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Research

Long-term health care use and diagnosis after hospitalization for COVID-19: a retrospective matched cohort study

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Abstract

Background: Knowledge pertaining to the health and health care utilization of patients after recovery from acute COVID-19 is limited. We sought to assess the frequency of new diagnoses of disease and health care use after hospitalization with COVID-19.

Methods: We included all patients hospitalized with COVID-19 in Alberta between Mar. 5 and Dec. 31, 2020. Additionally, 2 matched controls (SARS-CoV-2 negative) per case were included and followed up until Apr. 30, 2021. New diagnoses and health care use were identified from linked administrative health data. Repeated measures were made for the periods 1–30 days, 31–60 days, 61–90 days, 91–180 days, and 180 and more days from the index date. We used multivariable regression analysis to evaluate the association of COVID-19-related hospitalization with the number of physician visits during follow-up.

Results: The study sample included 3397 cases and 6658 controls. Within the first 30 days of follow-up, the case group had 37.12% (95% confidence interval [CI] 35.44% to 38.80%) more patients with physician visits, 11.12% (95% CI 9.77% to 12.46%) more patients with emergency department visits and 2.92% (95% CI 2.08% to 3.76%) more patients with hospital admissions than the control group. New diagnoses involving multiple organ systems were more common in the case group. Regression results indicated that recovering from COVID-19-related hospitalization, admission to an intensive care unit, older age, greater number of comorbidities and more prior health care use were associated with increased physician visits.

Interpretation: Patients recovered from the acute phase of COVID-19 continued to have greater health care use up to 6 months after hospital discharge. Research is required to further explore the effect of post-COVID-19 conditions, pre-existing health conditions and health-seeking behaviours on health care use.

Post-COVID-19 conditions (also described as long COVID and late sequelae) are medical complications that persist after the acute phase of COVID-19.[1,2] These conditions include any persisting symptoms or delayed complications up to many months after the onset of acute COVID-19;[2–4] there is little consensus on the precise symptoms and duration of post-COVID-19 conditions.[1,3] Emerging research evidence provides some information about the common symptoms, prevalence, pathophysiology and risk factors of post-COVID-19 conditions.[5–8] However, research into the longer-term health consequences of COVID-19 remains in a nascent phase,[9] and more robust research is required.[10,11] Existing research consists primarily of studies without long follow-up periods[8,12–15] and/or without a control group.[16–20] Studies with a short follow-up period can miss symptoms and diseases that persist (or develop) late in the trajectory of COVID-19,[21] and studies without a control group are prohibitive for testing associations of potential factors with the long-term effects of COVID-19.[4] As the long-term health care use after COVID-19 diagnosis increases the burden to health systems, there is an urgent need for robust research to support policymakers and clinicians to plan for and meet patients' long-term health care needs.[9–11]

In this study, we evaluated the diagnoses and health care utilization, including physician and emergency department visits and hospitalization, of individuals after they recovered from acute COVID-19. We focused on the cases of COVID-19 that required hospitalization because this patient group has a higher risk of post-COVID-19 conditions.[5,7,22] By including a control group, a longer follow-up period and a pragmatic approach to capture post-COVID-19 conditions, we aimed to gain better insight into the health care usage of people who survived COVID-19-related hospitalization.

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Methods

This study is based on routinely collected, administrative health data from Alberta, Canada. All Albertans accessing publicly funded health care services are registered with the Alberta Health Care Insurance Plan (AHCIP), except for members of the Canadian Armed Forces or the Royal Canadian Mounted Police, federal penitentiary inmates and residents who have opted out of the AHCIP. Province-wide administrative data capture about 95% of all health system contacts. Therefore, the administrative health data include comprehensive and relatively complete records of the health status and health care utilization of the Alberta population (approximately 4.42 million residents in 2021).[23,24]

We employed a population-based retrospective matched cohort study design. Our sample included people with and without confirmed SARS-CoV-2 infection by use of reverse transcription polymerase chain reaction (RT-PCR) tests. Included cases were individuals admitted to hospital for COVID-19, or diagnosed with COVID-19 while in hospital, between Mar. 5 and Dec. 31, 2020. We defined recovery from acute illness as discharge from hospital, and we followed the cases until Apr. 30, 2021, re-infection with SARS-CoV-2 or death (whichever was earlier). We included all new diagnoses after discharge as potential post-COVID-19 conditions (see Data sources). Patients of any age and either sex were included as cases. Patients who died before hospital discharge were excluded. For each COVID-19 case, we matched 2 controls, randomly selected from a pool of candidates with negative RT-PCR tests, using an exact match of age group, sex and region, and a closest match on the laboratory test date within a 2-week range. The index date (i.e., beginning of follow-up) was the day after hospital discharge for each case. We assigned the index date of each case to the matched controls. This study is reported in accordance with the Reporting of Studies Conducted Using Observational Routinely-collected Data statement.[25]

Data sources

Alberta Health Services is the single health authority for Albertans and monitors COVID-19 trends using multiple data sources, including the Communicable Disease and Outbreak Management information system and Provincial Public Health Laboratory (ProvLab) database. We accessed these data and identified the cases and controls. Each person registered with the AHCIP has a 9-digit unique lifetime identifier. This identifier was the key for deterministic (i.e., exact) linkage of individuals to health care utilization data.

Data from the Physician Billing Claims, National Ambulatory Care Reporting System (NACRS) and Discharge Abstract Database (DAD) were extracted to determine health care use. The number of physician visits, emergency department or urgent care clinic visits, and hospital admissions were derived from the dates of visits (i.e., start and end of service episodes). Also extracted were up to 3 diagnoses (coded in the *International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM]) from each physician claim, 10 diagnoses from each NACRS abstract (coded in the Canadian version of the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* [ICD-10-CA]), and 25 diagnoses from each DAD abstract (ICD-10-CA). A complete list of data elements can be found in Appendix 1, available at www.cmajopen.ca/content/11/4/E706/suppl/DC1. Data from the aforementioned sources have been used in other health and health services research;[26–29] the validity of these data has been reported elsewhere.[23,30]

Outcome measures

To assess new diagnoses during follow-up, all diagnoses found in the physician visit data, emergency department or urgent care clinic data, and hospitalization data were included. Adopting a method of the Manitoba Centre for Health Policy research group,[31] we classified the physician visit diagnosis (i.e., ICD-9 codes) into 20 types of health conditions that correspond to specific organ systems or ICD-9 chapters. The ICD-10-CA diagnoses in the emergency department or urgent care clinic and hospitalization data were first converted to ICD-9 codes,[32] then mapped to the same disease classes. See Appendix 1, Table A2 for the definition of the disease classes based on ICD codes. To capture all conditions associated with postacute and chronic phases of COVID-19, we did not predefine a list of post-COVID-19 conditions.[1] Instead, we applied a controlled before–after technique. From the cases and matched controls, we examined the disease classes up to 3 years before the index date (i.e., "before") and during the entire follow-up (i.e., "after") period. New disease classes (found only in the "after" period) between the case and control groups were compared. This technique mitigates potential biases due to unmeasured confounders and contemporaneous trends (e.g., systemic changes during the pandemic period).

Health care utilization was measured at these intervals: within 30 days, 31–60 days, 61–90 days, 91–180 days, and 180 and more days from the index date. The period of 180 and more days covered from the seventh month following the index date to the end of follow-up (i.e., up to 13 mo).

Explanatory variables

The main predictor was a 3-level variable that categorized members of 3 mutually exclusive groups, that is, patients with COVID-19 who were also admitted to an intensive care unit (ICU), patients hospitalized with COVID-19 without ICU admission, and people without COVID-19. Age, sex, health zone and the Pampalon deprivation index were included as the sociodemographic variables in the models. The deprivation index was constructed using 2016 Canada Census data (the latest available data);[33] the material and social dimensions were combined into a single score.[34] Based on an updated list of Charlson Comorbidity Index conditions,[35] we assessed the list of pre-existing conditions of the individuals and calculated the Charlson Comorbidity Index. Definitions of these conditions have been published elsewhere.[36] Additionally, measures of baseline health care use were derived using data up to 12 months before the index date for number of physician visits, number of emergency department or urgent care clinic visits, and hospital

admission. Prior hospital admission was a dichotomous variable (yes/no), whereas the number of physician and emergency department or urgent care clinic visits was categorized to represent low, medium or high health care use at baseline.

Statistical analysis

We examined crude differences in the proportion of individuals with health care use; Wald χ^2 tests for matched binary data were conducted to assess statistical significance.[37] Similarly, we assessed the crude difference in the proportion of individuals with new diagnoses during the follow-up periods.

Factors associated with the frequency of physician visits during follow-up were evaluated. We focused on physician visits because previous research has indicated that post-COVID-19 conditions are primarily managed in community settings.[3] In multivariable negative binomial regression models, we included the member variable (described in Explanatory variables), age group, sex, deprivation index, Alberta Health Services geographic zone, number of comorbidities and health care use in the previous year as explanatory variables, and an offset term to account for irregularity of the number of follow-up days. For the categorical variables, we

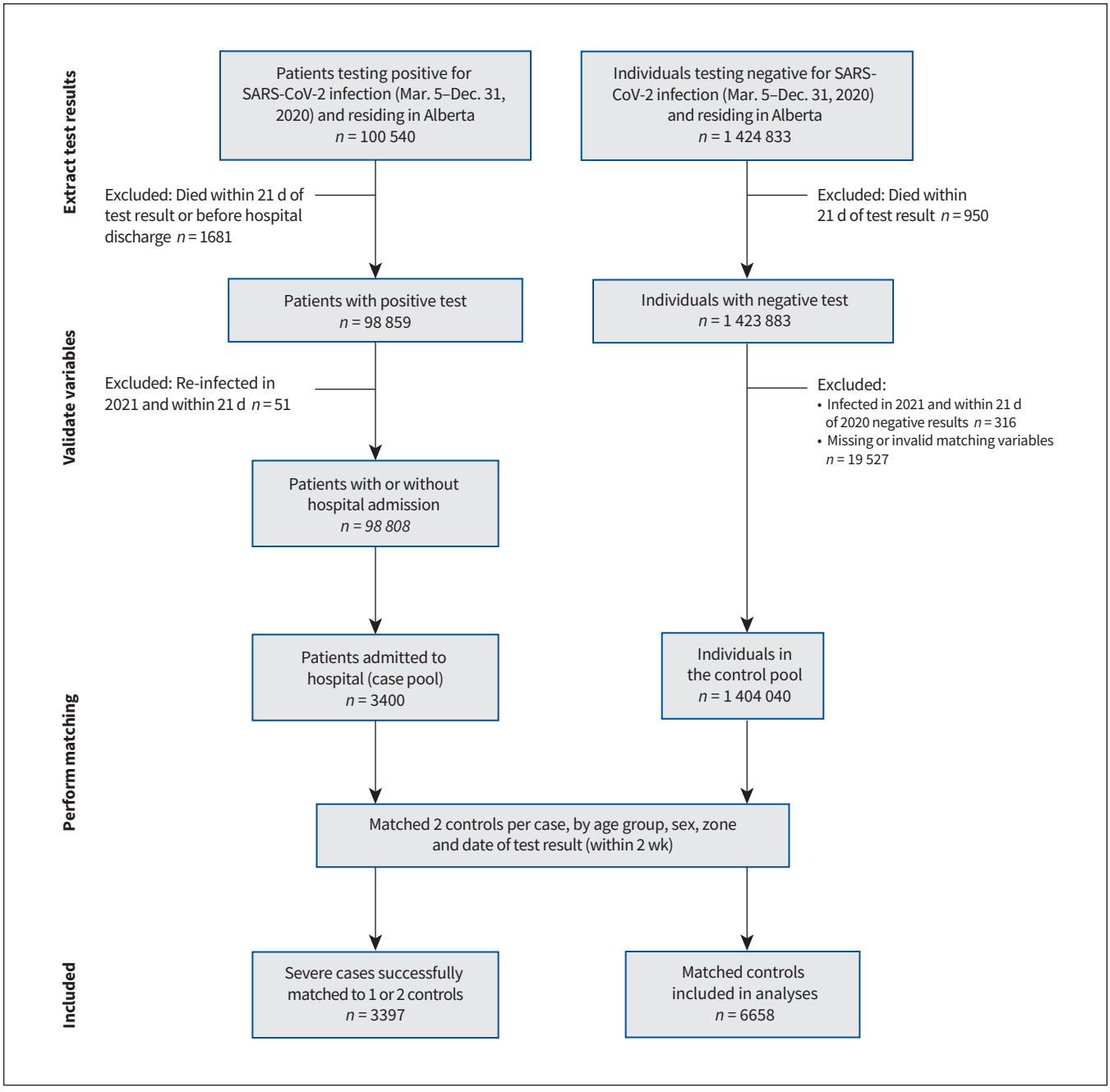

Figure 1: Flow chart of study sample (hospitalized COVID-19 cases and matched controls) inclusion and exclusion.

chose the level least likely to have a higher number of visits as the reference, guided by the literature.[18,38,39] Associations with the outcome were reported as incidence rate ratios (IRRs). All other statistical analyses were performed in SAS version 9.04 (SAS Institute Inc.).

Sensitivity analysis

Unlike a count of the comorbidities, the Charlson Comorbidity Index applies different weights to the conditions to account for their relative effects on a health outcome, such as mortality.[35] As a sensitivity analysis, we explored the robustness of our findings by substituting the Charlson Comorbidity Index for the count variable in the regression models.

Ethics approval

Ethics approvals were obtained from the Conjoint Health Research Ethics Board of Alberta (REB21-0430).

Results

The flow of inclusion and exclusion of cases and controls is illustrated in Figure 1. A total of 3400 patients with COVID-19 were admitted to hospital between March and December 2020. Among them, 3397 individuals (99.9%) were matched with 2 patients with negative SARS-CoV-2 tests. Other matching results can be found in Appendix 1, Table A3. Among patients admitted to hospital with COVID-19, 16.7% (n = 566) were admitted to the ICU. Compared with the matched controls, the cases had higher deprivation index scores, more comorbidities and more health care use, including physician visits, emergency department or urgent care clinic visits, and/or hospital admissions (Table 1). Also reported in Appendix 1 are detailed follow-up times of the cases and controls.

Table 1 (part 1 of 2): Baseline characteristics of patients with COVID-19 and hospital admission in Alberta and a matched control group selected randomly from the general population*

Characteristic	% of patients†	
	Cases (hospitalized with COVID-19) n = 3397	Matched controls (tested negative for SARS-CoV-2) n = 6658
Follow-up time, d, mean ± SD	158.27 ± 73.44	156.70 ± 75.78
Age, yr, mean ± SD	59.38 ± 20.39	58.67 ± 20.16
Age group, yr		
0–24	5.3	5.4
25–44	20.1	20.5
45–64	31.6	32.2
≥ 65	43.1	41.9
Sex		
Female	46.3	45.7
Male	53.7	54.3
Deprivation index		
1 (least deprived)	10.6	18.8
2	13.8	18.1
3	24.9	19.3
4	20.9	19.9
5 (most deprived)	29.8	23.9
Region		
Edmonton Zone	44.4	43.3
South Zone	4.8	4.9
Calgary Zone	33.5	34.2
Central Zone	9.1	9.3
North Zone	8.2	8.3
Comorbidities		
0	47.5	68.4
1	23.8	17.5
2	12.5	7.6
≥ 3	16.2	6.6

Health care utilization

The differences in the percentage of individuals with health system contacts are described in Table 2. More cases than controls had physician visits (including in-person and virtual visits; Appendix 1, Table A4), emergency department or urgent care clinic visits, and hospital admissions in each follow-up period. However, the differences between cases and controls in physician visits and emergency department or urgent care clinic visits decreased over time.

Diagnoses

Table 3 describes the differences between the case and control groups in the proportions of individuals with new diagnoses in each disease class. Compared with the controls, more new disease classes were found in the case group early in the follow-up but tended to diminish over time. These disease classes included infectious and parasitic, respiratory, circulatory, mental illness, digestive and all other conditions.

Regression results

Within 1 month from discharge, people who were hospitalized with COVID-19 had a 61% greater physician visit rate (IRR 1.61, 95% confidence interval [CI] 1.51 to 1.71; Table 4) than the controls, whereas people who were also admitted to the ICU had double (IRR 2.06, 95% CI 1.85 to 2.29) the rate of the controls. The difference among these 3 groups decreased over time.

Older age (i.e., ≥ 45 yr), more baseline comorbidities and more health care use (i.e., physician visits and/or visits to the ED or urgent care clinic) in the prior year were significantly associated with more physician visits during follow-up. The associations with physician visits appears to be consistent across the periods except for prior health care use

Table 1 (part 2 of 2): Baseline characteristics of patients with COVID-19 and hospital admission in Alberta and a matched control group selected randomly from the general population*

Characteristic	% of patients† Cases (hospitalized with COVID-19) *n* = 3397	Matched controls (tested negative for SARS-CoV-2) *n* = 6658
Pre-existing health conditions		
Myocardial infarction	6.0	3.4
Heart failure	12.2	6.6
Peripheral vascular disease	5.8	3.7
Cerebrovascular disease	9.2	5.6
Dementia	12.9	6.4
Chronic pulmonary disease	26.1	15.7
Rheumatologic disease	3.1	2.0
Peptic ulcer	2.4	1.0
Liver disease (mild)	7.1	2.8
Diabetes without chronic complication	22.1	8.0
Diabetes with chronic complication	15.7	4.8
Hemiplegia or paraplegia	2.1	0.6
Renal disease	13.1	6.4
Malignancy (any)	12.5	10.4
Liver disease (moderate or severe)	1.0	0.3
Metastatic solid tumour	2.1	1.8
AIDS/HIV	0.6	0.2
No. of physician visits (last 12 mo)		
0–4	2.6	25.5
5–9	10.9	29.8
≥ 10	86.5	44.8
ED or UCC visits (last 12 mo)		
0	49.4	73.2
1	20.0	15.9
≥ 2	30.7	11.0
Hospital admissions (last 12 mo)	25.2	7.8

Note: ED = emergency department, UCC = urgent care clinic.
*Baseline characteristics of the sample (COVID-19 patients and controls) from Mar. 5 to Dec. 31, 2020, in Alberta, Canada. Individuals in the control group were randomly drawn from the general population with negative reverse transcription polymerase chain reaction results for SARS-CoV-2 during the same period. Two controls were matched with each COVID-19 patient by age group, sex, geographic region and laboratory test date.
†Unless stated otherwise.

Table 2: Differences in health care utilization during follow-up between patients hospitalized with COVID-19 (cases) and matched controls*

Period, d	Cases, %	Controls, %	Difference (95% CI), %
Physician visits			
1–30	85.7	48.6	37.12 (35.44 to 38.80)
31–60	75.7	48.1	27.65 (25.78 to 29.51)
61–90	69.9	48.0	21.93 (19.98 to 23.88)
91–180	75.9	56.0	19.83 (17.94 to 21.72)
≥ 180	74.2	67.1	7.05 (3.65 to 10.46)
ED or UCC visits			
1–30	16.0	4.9	11.12 (9.77 to 12.46)
31–60	11.7	4.5	7.15 (5.95 to 8.36)
61–90	10.6	3.9	6.75 (5.59 to 7.90)
91–180	14.8	6.2	8.64 (7.27 to 10.02)
≥ 180	16.9	11.7	5.26 (2.02 to 8.50)
Hospital admissions			
1–30	5.4	2.5	2.92 (2.08 to 3.76)
31–60	5.3	1.8	3.52 (2.70 to 4.34)
61–90	4.5	1.5	3.00 (2.23 to 3.76)
91–180	6.3	2.1	4.23 (3.32 to 5.14)
≥ 180	7.4	5.0	2.44 (0.28 to 4.59)

Note: ED = emergency department, UCC = urgent care clinic.
*Observation periods were based on number of days since the index date. The last period (≥ 180 d) covered until the end of the follow-up. Difference in proportions were crude and not adjusted to other variables.

(Table 4). Other details of the models can be found in Appendix 1, Table A5.

Though sensitivity analysis produced similar results, both the Akaike and Bayesian information criteria (Appendix 1, Table A6) did not indicate that using Charlson Comorbidity Index in place of a count of comorbidities improved model fit.

Interpretation

Our findings show that people who had COVID-19 and were admitted to hospital continued to have significantly more health care use, including physician visits, emergency department or urgent care clinic visits, and hospital admissions after hospital discharge than people who were not diagnosed with COVID-19. They also had more new diagnoses corresponding to multiple ICD chapters and various organ systems, though the differences between hospitalized COVID-19 cases and controls with negative SARS-CoV-2 tests was mainly found within 30 days after discharge. Together, these findings provide further evidence that people who survived COVID-19-related hospitalization continue to require more health care services well after the acute phase of illness, and that post-COVID-19 conditions may involve multiple organ systems.

Even after controlling for sociodemographic characteristics, comorbidities and prior health care use, people with COVID-19-related hospitalization continued to have significantly more physician visits up to 6 months after discharge, though the increase in health care use diminished over time. Furthermore, patients with COVID-19 who were also admitted to the ICU had notably higher physician visit rates during the first 3 months after hospital discharge than those who were not admitted to the ICU.

Our findings are supported by the results of other studies that showed postacute sequelae are common among patients

Table 3: Differences in the proportion of new disease classes diagnosed during follow-up between patients hospitalized with COVID-19 (cases) and matched controls*

	Difference (95% CI), %				
Disease	Period: 1–30 d	Period: 31–60 d	Period: 61–90 d	Period: 90–180 d	Period: ≥ 180 d
Infectious and parasitic	5.76 (4.82 to 6.71)	1.38 (0.74 to 2.01)	0.87 (0.33 to 1.41)	0.71 (0.02 to 1.40)	–2.03 (–3.77 to –0.30)
All others	3.21 (2.60 to 3.81)	1.42 (1.01 to 1.82)	1.34 (0.92 to 1.76)	1.25 (0.83 to 1.66)	2.84 (1.51 to 4.16)
Respiratory	2.00 (1.41 to 2.59)	0.26 (–0.12 to 0.63)	0.19 (–0.17 to 0.55)	0.09 (–0.31 to 0.49)	–0.35 (–0.99 to 0.29)
Circulatory	1.27 (0.78 to 1.76)	0.63 (0.23 to 1.03)	0.78 (0.36 to 1.21)	0.73 (0.19 to 1.27)	–0.24 (–1.72 to 1.24)
Mental illness	1.22 (0.67 to 1.76)	0.61 (0.13 to 1.09)	0.35 (–0.09 to 0.78)	0.30 (–0.28 to 0.88)	–0.85 (–2.14 to 0.44)
Digestive	1.04 (0.53 to 1.55)	0.89 (0.43 to 1.35)	0.27 (–0.15 to 0.70)	0.25 (–0.27 to 0.76)	0.65 (–0.72 to 2.02)
Blood disorders	0.89 (0.47 to 1.31)	0.55 (0.47 to 1.31)	0.41 (0.08 to 0.74)	0.44 (0.00 to 0.87)	1.28 (0.19 to 2.36)
Ill-defined conditions	0.81 (0.32 to 1.30)	0.43 (0.02 to 0.85)	0.02 (–0.32 to 0.36)	–0.13 (–0.58 to 0.32)	–0.30 (–1.44 to 0.85)
Injury and poisoning	0.60 (0.17 to 1.04)	0.30 (–0.16 to 0.76)	–0.04 (–0.45 to 0.38)	0.25 (–0.28 to 0.77)	–0.10 (–1.42 to 1.23)
Nervous system	0.53 (0.13 to 0.93)	0.44 (0.13 to 0.93)	0.33 (–0.11 to 0.77)	0.18 (–0.35 to 0.71)	2.14 (0.66 to 3.62)
Health status and contact factors†	0.46 (0.10 to 0.82)	0.16 (–0.19 to 0.50)	–0.07 (–0.38 to 0.25)	0.14 (–0.25 to 0.52)	–0.02 (–1.10 to 1.06)
Endocrine and metabolic	0.44 (0.04 to 0.84)	0.25 (–0.16 to 0.66)	0.13 (–0.25 to 0.50)	0.84 (0.28 to 1.39)	0.04 (–1.19 to 1.27)
Skin disorders	0.29 (–0.12 to 0.70)	0.33 (–0.10 to 0.77)	0.15 (–0.26 to 0.56)	1.24 (0.63 to 1.85)	–0.37 (–1.72 to 0.98)
Genitourinary and breast	0.25 (–0.18 to 0.67)	–0.25 (–0.18 to 0.67)	–0.18 (–0.56 to 0.20)	0.40 (–0.18 to 0.98)	0.85 (–0.57 to 2.28)
Perinatal conditions	0.20 (0.01 to 0.40)	0.16 (0.00 to 0.32)	0.07 (–0.06 to 0.20)	0.19 (0.02 to 0.36)	0.20 (–0.20 to 0.60)
Cancer	–0.18 (–0.53 to 0.17)	–0.08 (–0.44 to 0.29)	0.08 (–0.32 to 0.48)	0.02 (–0.48 to 0.53)	–0.51 (–1.90 to 0.88)
Musculoskeletal	–0.17 (–0.55 to 0.21)	–0.02 (–0.10 to 0.77)	0.15 (–0.24 to 0.55)	–0.01 (–0.51 to 0.50)	0.04 (–1.13 to 1.21)
Pregnancy and birth	0.14 (–0.05 to 0.34)	–0.10 (–0.25 to 0.06)	–0.10 (–0.33 to 0.12)	–0.18 (–0.39 to 0.02)	0.07 (–0.38 to 0.51)
Congenital anomalies	0.09 (–0.07 to 0.25)	0.20 (0.01 to 0.40)	0.12 (–0.06 to 0.29)	0.28 (0.07 to 0.50)	–0.28 (–0.81 to 0.26)
External cause injury	0.02 (–0.28 to 0.32)	0.28 (–0.11 to 0.68)	0.01 (–0.30 to 0.32)	0.32 (–0.13 to 0.77)	0.25 (–0.74 to 1.25)

Note: CI = confidence interval.
*All diagnoses are grouped into the corresponding *International Classification of Diseases, 9th Revision* chapters with an additional category (all others) that captures missing and incorrect codes. Difference in proportions were crude and not adjusted to other variables.
†Factors influencing health status and contact with health services.

with COVID-19 discharged from the hospital[5,7,22] and that ICU-admitted patients may have more symptoms at 6 months after SARS-CoV-2 infection than those who were not admitted to the ICU.[40] Morin and colleagues described the respiratory, cognitive and functional symptoms at 4 months among patients hospitalized for COVID-19 in a university hospital in

Table 4 (part 1 of 2): Adjusted incidence rate ratios of physician visits by follow-up period*

Variable	Incidence rate ratio (95% CI)				
	Model 1: 1–30 d	Model 2: 31–60 d	Model 3: 61–90 d	Model 4: 90–180 d	Model 5: ≥ 180 d
Patient group					
COVID-19 (ICU admitted)	2.06 (1.85 to 2.29)	1.60 (1.43 to 1.79)	1.32 (1.17 to 1.49)	1.18 (1.05 to 1.33)	0.88 (0.70 to 1.09)
COVID-19 (hospitalized)	1.61 (1.51 to 1.71)	1.32 (1.23 to 1.41)	1.19 (1.11 to 1.28)	1.16 (1.09 to 1.24)	0.98 (0.87 to 1.11)
Controls	Ref.	Ref.	Ref.	Ref.	Ref.
Age group, yr					
≥ 65	1.52 (1.40 to 1.64)	1.48 (1.36 to 1.61)	1.59 (1.46 to 1.74)	1.60 (1.47 to 1.73)	1.42 (1.23 to 1.65)
45–64	1.21 (1.12 to 1.32)	1.15 (1.06 to 1.26)	1.22 (1.11 to 1.33)	1.25 (1.16 to 1.36)	1.10 (0.96 to 1.27)
0–24	0.98 (0.85 to 1.13)	1.07 (0.91 to 1.24)	0.92 (0.79 to 1.09)	0.95 (0.83 to 1.09)	0.66 (0.50 to 0.87)
25–44	Ref.	Ref.	Ref.	Ref.	Ref.
Sex, female	0.98 (0.93 to 1.03)	1.03 (0.97 to 1.09)	1.05 (0.99 to 1.12)	1.12 (1.06 to 1.18)	1.10 (0.99 to 1.22)
Deprivation quintile					
Lowest (most deprived)	1.04 (0.96 to 1.14)	0.98 (0.89 to 1.07)	1.12 (1.02 to 1.23)	1.09 (1.00 to 1.19)	1.17 (0.99 to 1.38)
Lower middle	1.06 (0.97 to 1.16)	0.95 (0.86 to 1.04)	1.03 (0.94 to 1.14)	1.02 (0.93 to 1.12)	1.02 (0.86 to 1.21)
Middle	1.00 (0.92 to 1.10)	0.85 (0.77 to 0.93)	0.96 (0.87 to 1.06)	0.89 (0.81 to 0.97)	1.03 (0.87 to 1.22)
Upper middle	0.99 (0.90 to 1.08)	0.87 (0.79 to 0.96)	0.91 (0.82 to 1.02)	0.99 (0.91 to 1.09)	1.00 (0.84 to 1.20)
Highest (least deprived)	Ref.	Ref.	Ref.	Ref.	Ref.
Region (zone)					
North	0.81 (0.73 to 0.90)	0.77 (0.69 to 0.87)	0.71 (0.63 to 0.80)	0.72 (0.65 to 0.80)	0.62 (0.52 to 0.76)
Central	0.89 (0.81 to 0.98)	0.94 (0.85 to 1.04)	0.92 (0.82 to 1.02)	0.90 (0.82 to 0.99)	0.85 (0.70 to 1.04)
Calgary	1.09 (1.03 to 1.16)	1.04 (0.98 to 1.11)	1.09 (1.02 to 1.16)	1.05 (0.99 to 1.12)	1.15 (1.01 to 1.31)
South	0.91 (0.80 to 1.03)	0.80 (0.70 to 0.93)	0.88 (0.76 to 1.02)	0.85 (0.75 to 0.97)	0.90 (0.75 to 1.09)
Edmonton	Ref.	Ref.	Ref.	Ref.	Ref.
Comorbidities					
≥ 3	1.86 (1.71 to 2.03)	1.82 (1.66 to 1.99)	1.85 (1.68 to 2.04)	1.82 (1.66 to 1.99)	1.98 (1.66 to 2.37)
2	1.52 (1.39 to 1.66)	1.52 (1.38 to 1.67)	1.60 (1.45 to 1.76)	1.52 (1.39 to 1.67)	1.27 (1.06 to 1.51)
1	1.17 (1.07 to 1.27)	1.17 (1.07 to 1.28)	1.22 (1.11 to 1.34)	1.17 (1.08 to 1.28)	1.27 (1.08 to 1.48)
0	Ref.	Ref.	Ref.	Ref.	Ref.

Table 4 (part 2 of 2): Adjusted incidence rate ratios of physician visits by follow-up period*

Variable	Incidence rate ratio (95% CI)				
	Model 1: 1–30 d	Model 2: 31–60 d	Model 3: 61–90 d	Model 4: 90–180 d	Model 5: ≥ 180 d
Prior visits (last 12 mo)					
≥ 10	4.74 (4.30 to 5.22)	4.32 (3.90 to 4.79)	3.74 (3.37 to 4.15)	3.45 (3.15 to 3.77)	2.58 (2.17 to 3.07)
5–9	1.95 (1.76 to 2.17)	1.73 (1.55 to 1.94)	1.77 (1.58 to 1.98)	1.66 (1.51 to 1.83)	1.62 (1.36 to 1.94)
0–4	Ref.	Ref.	Ref.	Ref.	Ref.
ED or UCC visits (last 12 mo)					
≥ 2	1.36 (1.25 to 1.47)	1.47 (1.35 to 1.60)	1.49 (1.36 to 1.63)	1.48 (1.36 to 1.61)	1.19 (1.02 to 1.38)
1	1.10 (1.02 to 1.18)	1.14 (1.06 to 1.24)	1.13 (1.04 to 1.22)	1.12 (1.04 to 1.21)	0.95 (0.83 to 1.09)
0	Ref.	Ref.	Ref.	Ref.	Ref.
Hospital admission (last 12 mo)	0.97 (0.89 to 1.05)	0.98 (0.90 to 1.08)	1.00 (0.91 to 1.10)	1.05 (0.96 to 1.15)	1.41 (1.20 to 1.65)

Note: CI = confidence interval, ED = emergency department, ICU = intensive care unit, Ref. = reference category, UCC = urgent care clinic.
*The table presents the incidence rate ratios from negative binomial regression analyses for the number of physician visits of the individuals in each of the 5 follow-up periods. Model covariates included age group, sex, deprivation index, zone, comorbidity count categories and physician visits, ED or UCC visits, and hospital admission (Y/N) in the prior year. Model intercept, coefficients and model-fit statistics are reported in Appendix 1, Table A5 (available at www.cmajopen.ca/content/11/4/E706/suppl/DC1).

France; 51% of the patients had at least 1 new-onset symptom at follow-up.[41] Munblit and colleagues studied the consequences of COVID-19 in hospitalized adults in Moscow, Russia, 6–8 months after discharge.[19] They found that the most common persistent symptom categories were chronic fatigue (25%), respiratory (17%), neurologic (15%), mood and behaviour changes (11%) and dermatologic symptoms (7.9%).[19] Consistent with these findings, our results also suggest that a significant proportion of hospitalized patients with COVID-19 have sequelae after recovering from the acute stage of the disease, and that these conditions involve multiple organ systems. Additionally, our finding that shows a decrease in additional use of health care by people who had COVID-19 and were hospitalized across the observation periods is consistent with the findings of previous studies that used repeated measures and showed that post-COVID-19 conditions decreased with time.[38,42]

This study employed a large population-based cohort, included a matched comparison group, controlled for pre-existing conditions, prior health care use and sociodemographic factors, and made multiple measures for more than 180 days. Our findings provide detailed information on health care use and factors affecting health care use in both the post-acute and chronic phases of COVID-19 in people who were admitted to hospital.

Future studies should explore any unmet health care needs in people who had COVID-19 and the underlying reasons, such as accessibility factors and health care–seeking behaviours, to assess the differences in health care use between patient groups.

Limitations

There are several limitations in this observational study and the findings must be interpreted cautiously. Health care use may or may not represent health care need, and not all patients who report post-COVID-19 conditions seek medical care.[18,43] Hence, without directly assessing the excess in health care need, we might have underestimated unbiased associations with COVID-19-related hospital admission. We noted that the case and control groups were quite heterogeneous and may have used health care in different amounts for different reasons. At baseline, the cases had greater material and social deprivation and had more comorbidities and more health system contacts compared with the controls. Despite controlling for some health and sociodemographic variables in the models, residual confounding and unmeasured heterogeneity of the patients are possible, and COVID-19 may not be the sole cause of the differences observed between the groups during follow-up. Our results may not be generalizable to people who had COVID-19 but were not hospitalized.[8] Because our cases included both people hospitalized for COVID-19 and with COVID-19, results should be interpreted with care. Nevertheless, no report has indicated that either group is more likely than the other to develop COVID-19-related long-term health consequences.

Conclusion

COVID-19 has had major impacts on the health of individuals and on health care systems. Our findings contribute to characterizing this burden through an examination of health care use of people surviving COVID-19 who were admitted to hospital in Alberta, which we found to remain elevated up to 6 months

after hospital discharge. Admission to the ICU, older age, more comorbidities, and prior physician visits and emergency department or urgent care clinic visits were associated with significantly increased physician visits during follow-up.

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