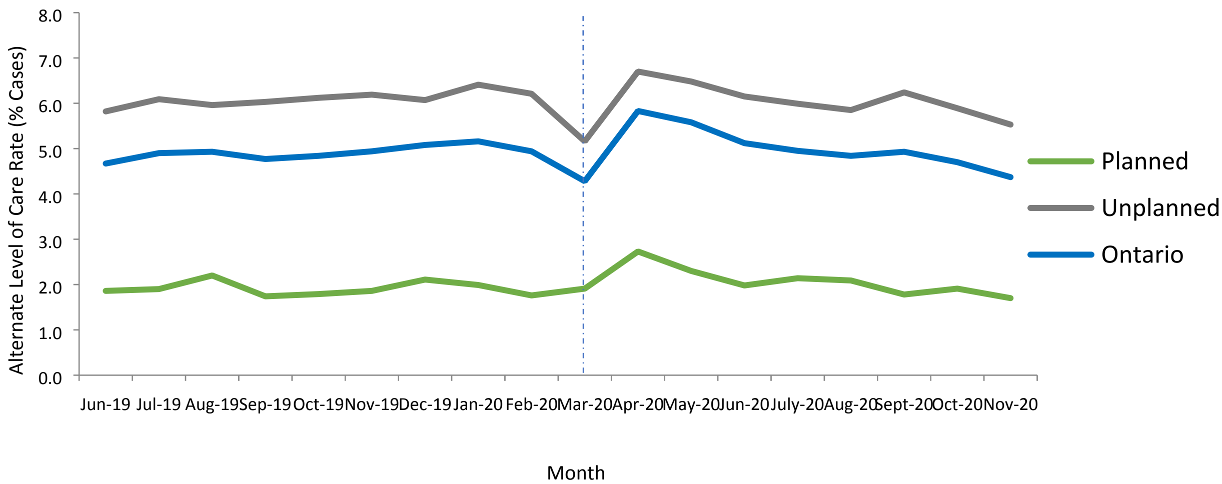
Abbreviations: IQR: Interquartile Range; SD: Standard Deviation; ALC: Alternate Level of Care; CIHI: Canadian Institute for Health Information; SBC: Schwartz's Bayesian information criterion

Table 1. Baseline Characteristics of Individuals Discharged from Inpatient Acute Care During Study Period, Ontario, Canada, Stratified by Time Period (Balanced Data)

Characteristics	Pre-COVID-19 Hospitalization (June 1, 2019 – February 29, 2020)		Post/Onset COVID-19 Hospitalization (March 1, 2020 to November 30, 2020)		Standardized Difference (Pre ALC vs. Onset ALC)^
	ALC Status^	No ALC Status	ALC Status^	No ALC Status	
# of Admissions	43,392	839,335	38,200	737,781	
Age					
Mean (SD)	77.01 (14.5)	48.76 (29.3)	77.26 (14.3)	48.1 (29.3)	0.02
Median (IQR)	80 (70-87)	56 (28-73)	80 (70-88)	54 (28-73)	
Sex					
Female	23,433 (54.0)	467,780 (55.7)	20,729 (54.3)	411,799 (55.8)	0.00
Male	19,956 (46.0)	369,369 (44.0)	17,468 (45.7)	323,867 (43.9)	0.00
Neighbourhood Income					
Q1 (Low)	12,308 (28.4)	195,950 (23.4)	11,080 (29.0)	171,589 (23.3)	0.00
Q2	9,755 (22.5)	173,436 (20.7)	8,589 (22.5)	151,669 (20.6)	0.00
Q3	8,085 (18.6)	165,694 (19.7)	7,016 (18.4)	145,546 (19.7)	0.00
Q4	6,663 (15.4)	154,330 (18.4)	5,886 (15.4)	136,104 (18.5)	0.00
Q5 (High)	6,265 (14.4)	141,991 (16.9)	5,344 (14.0)	124,742 (16.9)	0.00
Rural					
No	38,558 (88.9)	726,697 (86.6)	33,873 (88.7)	638,610 (86.6)	0.00
Yes	4,526 (10.4)	105,113 (12.5)	4,052 (10.6)	91,372 (12.4)	0.00
Comorbidities					
0	629 (1.5)	195,432 (23.3)	560 (1.5)	183,181 (24.8)	0.00
1	1,280 (3.0)	90,051 (10.7)	1,112 (2.9)	79,129 (10.7)	0.00
2	2,525 (5.8)	96,052 (11.4)	2,163 (5.7)	84,443 (11.5)	0.01
3	4,253 (9.8)	93,826 (11.2)	3,543 (9.3)	82,317 (11.2)	0.02
4	5,574 (12.9)	88,113 (10.5)	4,931 (12.9)	75,370 (10.2)	0.00
5+	29,131 (67.1)	275,861 (32.9)	25,891 (67.8)	233,341 (31.6)	0.01
# of Unique Drugs* Mean (SD)	10.3 (8.0)	4.7 (7.5)	10.4 (8.0)	4.6 (7.4)	0.02
Hospital Harm**					
# Harm Admissions	3,776 (8.7)	19,763 (2.4)	2,954 (7.7)	17,377 (2.4)	0.00
Category A: Care/Medications	2,246 (5.2)	10,778 (1.3)	1,650 (4.3)	9,646 (1.3)	0.00
Category B: Infections	1,980 (4.6)	5,537 (0.7)	1,659 (4.3)	4,932 (0.7)	0.00
Category C: Patient Accidents	253 (0.6)	533 (0.1)	200 (0.5)	512 (0.1)	0.00
Category D: Procedure	428 (1.0)	6,602 (0.8)	303 (0.8)	5,886 (0.8)	0.00
Hospital Frailty Score Mean (SD)	8.2 (5.2)	1.6 (2.8)	8.4 (5.3)	1.7 (3.0)	0.04
Type of Admission					
Planned elective	4,774 (11.0)	244,807 (29.2)	4,283 (11.2)	203,713 (27.6)	0.03
Unplanned	38,618 (89.0)	594,528 (70.8)	33,917 (88.8)	534,068 (72.4)	0.03
Major Clinical Category					
Surgical	9,836 (22.7)	250,296 (29.8)	8,163 (21.4)	212,304 (28.8)	0.02
Medical	33,556 (77.3)	589,039 (70.2)	30,037 (78.6)	525,477 (71.2)	0.02

Abbreviations: SD = standard deviation, ALC = Alternate Level of Care; *Number of unique drugs in the year prior to observation window for those eligible in the Ontario Drug Benefit Program; ** Hospital Harm as per the Canadian Institute of Health Information Hospital Harm Index;^Standardized Difference comparing characteristics of those with ALC status pre and COVID-19 on

Figure 1. Monthly Alternate Level of Care Rate (% Cases) Over the 18 Months of Observation (June 2019 to November 2020) in Ontario, Canada, Overall and by Admission Type (Planned, Unplanned)



Legend: Monthly alternate level of care rate (%) over the 18 months of observation (June 2019 to November 2020) in Ontario, Canada. The dotted vertical line indicates the onset of COVID-19 in Ontario, Canada as of March 1, 2020. The monthly ALC rate was calculated by the total number of ALC patients per the total number of discharges per month multiplied by 100.

Figure 2. Monthly Alternate Level of Care Rates (% Cases) by Major Clinical Category (Surgical, Medical, Overall) Over the 18 Months of Observation (June 2019 to November 2020) in Ontario, Canada

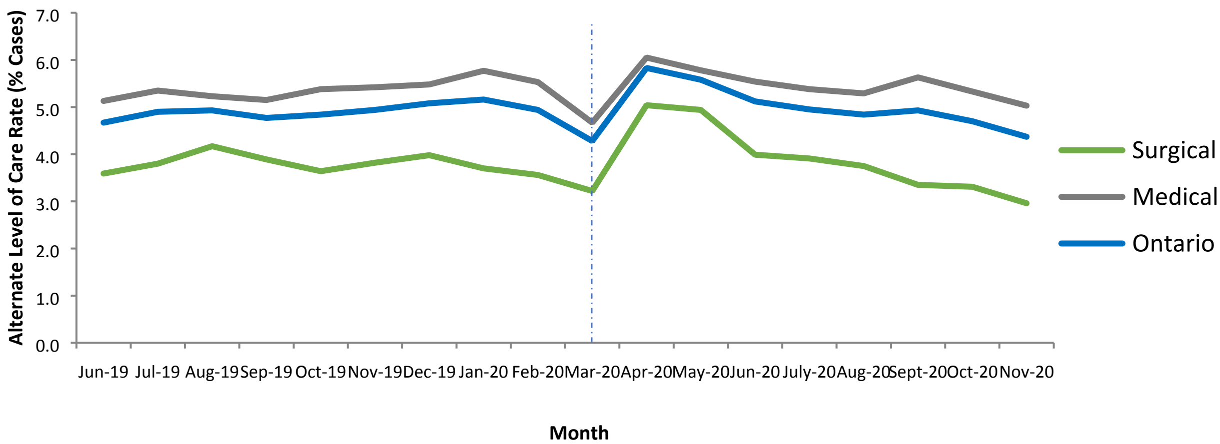


Figure 2 Legend: Monthly alternate level of care rates (%) over the 18 months of observation (June 2019 to November 2020) in Ontario, Canada, stratified by major clinical category (surgical, medical). The dotted vertical line indicates the onset of COVID-19 in Ontario, Canada as of March 1, 2020. The monthly ALC rate was calculated by the total number of ALC patients per the total number of discharges per month multiplied by 100.

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