The risk of death or unplanned readmission after discharge from a COVID-19 hospitalization in Alberta and Ontario

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Abstract

Background: The frequency of readmissions after COVID-19 hospitalizations is uncertain, as is whether current readmission prediction equations are useful for discharge risk stratification of COVID-19 survivors or for comparing among hospitals. We sought to determine the frequency and predictors of death or unplanned readmission after a COVID-19 hospital discharge.

Methods: We conducted a retrospective cohort study of all adults (≥ 18 yr) who were discharged alive from hospital after a nonpsychiatric, nonobstetric, acute care admission for COVID-19 between Jan. 1, 2020, and Sept. 30, 2021, in Alberta and Ontario.

Results: Of 843 737 individuals who tested positive for SARS-CoV-2 by reverse transcription polymerase chain reaction during the study period, 46 412 (5.5%) were adults admitted to hospital within 14 days of their positive test. Of these, 8496 died in hospital and 34 846 were discharged alive (30 336 discharged after an index admission of ≤ 30 d and 4510 discharged after an admission > 30 d). One in 9 discharged patients died or were readmitted within 30 days after discharge (3173 [10.5%] of those with stay ≤ 30 d and 579 [12.8%] of those with stay > 30 d). The LACE score (length of stay, acuity, Charlson Comorbidity Index and number of emergency visits in previous 6 months) for predicting urgent readmission or death within 30 days had a c-statistic of 0.60 in Alberta and 0.61 in Ontario; inclusion of sex, discharge locale, deprivation index and teaching hospital status in the model improved the c-statistic to 0.73.

Interpretation: Death or readmission after discharge from a COVID-19 hospitalization is common and had a similar frequency in Alberta and Ontario. Risk stratification and interinstitutional comparisons of outcomes after hospital admission for COVID-19 should include sex, discharge locale and socioeconomic measures, in addition to the LACE variables.

Despite all the attention focused on COVID-19 hospital admissions and mortality rates, relatively little attention has been paid to readmission rates after a COVID-19 hospitalization. It is unknown whether current readmission prediction equations[1] are appropriate for the risk stratification of COVID-19 survivors. Studies of patients admitted to hospital with COVID-19 have reported 30-day all-cause, unplanned readmission rates between 3.6% and 10.4%, and few evaluated predictors.[2–12] Moreover, all studies focused on patients admitted to hospital during the first year of the pandemic, many captured readmissions only if at the same hospital as the index admission, most did not account for the competing risk of outpatient death, and some excluded events in the first 7 days after discharge.[2–12] These are substantial weaknesses, since as many as one-quarter of readmissions occur at different hospitals than the index admission[13] and 7%–10% of COVID-19 survivors die within 2 months after discharge.[14,15]

In the pre-COVID-19 era, hospital readmissions were recognized to be common and costly.[16] Knowing the readmission rate and resource implications for patients who have been discharged after a hospital admission for COVID-19 is important for health system resource planners as health care systems deal with subsequent waves of the pandemic, particularly with the increasing recognition of substantial postacute sequelae of SARS-CoV-2 infection.[17] Identifying risk factors for early readmission or death is important for both the in-hospital clinical team and the primary care physician who reassumes care after discharge, as well as for transition coordinators deciding which patients may benefit from additional resources at discharge, to

optimize outcomes. Finally, knowing the factors that predict readmission is essential for health services researchers and performance measurement systems comparing patient outcomes after COVID-19 admission among hospitals.

We sought to describe the frequency and predictors of urgent readmission or death in the first 30 days after discharge from a COVID-19 hospitalization. As studies in the pre-COVID era reported different risk factors for early versus late readmission,[18] we also evaluated unplanned readmissions or death within 7 days and 90 days of discharge.

Methods

Study design and population

We conducted a retrospective cohort study of all adults (≥ 18 yr) in Ontario and Alberta with at least 1 urgent, nonpsychiatric, non-obstetric, acute care hospital admission between Jan. 1, 2020, and Sept. 30, 2021, and who had a positive reverse transcription polymerase chain reaction (RT-PCR) test result for SARS-CoV-2 within 14 days before or during the index hospital admission. When people had multiple admissions, we included only their first admission. As is standard with Medicare and Canadian Institute for Health Information (CIHI) studies of postdischarge event rates, our primary analyses excluded patients with "atypical" flags[19] in their case mix grouping, including those who died during the index hospital admission, those with admissions exceeding 30 days, those who were transferred to a palliative care hospice or inpatient rehabilitation facility, or those who signed themselves out against medical advice. Of note, the median length of stay for patients admitted to hospital with COVID-19 differs among countries, but is less than 9 days in most countries;[20] thus, the CIHI definition of 30 days or less as a "typical" admission was felt to be an appropriate a priori length of stay for COVID-19 admissions. For patients transferred between hospitals, we combined data for each episode of care and designated the hospital where they spent the longest period as the most responsible hospital.

Study settings and data sources

We used population-level, deterministically linked, health administrative data from Ontario and Alberta. These 2 provinces account for 50.3% of the total Canadian population. Both provinces publicly fund hospital admission, visits to emergency departments (EDs) and physician visits, and administrative data capture these health care interactions.

We used the Discharge Abstract Database (which captures all hospital admissions and discharge destinations and records up to 25 diagnoses, coded with the *International Classification of Diseases, 10th Revision* [ICD-10]), the National Ambulatory Care Reporting System (which captures all visits to any ED in either province and records up to 10 ICD-10 diagnoses per visit), the provincial laboratory databases of both provinces (which capture all SARS-CoV-2 testing results, with genomic confirmation of all tests that screened positive for variants of concern after Feb. 7, 2021) and the provincial registry files (which capture date of death, if applicable). We also collected data on SARS-CoV-2 vaccination status. We used the definitions of the National Advisory Committee on Immunizations that were established before the surge in the Omicron variant. We considered an individual to be fully vaccinated if they tested positive for SARS-CoV-2 at least 2 weeks after their second dose of an approved SARS-CoV-2 vaccine, partially vaccinated if they had received at least 1 dose but did not yet meet the definition of full vaccination at the time of their positive SARS-CoV-2 swab, or nonvaccinated.

Outcomes

Our primary outcome was unplanned, all-cause readmission or death within 30 days after time of discharge. Our secondary outcomes were unplanned, all-cause readmissions or deaths within 7 days and 90 days of the index hospital discharge. The Canadian Institute for Health Information applies a proprietary case mix algorithm to discharge abstracts to cluster hospital admissions with similar primary diagnoses and resource use (including procedures) into 1 of 528 case mix groups, which can then be grouped into 21 major diagnostic categories. We evaluated the most common major diagnostic categories for readmissions after an index COVID-19 hospitalization.

Covariates

We identified comorbidities for each patient using previously validated case definitions based on ICD-10 codes for the index hospital admission and any admissions in the year before their index admission.[21,22] Other nonclinical covariates included hospital type (teaching v. nonteaching), patient residence (rural v. urban, as defined by the Canadian Census), socioeconomic status (defined using the Pampalon Deprivation Index in Alberta and the Ontario Marginalization Index in Ontario), residence in a long-term care facility, number of urgent hospital admissions in the previous 12 months, number of ED visits in the previous 6 months, LACE score (length of stay, acuity, Charlson Comorbidity Index and number of ED visits in previous 6 months),[23] Charlson Comorbidity Index score and day of discharge since these have been shown to influence readmission rates in other studies.[24,25]

Statistical analysis

We compared percentages and means with standard deviations (for normally distributed variables) or medians with 25th and 75th percentiles (for non-normally distributed variables) by 30-day death or urgent readmission status using Student *t* test and Wilcoxon rank-sum tests, respectively. We compared categorical variables using the χ^2 test. Although our primary analysis focused on CIHI-defined typical hospital admissions of 30 days or less,[19] we also explored outcomes in patients with "atypical" index admissions of longer than 30 days in a sensitivity analysis.

We explored the covariates associated with 30-day postdischarge events for our primary analyses and whether predictors were different for 7-day and 90-day events in our preplanned secondary analyses. We conducted patient-level analyses using multivariable logistic regression models with hospital identifier treated as a random effect to account for within-hospital clustering. Fixed-effects adjustment variables included age, sex, rural residence status, deprivation index quintiles, Charlson score, number of nonelective hospital admissions in the previous 12 months, number of ED visits in the previous 6 months, index discharge disposition location (i.e., home with or

without home care, or to long-term care or nursing facility), length of index admission (entered into the model as < 6 d v. ≥ 6 d, with the cutpoint determined from a restricted cubic spline function with 5 knots), admission to the intensive care unit during the index hospital admission, discharge on a weekend or holiday, hospital type (teaching v. nonteaching), SARS-CoV-2 strain and vaccination status.

As privacy laws preclude the sharing of health data across provincial boundaries, the Alberta analyses were conducted within the Alberta Strategy for Patient-Oriented Research Data and Research Services team and the Ontario analyses were performed at ICES. We then pooled multivariable risk estimates from each province using a random-effects model with restricted maximum likelihood estimates to account for heterogeneity between provinces.[26,27] This approach was chosen for its high efficiency when a small number of effect sizes are included.

We conducted all analyses using SAS version 9.4, except for the pooled random-effects model done using the metafor package (http://CRAN.R-project.org/package=metafor) in R Core Team 2020 version 1.4-0.

Ethics approval

The study was approved by the University of Alberta research ethics boards (Pro00101096_AME3) with a waiver of individual informed consent, given the use of deidentified data. The analysis of deidentified Ontario data is authorized under section 45 of Ontario's *Personal Health Information Protection Act*.

Results

Of the 843 737 people in Alberta and Ontario with a positive RT-PCR test for SARS-CoV-2 between Jan. 1, 2020, and Sept. 30, 2021, 46 412 (5.5%) were adults admitted to hospital within 14 days of their positive test. Of these, 8496 died in hospital and 34 846 were discharged alive (30 336 after an index admission of ≤ 30 d and 4510 after a hospital stay > 30 d, Figure 1). One in 9 discharged patients died or were readmitted within 30 days after discharge, including 3173 (10.5%) of those with a CIHI-defined "typical" hospital admission length[19] and 579 (12.8%) of those with a stay of more than 30 days. Although patients in Alberta were younger, more likely to live in a rural area, more likely to have preadmission hospital and ED encounters, more likely to be discharged home without support and less likely to come from a long-term care facility, most other covariables, including the average LACE scores for their index hospital admission, were similar in each province (Table 1 and Table 2).

Within 30 days of discharge after an index hospital admission for COVID-19 of 30 days or less, 783 (9.9%) patients in Alberta and 2390 (10.6%) patients in Ontario had an urgent readmission or died, and c-statistic for the LACE score was 0.60 in Alberta and 0.61 in Ontario (Appendix 1, eFigure 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.220272/tab-related-content). Patients who died or were readmitted were older, had a higher Charlson comorbidity burden, were more likely to be male, were more likely to have been discharged home with home care or to a long-term care facility and had higher rates of previous hospital admissions and ED visits (Table 1 and Table 3). The multivariable model incorporating these factors had a c-statistic of 0.73 in both Alberta and Ontario (Table 3).

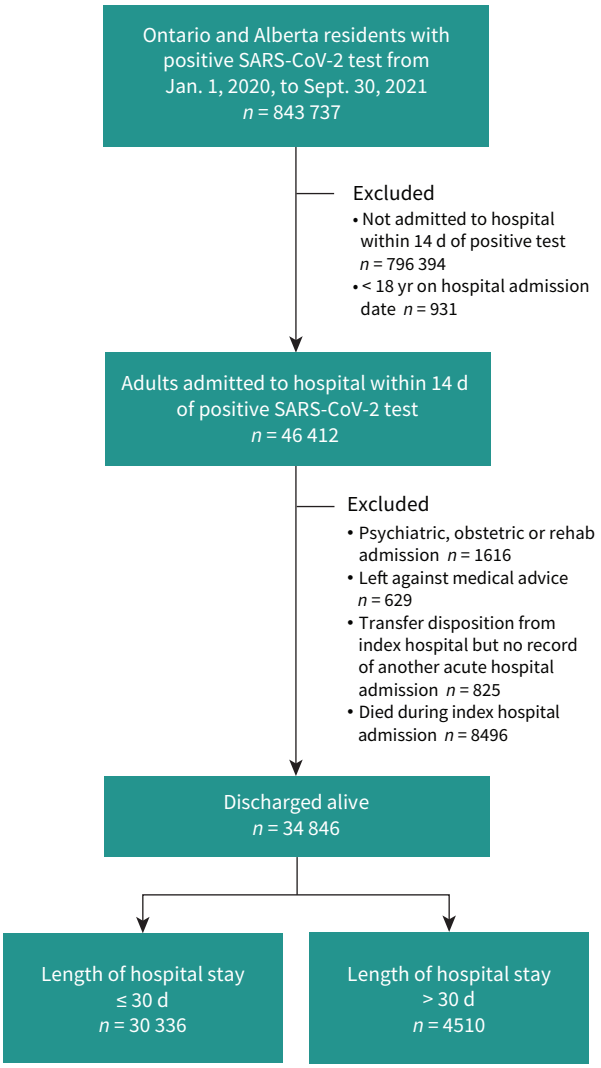

Figure 1: Cohort flow diagram.

The 5 most common primary diagnoses when patients were readmitted were COVID-19 (37.6%), nonspecified pneumonia or interstitial pulmonary disease (6.0%), heart failure (4.1%), pulmonary embolism (3.1%) and confusion (3.0%). The most common readmissions by CIHI major diagnostic categories are listed in Appendix 2, eTable 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.220272/tab-related-content. Diseases and disorders of the respiratory system accounted for 47.1% of diagnoses, and diseases and disorders of the circulatory system was the second most common diagnostic category at 11.2%.

We observed similar differences in patterns of demographics, comorbidities and health care use between patients who did and did not have an event (death or readmission) within 7 days or 90 days of discharge (Table 1, Table 2 and Appendix 2, eTable 2). Overall, 397 (5.0%) patients in Alberta and 1307 (5.8%) patients in Ontario were readmitted or died within 7 days of hospital discharge; within 90 days, these frequencies were 1169 (14.8%) in Alberta and 3356 (14.9%) in Ontario, respectively (Appendix 2, eTable 2). On multivariable analyses, we found similar predictors of postdischarge outcomes at 7 days and

Table 1: Baseline characteristics of adults in Alberta and Ontario admitted to hospital with a positive test for SARS-CoV-2 and who were discharged alive after a hospital stay of 30 days or less, between Jan. 1, 2020, and Sept. 30, 2021, stratified by readmission or death within 30 days of discharge

	No. (%) of patients in Alberta*			No. (%) of patients in Ontario*		
Characteristic	**Overall *n* = 7875**	**Readmission or death within 30 days *n* = 783**	**No readmission or death within 30 days *n* = 7092**	**Overall *n* = 22 461**	**Readmission or death within 30 days *n* = 2390**	**No readmission or death within 30 days *n* = 20 071**
Age at time of admission, yr, mean ± SD	57.44 ± 17.28	66.06 ± 18.29	56.90 ± 17.06	61.4 ± 17.2	70.1 ± 17.1	60.4 ± 16.9
Sex, male	4429 (56.2)	464 (59.3)	3965 (55.9)	12 333 (54.9)	1314 (55.0)	11 019 (54.9)
Rural resident	1474 (18.7)	158 (20.2)	1316 (18.6)	879 (3.9)	107 (4.5)	772 (3.8)
Deprivation index quintile†						
1 (least deprived)	951 (12.1)	80 (10.2)	871 (12.3)	3357 (14.9)	353 (14.8)	3004 (15.0)
2	1138 (14.5)	105 (13.4)	1033 (14.6)	3811 (17.0)	412 (17.2)	3399 (16.9)
3	1230 (15.6)	108 (13.8)	1122 (15.8)	4140 (18.4)	446 (18.7)	3694 (18.4)
4	1484 (18.8)	134 (17.1)	1350 (19.0)	4652 (20.7)	475 (19.9)	4177 (20.8)
5 (most deprived)	2187 (27.8)	222 (28.4)	1965 (27.7)	6275 (27.9)	677 (28.3)	5598 (27.9)
Unknown	885 (11.2)	134 (17.1)	751 (10.6)	226 (1.0)	27 (1.1)	199 (1.0)
Long-term care resident	98 (1.2)	24 (3.1)	74 (1.0)	516 (2.3)	150 (6.3)	366 (1.8)
Nonelective hospital admission in previous 12 mo	1666 (21.2)	290 (37.0)	1376 (19.4)	3183 (14.2)	746 (31.2)	2437 (12.1)
Nonelective hospital admission in previous 3 mo	1016 (12.9)	174 (22.2)	842 (11.9)	1576 (7.0)	446 (18.7)	1130 (5.6)
ED visit in previous 6 mo	4782 (60.7)	541 (69.1)	4241 (59.8)	13 096 (58.3)	1551 (64.9)	11 545 (57.5)
No. of ED visits in previous 6 mo, median (IQR)	1 (1–2)	2 (1–4)	1 (1–2)	0 (0–1)	1 (0–2)	0 (0–1)
SARS-CoV-2 strain						
Wild type, original strain	3018 (38.3)	318 (40.6)	2700 (38.1)	8647 (38.5)	1026 (42.9)	7621 (38.0)
Alpha VOC	1551 (19.7)	110 (14.0)	1441 (20.3)	7059 (31.4)	597 (25.0)	6462 (32.2)
Delta VOC	1429 (18.1)	146 (18.6)	1283 (18.1)	867 (3.9)	73 (3.1)	794 (4.0)
Other VOC	227 (2.9)	8 (1.0)	219 (3.1)	1464 (6.5)	129 (5.4)	1335 (6.7)
Untested or indeterminate	1650 (21.0)	201 (25.7)	1449 (20.4)	4424 (19.7)	565 (23.6)	3859 (19.2)
Vaccination status						
Fully vaccinated (≥ 2 doses)	312 (4.0)	63 (8.0)	249 (3.5)	312 (1.4)	60 (2.5)	252 (1.3)
Partially vaccinated (1 dose)	407 (5.2)	46 (5.9)	361 (5.1)	754 (3.4)	194 (8.1)	553 (2.8)
Unvaccinated	7156 (90.9)	674 (86.1)	6482 (91.4)	21 395 (95.3)	2136 (89.4)	19 266 (96.0)
Comorbidities from index hospital admission and admissions in previous year						
Charlson comorbidity score, mean ± SD	1.0 ± 1.6	1.8 ± 2.1	0.9 ± 1.5	0.4 ± 1.3	1.1 ± 2.1	0.3 ± 1.1
Chronic pulmonary disease (COPD or asthma)	593 (7.5)	91 (11.6)	502 (7.1)	1693 (7.5)	254 (10.6)	1439 (7.2)
Heart failure or cardiomyopathy	291 (3.7)	60 (7.7)	231 (3.3)	1296 (5.8)	335 (14.0)	961 (4.8)
Hypertension	933 (11.8)	137 (17.5)	796 (11.2)	6220 (27.7)	853 (35.7)	5367 (26.7)
Diabetes mellitus	2325 (29.5)	271 (34.6)	2054 (29.0)	7103 (31.6)	941 (39.4)	6162 (30.7)
Coronary artery disease, including previous myocardial infarction, CABG surgery, PCI or stenting	251 (3.2)	41 (5.2)	210 (3.0)	1301 (5.8)	272 (11.4)	1029 (5.1)
Peripheral arterial disease	46 (0.6)	10 (1.3)	36 (0.5)	235 (1.0)	66 (2.8)	169 (0.8)
Cerebrovascular disease (including previous stroke or transient ischemic attack)	96 (1.2)	12 (1.5)	84 (1.2)	477 (2.1)	92 (3.8)	385 (1.9)
Atrial fibrillation or flutter	314 (4.0)	53 (6.8)	261 (3.7)	1425 (6.3)	287 (12.0)	1138 (5.7)
Ventricular arrythmias	14 (0.2)	1 (0.1)	13 (0.2)	61 (0.3)	11 (0.5)	50 (0.2)
Renal disease	228 (2.9)	51 (6.5)	177 (2.5)	939 (4.2)	234 (9.8)	705 (3.5)
Cancer	214 (2.7)	57 (7.3)	157 (2.2)	1076 (4.8)	286 (12.0)	790 (3.9)
Other lung disease (non-COPD or asthma)	140 (1.8)	43 (5.5)	97 (1.4)	375 (1.7)	81 (3.4)	294 (1.5)
Peptic ulcer disease	47 (0.6)	8 (1.0)	39 (0.5)	143 (0.6)	41 (1.7)	102 (0.5)
Liver disease	171 (2.2)	37 (4.7)	134 (1.9)	431 (1.9)	81 (3.4)	350 (1.7)
Dementia	168 (2.1)	46 (5.9)	122 (1.7)	1065 (4.7)	295 (12.3)	770 (3.8)

Note: CABG = coronary artery bypass graft, COPD = chronic obstructive pulmonary disease, ED = emergency department, IQR = interquartile range, PCI = percutaneous coronary intervention, SD = standard deviation, VOC = variant of concern.
*Unless indicated otherwise.
†Results for Alberta are based on the Pampalon Deprivation Index and those for Ontario are based on the Ontario Marginalization Index.

Table 2: Characteristics of the index hospital admissions for COVID-19 in Alberta and Ontario among adults discharged alive after a hospital stay of 30 days or less, between Jan. 1, 2020, and Sept. 30, 2021, stratified by readmission or death within 30 days of discharge

Characteristic	No. (%) of patients in Alberta*			No. (%) of patients in Ontario*		
	Overall *n* = 7875	Readmission or death within 30 days *n* = 783	No readmission or death within 30 days *n* = 7092	Overall *n* = 22 461	Readmission or death within 30 days *n* = 2390	No readmission or death within 30 days *n* = 20 071
Elective hospital admission	148 (1.9)	24 (3.1)	124 (1.7)	313 (1.4)	40 (1.7)	273 (1.4)
Urgent or emergent hospital admission	7727 (98.1)	759 (96.9)	6968 (98.3)	22 148 (98.6)	2350 (98.3)	19 798 (98.6)
Tested positive for SARS-CoV-2 within 48 h of admission	7179 (91.2)	690 (88.1)	6489 (91.5)	21 184 (94.3)	2086 (87.3)	19 098 (95.2)
Tested positive for SARS-CoV-2 after 48 h of admission	696 (8.8)	93 (11.9)	603 (8.5)	1277 (5.7)	304 (12.7)	973 (4.8)
Discharged on weekend or holiday	2128 (27.0)	202 (25.8)	1926 (27.2)	4531 (20.2)	452 (18.9)	4079 (20.3)
Medical admission	7615 (96.7)	754 (96.3)	6861 (96.7)	21 774 (96.9)	2279 (95.4)	19 495 (97.1)
Surgical admission	260 (3.3)	29 (3.7)	231 (3.3)	687 (3.1)	111 (4.6)	576 (2.9)
ICU admission	1055 (13.4)	57 (7.3)	998 (14.1)	3487 (15.5)	244 (10.2)	3243 (16.2)
ICU hours among those with an ICU stay, median (Q1–Q3)	134 (75–219)	101 (46–205)	136 (76–220)	120 (65–209)	99 (44–215)	121 (66–208)
Teaching hospital	1316 (16.7)	136 (17.4)	1180 (16.6)	4671 (20.8)	542 (22.7)	4129 (20.6)
Length of stay, mean ± SD	8.1 ± 6.2	8.5 ± 6.9	8.0 ± 6.1	8.6 ± 6.7	9.4 ± 7.6	8.5 ± 6.6
Discharge disposition						
Home without home care	6683 (84.9)	542 (69.2)	6141 (86.6)	14 107 (62.8)	993 (41.5)	13 114 (65.3)
Home with home care	671 (8.5)	141 (18.0)	530 (7.5)	6470 (28.8)	1065 (44.6)	5405 (26.9)
Long-term care or skilled nursing facility	521 (6.6)	100 (12.8)	421 (5.9)	1884 (8.4)	332 (13.9)	1552 (7.7)
LACE score, mean ± SD	9.2 ± 2.9	10.2 ± 3.5	9.1 ± 2.8	8.6 ± 2.7	9.7 ± 3.3	8.4 ± 2.6

Note: ICU = intensive care unit; LACE = length of stay, acuity, Charlson Comorbidity Index and number of emergency department visits in previous 6 months; SD = standard deviation.
*Unless indicated otherwise.

90 days as at 30 days (Table 3). Although length of stay was significantly associated with postdischarge events (whereby a length of stay ≥ 6 d was associated with slightly lower postdischarge event rates), the association was strongest for the 7-day postdischarge period rather than 30 or 90 days. The c-statistics varied from 0.72 for 7-day outcome prediction to 0.76 for 90-day outcomes.

Of the 5845 patients in both provinces excluded from the primary analysis because their index length of stay was more than 30 days, 4510 (77.2%) were discharged alive. Among those discharged alive, 579 (12.8%) were readmitted or died within 30 days, 1013 (22.5%) were readmitted or died within 90 days and 234 (5.2%) were readmitted or died within 7 days. Another 375 (8.3%) had an ED visit without hospital admission within 30 days, compared with 756 (16.8%) within 90 days and 41 (3.3%) within 7 days of discharge.

Interpretation

Our finding that age, comorbidity profiles, living situation and previous health care use are significant predictors of postdischarge outcomes for patients surviving a hospital admission for COVID-19 in Canada is consistent with preliminary data from 1 health maintenance organization[11] in the United States. It is also consistent with previous work on readmission risk factors after nonobstetric, nonpsychiatric hospitalizations in the pre-COVID-19 era.[16,21,25] However, we found that, although in-hospital death was more likely and lengths of hospital stays were longer with SARS-CoV-2 than historical norms for other respiratory tract infections,[28–30] postdischarge event rates were similar after admissions for COVID-19 as with other medical causes of hospital admission before the pandemic in both provinces.[23,25,29–32] This mirrors data from England where the median length of stay for COVID-19 was 7 days (compared with 8 d in our study) and the risk of 6-month readmission or death was similar for hospital admission for COVID-19 in 2020 as it was for admissions for influenza in 2017–2019 (34.8% v. 37.8%, adjusted hazard ratio 0.95, 95% confidence interval [CI] 0.91–0.98).[12] Although outcome rates were similar in Alberta and Ontario, the discrimination performance of the LACE score for postdischarge readmission or death[23] was suboptimal in our study population; including sex, discharge locale and socioeconomic status in the model improved prediction performance (akin to previous studies of the LACE+ model).[25]

Table 3: Multivariable predictors of postdischarge readmission or death after a hospital admission for COVID-19 in Alberta and Ontario

Variable	Readmission or death within 30 days			Readmission or death within 7 days	Readmission or death within 90 days
	Ontario Adjusted OR* (95% CI)	Alberta Adjusted OR* (95% CI)	Pooled Adjusted OR* (95% CI)	Pooled Adjusted OR* (95% CI)	Pooled Adjusted OR* (95% CI)
Age, per yr	1.03 (1.02–1.03)	1.02 (1.01–1.03)	1.03 (1.02–1.04)	1.02 (1.02–1.03)	1.02 (1.00–1.04)
Male sex	1.18 (1.08–1.30)	1.24 (1.06–1.45)	1.20 (1.10–1.29)	1.33 (1.20–1.48)	1.16 (1.08–1.25)
Rural resident	1.15 (0.91–1.45)	1.02 (0.83–1.26)	1.08 (0.92–1.26)	1.05 (0.85–1.29)	1.03 (0.90–1.19)
Deprivation index quintile					
1 (least deprived)	0.96 (0.83–1.12)	0.87 (0.65–1.17)	0.94 (0.82–1.08)	0.77 (0.64–0.92)	0.90 (0.79–1.02)
2	1.03 (0.89–1.19)	1.03 (0.80–1.34)	1.03 (0.91–1.17)	1.00 (0.85–1.18)	0.99 (0.88–1.11)
3	1.02 (0.89–1.18)	0.95 (0.73–1.23)	1.00 (0.89–1.14)	0.95 (0.78–1.16)	0.97 (0.86–1.08)
4	0.96 (0.84–1.11)	0.91 (0.72–1.16)	0.95 (0.84–1.07)	1.00 (0.78–1.28)	0.97 (0.87–1.08)
5 (most deprived)	Ref.	Ref.	Ref.	Ref.	Ref.
Charlson Comorbidity Index score, per score point	1.12 (1.08–1.16)	1.11 (1.07–1.16)	1.12 (1.09–1.15)	1.08 (1.04–1.12)	1.16 (1.13–1.19)
No. of nonelective hospital admissions in previous 12 mo, per admission	1.21 (1.14–1.28)	1.24 (1.16–1.32)	1.22 (1.17–1.28)	1.16 (1.09–1.23)	1.35 (1.30–1.42)
No. of ED visits in previous 6 mo, per visit	1.06 (1.03–1.09)	1.07 (1.04–1.10)	1.07 (1.04–1.09)	1.03 (0.99–1.07)	1.09 (1.08–1.11)
Length of stay ≥ 6 d	0.67 (0.61–0.75)	0.78 (0.66–0.92)	0.71 (0.62–0.82)	0.48 (0.42–0.54)	0.80 (0.69–0.92)
ICU admission	0.77 (0.66–0.91)	0.71 (0.52–0.95)	0.76 (0.66–0.87)	0.71 (0.58–0.86)	0.71 (0.54–0.94)
Index discharge disposition					
Home without home care	Ref.	Ref.	Ref.	Ref.	Ref.
Home with home care	1.88 (1.68–2.09)	1.85 (1.46–2.35)	1.87 (1.70–2.07)	1.87 (1.64–2.12)	2.03 (1.69–2.44)
Long-term care or skilled nursing facility	1.53 (1.20–1.95)	1.60 (1.23–2.08)	1.56 (1.31–1.87)	1.53 (1.20–1.94)	1.81 (1.55–2.12)
Discharged on weekend or holiday	1.03 (0.91–1.16)	0.93 (0.78–1.10)	1.00 (0.90–1.10)	1.13 (1.00–1.28)	0.96 (0.88–1.05)
Teaching hospital	1.09 (0.93–1.29)	1.06 (0.81–1.39)	1.08 (0.94–1.24)	1.12 (0.94–1.33)	1.07 (0.95–1.21)
SARS-CoV-2 strain					
Wild type, original strain	Ref.	Ref.	Ref.	Ref.	Ref.
Alpha VOC	0.89 (0.79–1.00)	0.94 (0.73–1.20)	0.90 (0.81–1.00)	0.84 (0.67–1.06)	0.84 (0.76–0.93)
Delta VOC	0.95 (0.73–1.25)	1.19 (0.93–1.51)	1.07 (0.86–1.34)	1.15 (0.92–1.44)	0.89 (0.72–1.10)
Oter VOC	0.91 (0.74–1.13)	0.55 (0.26–1.13)	0.80 (0.53–1.23)	0.96 (0.75–1.24)	0.81 (0.61–1.07)
Untested or indeterminate	1.01 (0.89–1.14)	1.24 (1.02–1.52)	1.10 (0.90–1.34)	0.95 (0.83–1.09)	1.14 (1.03–1.26)
Vaccination status					
Fully vaccinated	1.08 (0.77–1.51)	1.26 (0.90–1.77)	1.17 (0.92–1.48)	0.95 (0.69–1.31)	1.44 (1.16–1.77)
Partially vaccinated	2.54 (2.09–3.09)	0.97 (0.69–1.37)	1.59 (0.62–4.07)	1.32 (0.51–3.46)	1.84 (0.66–5.15)
Unvaccinated	Ref.	Ref.	Ref.	Ref.	Ref.
C-statistic†	0.727	0.726	0.727 in Ontario 0.726 in Alberta	0.719 in Ontario 0.714 in Alberta	0.754 in Ontario 0.760 in Alberta

Note: CI = confidence interval, ED = emergency department, ICU = intensive care unit, OR = odds ratio, Ref. = reference, VOC = variant of concern.
*Unless indicated otherwise.
†The c-statistic is a measure of a model's discrimination and indicates the probability that a randomly selected individual who had the outcome (postdischarge readmission or death after a COVID-19 hospitalization) had a higher predicted risk (determined from the model) of the outcome than an individual who did not have the outcome.

Although vaccination did not appear to be associated with lower risk of poorer outcomes after discharge in this study, this likely reflects the effects of confounding by indication and selection bias rather than any lack of vaccine effectiveness. In both provinces, initial vaccine roll-out prioritized very high-risk individuals (such as older adults living in long-term care settings, adults with organ transplants or adults actively using immunosuppressants or chemotherapy), and although we adjusted for measured covariables, we could not adjust for unmeasured factors or confounding by indication for vaccination.[33] In addition, selection bias in our sample would influence our observed associations; high-risk, unvaccinated patients were more likely to die in hospital and therefore would have been excluded, while high-risk, vaccinated individuals were more likely to survive and thus potentially contribute events to our analyses. Thus, our study reports postdischarge outcomes for lower-risk, unvaccinated patients and higher-risk, vaccinated patients. One indicator of vaccine effectiveness is our finding that, of all the patients admitted with COVID-19 in both provinces, 91% in Alberta and 95% in Ontario were unvaccinated. In earlier work evaluating outcomes during the first 3 waves of the COVID-19 pandemic in Alberta and Ontario, we showed that vaccination improved outcomes in both provinces (pooled adjusted odds ratio [OR] 0.41 [95% CI 0.32–0.53] for death and 0.22 [95% CI 0.18–0.26) for hospital admission).[34]

Limitations

We acknowledge that our outcome data do not capture the full burden of "long COVID"[14,17] that did not result in hospital readmission. Given the retrospective design of our study, bias from unknown confounders is always possible. We were unable to account for the heterogeneity in management practices between hospitals and clinicians over the course of the pandemic as evidence on efficacious therapies accumulated and were increasingly used.[35] Although surges in inpatient COVID-19 caseloads appear to be associated with poorer patient outcomes,[36,37] we were unable to adjust for individual hospital caseloads. We relied on administrative data to define comorbidities and lack the clinical details needed to fully delineate illness severity. Although we acknowledge this weakness, we used validated ICD-10 codes and case definition algorithms to build comorbidity profiles, and the outcomes we evaluated (all-cause readmission and death) are relevant regardless of clinical status. Outpatient visits after discharge, particularly with familiar physicians, are known to reduce readmissions,[38,39] but we do not have any data on follow-up frequency after discharge. Although we excluded a large number of hospital admissions with "atypical" flags, as designated by CIHI independently of our study, this was an a priori decision based on current best practices for evaluating postdischarge outcomes,[19] and we did conduct a sensitivity analysis to explore event rates in those with prolonged index admissions. We had no data on distance from patient home to hospital, nor factors such as homelessness or substance use that may have influenced outcomes. Finally, given the lack of a uniform definition, we were unable to distinguish between patients being admitted "with" COVID-19 from those being admitted specifically "for" COVID-19 (i.e., with viral pneumonia or other direct manifestations of SARS-CoV-2 infection).

Conclusion

Despite fears of high rates of readmission after COVID-19 hospitalizations, we found that outcomes in the 30 days after discharge were consistent with admissions for other medical diagnoses. Thus, current system approaches to transitioning patients from hospital to home do not appear to need adjustment. However, future research should determine other system effects for COVID-19 survivors, particularly with respect to postacute COVID-19 symptomatology. During the 2020 and 2021 pandemic, risk prediction equations such as the widely used LACE score were less useful for risk stratification of COVID-19 survivors at discharge. We suggest that models comparing postdischarge outcomes of COVID-19 survivors among hospitals include sex, socioeconomic status and discharge locale as well as the LACE variables.

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Data sharing: To comply with each province's *Health Information Protection Act*, the data set used for this study cannot be made publicly available. The data set from this study is held securely in coded form within the Alberta Strategy for Patient-Oriented Research Support Unit (AbSPORU) Data Platform (Alberta data) and at ICES (Ontario data). Although legal data sharing agreements between ICES, AbSPORU and data providers (e.g., health care organizations and government) prohibit ICES or AbSPORU from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at www.ices.on.ca/DAS (email das@ices.on.ca) for the Ontario data and www.absporu.ca (email absporu@albertainnovates.ca) for the Alberta data. The full data set 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 or AbSPORU.

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