cmajOPEN

Research

Hospital admission from the emergency department for selected emergent diagnoses during the first year of the COVID-19 pandemic in Ontario: a retrospective population-based study

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Abstract

Background: Avoidance of care during the pandemic may have contributed to delays in care, and as a result, worse patient outcomes. We evaluated markers of illness acuity on presentation to the emergency department among patients with non-COVID-19–related emergent diagnoses and associated outcomes.

Methods: We conducted a retrospective study using linked administrative data from Ontario. We selected 4 emergent diagnoses, namely appendicitis, ectopic pregnancy, renal failure and diabetic ketoacidosis. We used the nonemergent diagnosis of cellulitis as a control. Our primary outcome of interest was hospital admission. Secondary outcomes were ambulance arrival, surgical intervention, subsequent hospital admission within 30 days of discharge from the emergency department or hospital and 30-day mortality. We compared outcomes during the first year of the COVID-19 pandemic (Mar. 15–Dec. 31, 2020) with a control period (Mar. 15–Dec. 31, 2018, and Mar. 15–Dec. 31, 2019).

Results: Emergency department visits for all conditions initially decreased during the pandemic. During this period, patients across all study diagnoses were more likely to arrive to the emergency department via ambulance. Patients with an ectopic pregnancy had higher odds of surgery in the pandemic period (odds ratio [OR] 1.27, 95% confidence interval [CI] 1.04–1.55) but this was not observed among patients with appendicitis. Patients with renal failure had increased odds of hospital admission (OR 1.14, 95% CI 1.04–1.24) and 30-day mortality (OR 1.17, 95% CI 1.04–1.31) during the pandemic period.

Interpretation: The pandemic period was associated with increased arrival to the emergency department via ambulance across all study diagnoses. Although patients with renal failure had increased hospital admission and death, and patients with ectopic pregnancy had an increased risk of surgery, there were no differences in outcomes for other populations, suggesting the health care system was able to care for these patients effectively.

On Mar. 11, 2020, the World Health Organization declared COVID-19 a global pandemic.[1] Although the direct health consequences of COVID-19 are being heavily researched, the indirect effects of the pandemic have not been well explored. At the beginning of the COVID-19 pandemic, emergency department volumes across Canada decreased by up to 50%.[2–4] Delays or avoidance of the emergency department for acute, emergent medical conditions could result in detrimental effects downstream, including patient morbidity and death. For instance, before the pandemic, patients with acute coronary syndrome and stroke with delays to definitive care had worse outcomes compared with those who did not.[5,6]

For patients with emergent conditions, there are relatively few alternative care options other than the emergency department. During the COVID-19 pandemic, studies reported reduced rates of in-person physician visits, and increased uptake of virtual care options such as video or telephone care.[7,8] However, virtual care may not be ideal for emergent conditions as physicians are unable to physically examine a patient and may not be able to arrange same-day bloodwork or imaging. Therefore, although virtual care may be sufficient for many conditions, such care may still result in delays to definitive care for certain

Competing interests: Keerat Grewal reports research funding from the Canadian Institutes of Health Research and the Canadian Association of Emergency Physicians. Bjug Borgundvaag sits on the board of directors with Stella's Place. No other competing interests were declared.

This article has been peer reviewed.

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***CMAJ Open* 2023 October 24. DOI:10.9778/cmajo.20230017**

time-sensitive, emergent conditions, even if arranged in a timely way. As such, avoidance virtual care, or of care altogether, for emergent conditions may contribute to delays in care, and as a result, worse patient outcomes. Therefore, the primary objective of this study was to use population-level data from a publicly funded health care system to a evaluate a marker or patient acuity on presentation, namely hospital admission from the emergency department, among patients with 4 emergent, non-COVID-19–related surgical and medical diagnoses during the first year of the pandemic, compared with a historical control period. Secondary objectives were to evaluate other markers of patient acuity, such as arrival by ambulance, and associated outcomes (surgery, hospital admissions within 30 days of emergency department or hospital discharge and 30-day mortality).

Methods

Study design and setting

We conducted a retrospective cohort study of population-based health data from 2018 to 2020 in Ontario, Canada. We obtained patient information from province-wide administrative health databases held at ICES. We compared data from the first year of the COVID-19 pandemic (Mar. 15–Dec. 31, 2020) to a historical control period, which was the same time period in 2018 and 2019 (Mar. 15–Dec. 31, 2018, and Mar. 15–Dec. 31, 2019). The pandemic timeline explored in this study coincided with waves 1 and 2 of the pandemic in Ontario, before the emergence of variants of concern.

Data sources

We obtained information regarding emergency department visits from the Canadian Institute for Health Information (CIHI) National Ambulatory Care Reporting System (NACRS). We obtained information on acute care hospital admissions and inpatient surgical procedures from CIHI's Discharge Abstract Database. We used the Ontario Mental Health Reporting System to identify hospital episodes of care for mental health. The Ontario Health Insurance Plan (OHIP) database contains physician billings for medically necessary care. We used the Same Day Surgery database to identify surgery and other procedures. The Registered Persons Database contains information on deaths among Ontario residents, including out-of-hospital deaths. We used the Ontario Laboratory Information System to identify patients who tested positive for COVID-19. We also used these databases to obtain demographics and comorbidities. Patients were linked to the databases using unique encoded identifiers and data were analyzed at ICES. Appendix 1, eMethods (available at www.cmajopen.ca/content/11/5/E969/suppl/DC1) provides further description of databases.

Study participants

Using NACRS, we identified patients aged 18 years and older with a valid OHIP number who were seen in an emergency department with one of 4 preselected, time-sensitive (emergent) diagnoses (appendicitis, ectopic pregnancy, renal failure or hyperkalemia and diabetic ketoacidosis) during the first year of the pandemic (Mar. 15–Dec. 31, 2020). We chose these conditions a priori because they are time-sensitive diagnoses (with potentially severe outcomes if missed) that were not expected to change substantially in prevalence during the pandemic. Furthermore, the impact of the pandemic on these conditions has not been well explored compared with diagnoses such as stroke and acute myocardial infarction.[9–11] Some patients with these emergent diagnoses may be managed as outpatients (e.g., appendicitis with outpatient antibiotics, nonruptured ectopic pregnancy with misoprostol) if they meet certain clinical criteria, including earlier presentation for care. We included a fifth diagnosis, cellulitis, as a control condition, as it is typically not emergent and can be managed in an outpatient setting with oral antibiotics if the patient is systemically well. We identified diagnoses using the emergency department discharge diagnosis in NACRS, which uses the 10th version of the *International Statistical Classification of Diseases and Related Health Problems* (ICD-10) codes (Appendix 1, eMethods). We included only the first emergency department visit for each diagnosis during the study period. We excluded patients who left the emergency department without being seen or who left against medical advice.

Outcome variables

The primary outcome was hospital admission from the emergency department. If a greater proportion of patients presenting with the emergent diagnosis in question were admitted to hospital, we considered that a marker of higher acuity and severity on emergency department presentation. Secondary outcomes of interest included arrival to the emergency department by ambulance, surgical intervention (for appendicitis and ectopic pregnancy), hospital admissions within 30 days of emergency department or hospital discharge and 30-day mortality.

Exposure variables

The main exposure variable was the time period in which the emergency department visit occurred, either during the first year of the pandemic (Mar. 15–Dec. 31, 2020) or a historical control period, which was the same time period in 2018 and 2019 (Mar. 15–Dec. 31, 2018, and Mar. 15–Dec. 31, 2019).

Covariates

We chose the covariates for the statistical models a priori, including demographics (age, sex, rural residence and income quintile), comorbidities (Johns Hopkins ACG System Adjusted Diagnostic Group [ADG] score, asthma, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, cancer, diabetes, hypertension stroke, liver failure and renal failure) and emergency department characteristics (day of emergency department visit, time of emergency department visit and hospital type, including academic, community small and pediatric hospitals). We treated each comorbidity as a separate variable (Appendix 1, eMethods).

Data analysis

We evaluated the frequency of emergency department visits during the study time periods. We graphically plotted monthly emergency department visits for each diagnosis from 2018 to 2020. We then used standardized differences to compare

patient characteristics within each diagnostic group between those seen during the pandemic period and those seen during the control period. We used a cut-off for standardized differences of less than 0.10 to indicate that patients in the 2 time periods were similar.[11] We used multivariable logistic regression models to evaluate the adjusted associations of the covariates with hospital admission, ambulance arrival, surgery and 30-day mortality. We created these models for each diagnostic group (i.e., the diagnostic conditions were examined individually in relation to outcomes), and calculated odds ratios (ORs) with 95% confidence intervals (CIs). We used Cox proportional hazards models to estimate hazard ratios (HRs) and 95% CIs of first repeat hospital admission within 30-day of emergency department or hospital discharge by diagnostic group, with censoring for death or at 30 days. By censoring for the competing risk of death, we estimated cause-specific HRs. We conducted analyses using SAS (version 9.3).

Ethics approval

The study was approved by the Sinai Health Research Ethics Board.

Results

There was an initial reduction in monthly emergency department visits for all 4 emergent diagnoses, and for the control diagnosis during the pandemic period relative to the control period. Figures 1 and 2 show the monthly emergency department visits

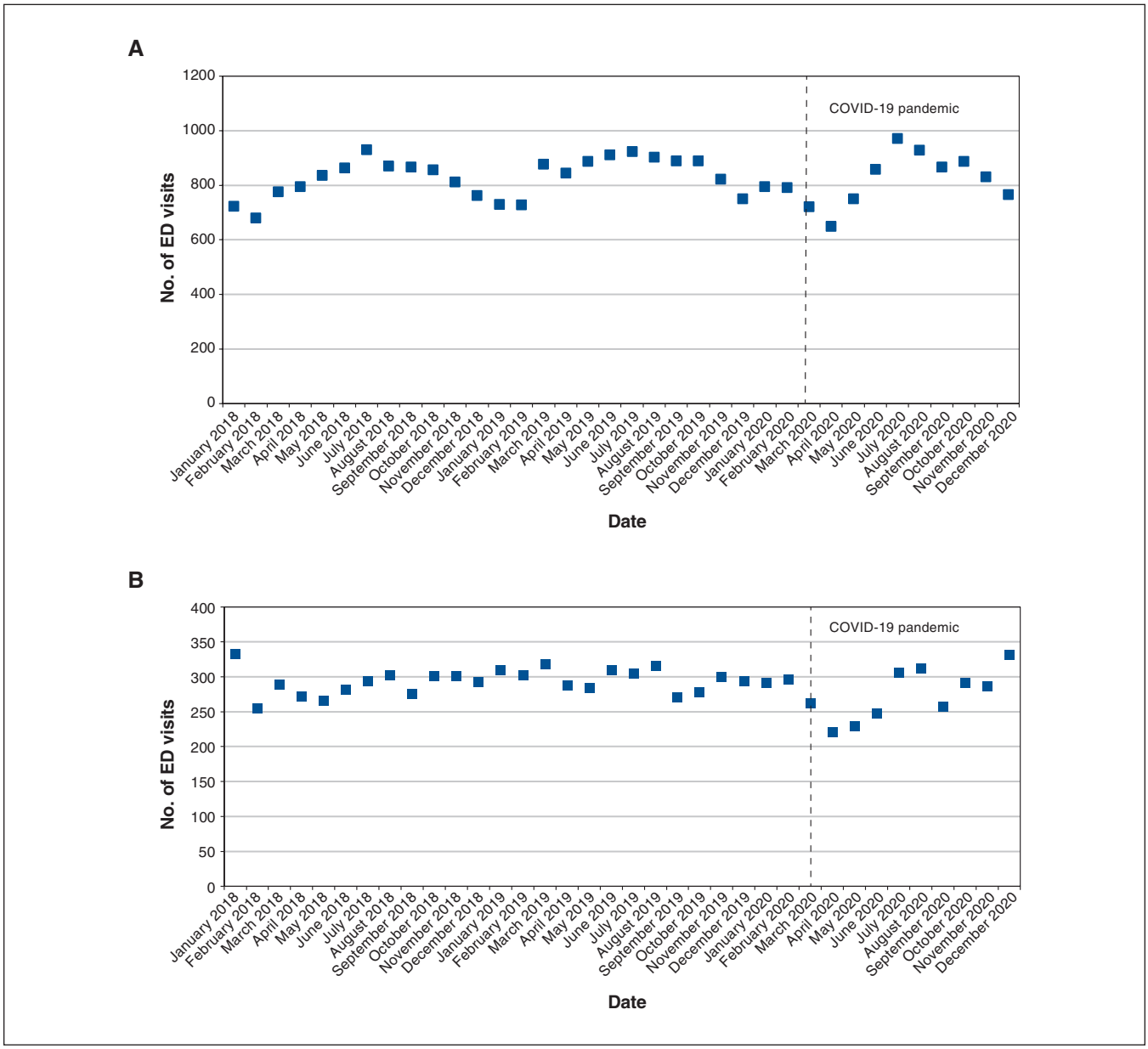

Figure 1: Monthly emergency department (ED) visits for (A) appendicitis and (B) ectopic pregnancy.

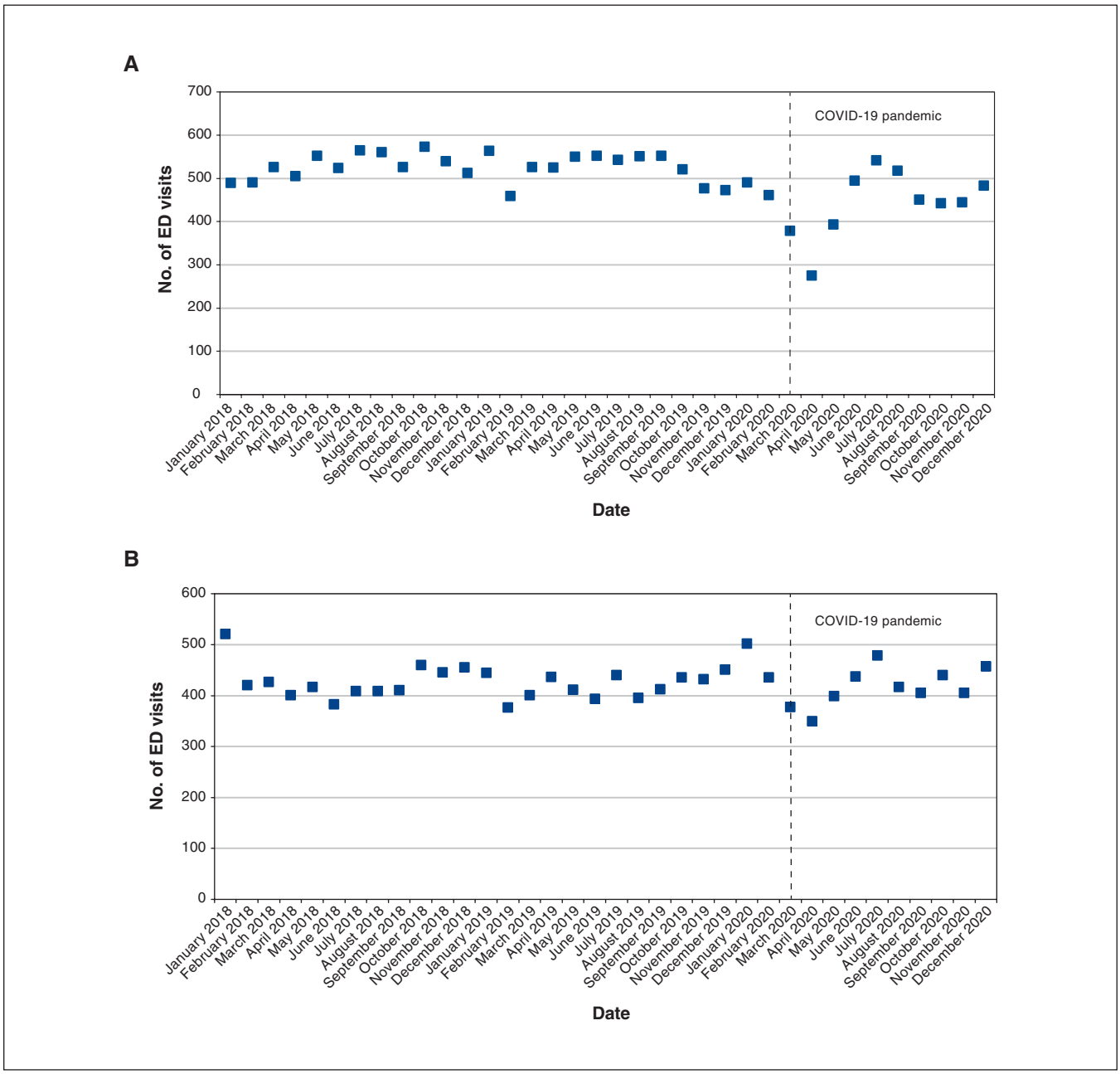

Figure 2: Monthly emergency department (ED) visits for (A) renal failure or hyperkalemia and (B) diabetic ketoacidosis.

for each emergent diagnosis, and Figure 3 shows the same for the control diagnosis. For all diagnostic groups, visits appeared to return to baseline by July 2020.

Baseline characteristics of patients with each diagnosis did not vary significantly between the control and the pandemic period (Tables 1, 2, 3, 4 and 5). The one exception was patients with diabetic ketoacidosis, where there was 1 variable with a standardized difference of 0.16 for a documented comorbidity of diabetes. This was accounted for in adjusted analyses. In adjusted analyses, across all diagnoses, patients seen in the emergency department during the pandemic study period had increased odds of arrival via ambulance compared with the control period. Table 6 shows outcomes among patients with each diagnosis.

For patients with an emergency department visit for appendicitis during the pandemic period, there was no difference in the adjusted analyses of hospital admission or surgeries performed during the pandemic study period, compared with the control period. There was a trend toward increased hospital admissions within 30 days of emergency department or hospital discharge (adjusted HR 1.13, 95% CI 1.00–1.24). There were too few deaths within 30 days in this group to analyze mortality.

For patients with an ectopic pregnancy, there was an increased odds of surgery during the pandemic compared with

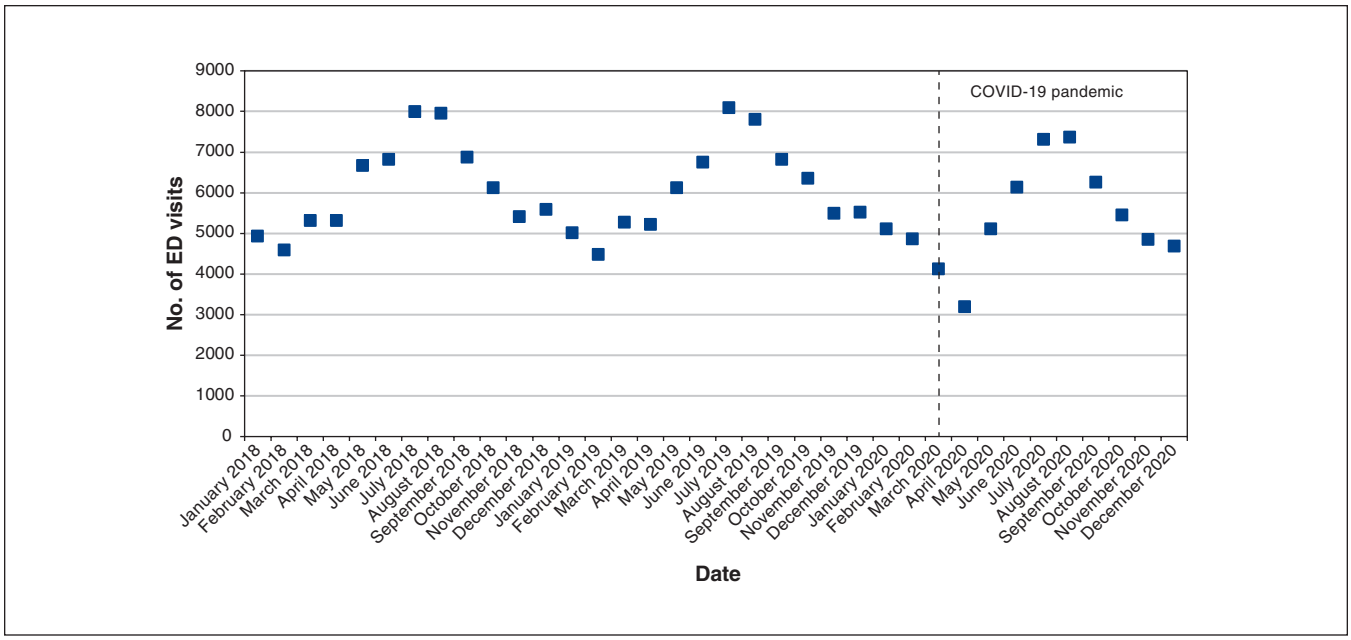

Figure 3: Monthly emergency department (ED) visits for the control condition, cellulitis.

the control period (adjusted OR 1.27, 95% CI 1.04–1.55). There were too few deaths within 30 days to analyze. There were no differences in hospital admission or admission within 30 days of discharge for these patients.

Among patients with renal failure or hyperkalemia, there was an increased odds of hospital admission on emergency department presentation (adjusted OR 1.14, 95% CI 1.04–1.24) and 30-day mortality (adjusted OR 1.17, 95% CI 1.04–1.31) during the study period compared with the control period.

For patients with diabetic ketoacidosis and cellulitis, there were no significant differences in outcomes other than arrival by ambulance.

Interpretation

In this population-based study, we found an initial reduction in the volume of emergency department visits at the start of the pandemic for all 4 of the emergent diagnoses, similar to reports of overall reduced volumes of emergency department visits globally.[2,13–17] We found that patients with renal failure had a higher association of being admitted to hospital when they presented to an emergency department during the pandemic period, but also to die within 30 days. These patients had the largest decline in emergency department volumes early on in the pandemic, which may have been associated with higher admission rates and mortality when they presented, possibly owing to delays in treatment. These patients are typically older (66% of the patients in this group were older than 65 years, in contrast to other groups) and have many frequent health care interactions per year,[18,19] which may cause them to be less quick to seek care when they encounter symptoms. In addition to desensitization, they may also have less easy access to transport to an emergency department, with fewer support systems or resources, compared with younger cohorts. Although patients with chronic kidney disease or who develop renal failure and have COVID-19 had worse outcomes early in the pandemic,[20] most patients in our study with renal failure or hyperkalemia were not positive for SARS-CoV-2; therefore, this is likely not the reason for worse outcomes in this population.

Our study also found that patients with an ectopic pregnancy were more likely to be treated surgically early on during the pandemic. This may indicate that more patients were presenting outside the window of opportunity for medical management or were at an increased risk of rupture, necessitating surgical management. Several studies have reported increased rates of ruptured ectopic pregnancy during the pandemic in other regions.[21–23] However, a study using Ontario data did not find a difference in surgical management of ectopic pregnancy during the first 15 weeks of the pandemic.[13] This observed difference may be related to the different time periods and differing inclusion criteria. Our finding of an increased risk of requiring surgery may portend increased known long-term complications from surgical procedures such as infection, bowel obstruction and adhesions; however, long-term studies are needed to accurately anticipate potential complications.

Patients with appendicitis seen during the pandemic period in our study had a trend toward increased hospital admissions within 30 days of discharge, but no change in surgical intervention at the time of presentation to the emergency department. The increase in hospital admissions after discharge could potentially reflect higher frequency of ruptured appendicitis.

Similar to our control group of patients with cellulitis, there were no significant differences in hospital admission, mortality or repeat hospital admissions during the first year of

Table 1: Patient and emergency department visit characteristics and outcomes for patients with appendicitis

Characteristic	No. (%) of patients*			Standardized difference
	Total *n* = 23 962	Pandemic period *n* = 7771	Control period *n* = 16 191	
Demographics				
Age, yr				
18–64	20 835 (87.0)	6711 (86.4)	14 124 (87.2)	0.03
≥ 65	3127 (13.0)	1060 (13.6)	2067 (12.8)	0.03
Sex				
Female	12 238 (51.1)	3944 (50.8)	8294 (51.2)	0.01
Rural				
Urban	22 460 (94.6)	7266 (94.4)	15 194 (94.6)	0.01
Rural	1293 (5.4)	430 (5.6)	863 (5.4)	0.01
Income quintile				
1 (high)	4645 (19.4)	1489 (19.2)	3156 (19.6)	0.01
2	4777 (20.0)	1513 (19.5)	3264 (20.2)	0.02
3	4647 (19.5)	1525 (19.7)	3122 (19.3)	0.01
4	4879 (20.4)	1562 (20.2)	3317 (20.6)	0.01
5 (low)	4942 (20.7)	1661 (21.4)	3281 (20.3)	0.03
Comorbidities				
ADG score				
Mean ± SD	8.75 ± 4.36	8.64 ± 4.43	8.81 ± 4.33	0.04
Median (IQR)	9 (6–12)	8 (5–12)	9 (6–12)	0.04
Coronary artery disease	957 (4.0)	316 (4.1)	641 (4.0)	0.01
Chronic obstructive pulmonary disease	1472 (6.1)	476 (6.1)	996 (6.2)	0
Congestive heart failure	407 (1.7)	135 (1.7)	272 (1.7)	0
Diabetes mellitus	2135 (8.9)	693 (8.9)	1442 (8.9)	0
Hypertension	4785 (20.0)	1517 (19.5)	3268 (20.2)	0.02
Asthma	4205 (17.5)	1334 (17.2)	2871 (17.7)	0.01
Cancer	521 (2.2)	171 (2.2)	350 (2.2)	0
Stroke	231 (1.0)	67 (0.9)	164 (1.0)	0.02
Liver failure	74 (0.3)	28 (0.4)	46 (0.3)	0.01
Renal failure	318 (1.3)	104 (1.3)	214 (1.3)	0
ED characteristics				
Weekday ED visit (Monday to Friday)	17 999 (75.1)	5818 (74.9)	12 181 (75.2)	0.01
Time of ED visit				
Day (08:00–16:59)	13 284 (55.4)	4314 (55.5)	8970 (55.4)	0
Evening (17:00–23:59)	6223 (26.0)	2057 (26.5)	4166 (25.7)	0.02
Night (00:00–07:59)	4455 (18.6)	1400 (18.0)	3055 (18.9)	0.02
Hospital type				
Community	18 084 (75.5)	5881 (75.7)	12 203 (75.4)	0.01
Small	661 (2.8)	213 (2.7)	448 (2.8)	0
Teaching	5217 (21.8)	1677 (21.6)	3540 (21.9)	0.01
Outcomes				
Ambulance arrival	2169 (9.1)	869 (11.2)	1300 (8.0)	0.11
Hospital admission	20 717 (86.5)	6745 (86.8)	13 972 (86.3)	0.01
Surgery	17 955 (86.7)	5837 (86.5)	12 118 (86.7)	0.01
Hospital admission within 30 d of discharge	1649 (6.9)	570 (7.3)	1079 (6.7)	0.03
30-d mortality	44 (0.2)	16 (0.2)	28 (0.2)	0.01

Note: ADG = adjusted diagnostic group, ED = emergency department, IQR = interquartile range, SD = standard deviation.
*Unless indicated otherwise.

Table 2: Patient and emergency department visit characteristics and outcomes for patients with ectopic pregnancy

Characteristic	No. (%) of patients*			Standardized difference
	Total *n* = 7776	Pandemic period *n* = 2490	Control period *n* = 5286	
Demographics				
Age, yr				
18–64	7776 (100.0)	2490 (100.0)	5286 (100.0)	
Sex				
Female	7776 (100.0)	2490 (100.0)	5286 (100.0)	
Rural				
Urban	7258 (94.2)	2321 (94.2)	4937 (94.1)	0
Rural	450 (5.8)	142 (5.8)	308 (5.9)	0
Income quintile				
1 (high)	1977 (25.5)	632 (25.4)	1345 (25.5)	0
2	1710 (22.0)	558 (22.4)	1152 (21.8)	0.02
3	1562 (20.1)	532 (21.4)	1030 (19.5)	0.05
4	1428 (18.4)	438 (17.6)	990 (18.7)	0.03
5 (low)	1091 (14.0)	326 (13.1)	765 (14.5)	0.04
Comorbidities				
ADG score				
Mean ± SD	9.10 ± 4.03	8.77 ± 4.05	9.25 ± 4.01	0.12
Median (IQR)	9 (6–12)	9 (6–12)	9 (7–12)	0.12
Coronary artery disease	21 (0.3)	7 (0.3)	14 (0.3)	0
Chronic obstructive pulmonary disease	17 (0.2)	7 (0.3)	10 (0.2)	0.02
Congestive heart failure	0	0	0	0
Diabetes mellitus	208 (2.7)	59 (2.4)	149 (2.8)	0.03
Hypertension	228 (2.9)	58 (2.3)	170 (3.2)	0.05
Asthma	1485 (19.1)	450 (18.1)	1035 (19.6)	0.04
Cancer	21 (0.3)	7 (0.3)	14 (0.3)	0
Stroke	7 (0.1)	≤ 5	≤ 10	0.03
Liver failure	6 (0.1)	≤ 5	≤ 5	0
Renal failure	15 (0.2)	≤ 5	≤ 15	0.04
ED characteristics				
Weekday ED visit (Monday to Friday)	6007 (77.3)	1921 (77.1)	4086 (77.3)	0
Time of ED visit				
Day (08:00–16:59)	4868 (62.6)	1604 (64.4)	3264 (61.7)	0.06
Evening (17:00–23:59)	2217 (28.5)	687 (27.6)	1530 (28.9)	0.03
Night (00:00–07:59)	691 (8.9)	199 (8.0)	492 (9.3)	0.05
Hospital type				
Community	5934 (76.3)	1919 (77.1)	4015 (76.0)	0.03
Small	237 (3.0)	89 (3.6)	148 (2.8)	0.04
Teaching	1605 (20.6)	482 (19.4)	1123 (21.2)	0.05
Outcomes				
Ambulance arrival	501 (6.4)	195 (7.8)	306 (5.8)	0.08
Hospital admission	2287 (29.4)	753 (30.2)	1534 (29.0)	0.03
Surgery	1877 (82.1)	637 (84.6)	1240 (80.8)	0.1
Hospital admission within 30 d of discharge	771 (9.9)	232 (9.3)	539 (10.2)	0.03
30-d mortality	≤ 5 (0.0)	–	–	–

Note: ADG = adjusted diagnostic group, ED = emergency department, IQR = interquartile range, SD = standard deviation.
*Unless indicated otherwise. Some cells have been suppressed to prevent back calculation of low cell volumes.

Table 3: Patient and emergency department visit characteristics and outcomes for patients with renal failure or hyperkalemia

Characteristic	No. (%) of patients*			Standardized difference
	Total *n* = 13 502	Pandemic period *n* = 3942	Control period *n* = 9560	
Demographics				
Age, yr				
18–64	4565 (33.8)	1330 (33.7)	3235 (33.8)	0
≥ 65	8937 (66.2)	2612 (66.3)	6325 (66.2)	0
Sex				
Female	6128 (45.4)	1757 (44.6)	4371 (45.7)	0.02
Rural				
Urban	11 571 (88.4)	3343 (87.5)	8228 (88.7)	0.04
Rural	1520 (11.6)	476 (12.5)	1044 (11.3)	0.04
Income quintile				
1 (high)	3923 (29.2)	1092 (27.8)	2831 (29.7)	0.04
2	2955 (22.0)	925 (23.5)	2030 (21.3)	0.05
3	2547 (18.9)	745 (19.0)	1802 (18.9)	0
4	2162 (16.1)	614 (15.6)	1548 (16.3)	0.02
5 (low)	1861 (13.8)	552 (14.1)	1309 (13.8)	0.01
Comorbidities				
ADG score				
Mean ± SD	14.22 ± 4.43	14.33 ± 4.47	14.17 ± 4.41	0.04
Median (IQR)	15 (11–17)	15 (12–18)	15 (11–17)	0.04
Coronary artery disease	4067 (30.1)	1152 (29.2)	2915 (30.5)	0.03
Chronic obstructive pulmonary disease	4136 (30.6)	1187 (30.1)	2949 (30.8)	0.02
Congestive heart failure	4671 (34.6)	1372 (34.8)	3299 (34.5)	0.01
Diabetes mellitus	8883 (65.8)	2605 (66.1)	6278 (65.7)	0.01
Hypertension	11 526 (85.4)	3340 (84.7)	8186 (85.6)	0.03
Asthma	2534 (18.8)	718 (18.2)	1816 (19.0)	0.02
Cancer	1413 (10.5)	409 (10.4)	1004 (10.5)	0
Stroke	1303 (9.7)	376 (9.5)	927 (9.7)	0.01
Liver failure	549 (4.1)	169 (4.3)	380 (4.0)	0.02
Renal failure	7250 (53.7)	2133 (54.1)	5117 (53.5)	0.01
ED characteristics				
Weekday ED visit (Monday to Friday)	10 642 (78.8)	3142 (79.7)	7500 (78.5)	0.03
Time of ED visit				
Day (08:00–16:59)	8382 (62.1)	2445 (62.0)	5937 (62.1)	0
Evening (17:00–23:59)	3818 (28.3)	1104 (28.0)	2714 (28.4)	0.01
Night (00:00–07:59)	1302 (9.6)	393 (10.0)	909 (9.5)	0.02
Hospital type				
Community	9608 (71.2)	2833 (71.9)	6775 (70.9)	0.02
Small	1022 (7.6)	319 (8.1)	703 (7.4)	0.03
Teaching	2872 (21.3)	790 (20.0)	2082 (21.8)	0.04
Outcomes				
Ambulance arrival	4343 (32.2)	1387 (35.2)	2956 (30.9)	0.09
Hospital admission	5770 (42.7)	1763 (44.7)	4007 (41.9)	0.06
Hospital admission within 30 d of discharge	2308 (17.1)	641 (16.3)	1667 (17.4)	0.03
30-day mortality	1185 (8.8)	381 (9.7)	804 (8.4)	0.04

Note: ADG = adjusted diagnostic groups, ED = emergency department, IQR = interquartile range, SD = standard deviation.
*Unless indicated otherwise.

Table 4: Patient and emergency department visit characteristics and outcomes for patients with diabetic ketoacidosis

Characteristic	No. (%) of patients*			Standardized difference
	Total *n* = 9957	Pandemic period *n* = 3376	Control period *n* = 6581	
Demographics				
Age, yr				
18–64	7668 (77.0)	2571 (76.2)	5097 (77.5)	0.03
≥ 65	2289 (23.0)	805 (23.8)	1484 (22.5)	0.03
Sex				
Female	4679 (47.0)	1505 (44.6)	3174 (48.2)	0.07
Rural				
Urban	8844 (91.2)	3010 (91.7)	5834 (90.9)	0.03
Rural	854 (8.8)	271 (8.3)	583 (9.1)	0.03
Income quintile				
1 (high)	3109 (31.4)	1061 (31.5)	2048 (31.3)	0.01
2	2216 (22.4)	777 (23.1)	1439 (22.0)	0.03
3	1780 (18.0)	588 (17.5)	1192 (18.2)	0.02
4	1567 (15.8)	528 (15.7)	1039 (15.9)	0
5 (low)	1240 (12.5)	409 (12.2)	831 (12.7)	0.02
Comorbidities				
ADG score				
Mean ± SD	11.93 ± 5.01	11.62 ± 5.07	12.08 ± 4.98	0.09
Median (IQR)	12 (8–16)	12 (8–15)	12 (9–16)	0.09
Coronary artery disease	1201 (12.1)	404 (12.0)	797 (12.1)	0
Chronic obstructive pulmonary disease	1325 (13.3)	441 (13.1)	884 (13.4)	0.01
Congestive heart failure	838 (8.4)	277 (8.2)	561 (8.5)	0.01
Diabetes mellitus	8750 (87.9)	2850 (84.4)	5900 (89.7)	0.16
Hypertension	4504 (45.2)	1525 (45.2)	2979 (45.3)	0
Asthma	2137 (21.5)	714 (21.1)	1423 (21.6)	0.01
Cancer	414 (4.2)	149 (4.4)	265 (4.0)	0.02
Stroke	460 (4.6)	163 (4.8)	297 (4.5)	0.01
Liver failure	141 (1.4)	43 (1.3)	98 (1.5)	0.02
Renal failure	1210 (12.2)	404 (12.0)	806 (12.2)	0.01
ED characteristics				
Weekday ED visit (Monday to Friday)	7225 (72.6)	2449 (72.5)	4776 (72.6)	0
Time of ED visit				
Day (08:00–16:59)	5207 (52.3)	1777 (52.6)	3430 (52.1)	0.01
Evening (17:00–23:59)	3129 (31.4)	1065 (31.5)	2064 (31.4)	0
Night (00:00–07:59)	1621 (16.3)	534 (15.8)	1087 (16.5)	0.02
Hospital type				
Community	6933 (69.6)	2370 (70.2)	4563 (69.3)	0.02
Small	630 (6.3)	209 (6.2)	421 (6.4)	0.01
Teaching	2394 (24.0)	797 (23.6)	1597 (24.3)	0.02
Outcomes				
Ambulance arrival	5126 (51.5)	1850 (54.8)	3276 (49.8)	0.1
Hospital admission	8684 (87.3)	2976 (88.2)	5718 (86.9)	0.04
Hospital admission within 30 d of discharge	1236 (12.4)	417 (12.4)	819 (12.4)	0
30-d mortality	387 (3.9)	146 (4.3)	241 (3.7)	0.03

Note: ADG = adjusted diagnostic group, ED = emergency department, IQR = interquartile range, SD = standard deviation.
*Unless indicated otherwise.

Table 5: Patient and emergency department visit characteristics and outcomes for patients with cellulitis

Characteristic	No. (%) of patients*			Standardized difference
	Total *n* = 160 788	Pandemic period *n* = 47 886	Control period *n* = 112 902	
Demographics				
Age, yr				
18–64	106 726 (66.4)	31 960 (66.7)	74 765 (66.2)	0.01
≥ 65	54 062 (33.6)	15 925 (33.3)	38 137 (33.8)	0.01
Sex				
Female	72 098 (44.8)	20 888 (43.6)	51 210 (45.4)	0.03
Rural				
Urban	133 276 (85.2)	39 637 (85.0)	93 639 (85.3)	0.01
Rural	23 124 (14.8)	6991 (15.0)	16 133 (14.7)	0.01
Income quintile				
1 (high)	41 606 (26.0)	12 563 (26.4)	29 043 (25.8)	0.01
2	33 627 (21.0)	10 101 (21.2)	23 526 (20.9)	0.01
3	30 571 (19.1)	8949 (18.8)	21 622 (19.2)	0.01
4	28 181 (17.6)	8358 (17.5)	19 823 (17.6)	0
5 (low)	26 060 (16.3)	7689 (16.1)	18 371 (16.3)	0.01
Comorbidities				
ADG score				
Mean ± SD	11.46 ± 4.83	11.47 ± 4.83	11.45 ± 4.83	0
Median (IQR)	12 (8–15)	12 (8–15)	12 (8–15)	0.01
Coronary artery disease	17 649 (11.0)	5140 (10.7)	12 509 (11.1)	0.01
Chronic obstructive pulmonary disease	29 535 (18.4)	8871 (18.5)	20 664 (18.3)	0.01
Congestive heart failure	15 741 (9.8)	4641 (9.7)	11 100 (9.8)	0
Diabetes mellitus	40 828 (25.4)	12 095 (25.3)	28 733 (25.4)	0
Hypertension	68 935 (42.9)	20 155 (42.1)	48 780 (43.2)	0.02
Asthma	33 642 (20.9)	10 332 (21.6)	23 310 (20.6)	0.02
Cancer	7304 (4.5)	2098 (4.4)	5206 (4.6)	0.01
Stroke	5131 (3.2)	1456 (3.0)	3675 (3.3)	0.01
Liver failure	2020 (1.3)	646 (1.3)	1374 (1.2)	0.01
Renal failure	9188 (5.7)	2692 (5.6)	6496 (5.8)	0.01
ED characteristics				
Weekday ED visit (Monday to Friday)	114 962 (71.5)	34 581 (72.2)	80 381 (71.2)	0.02
Time of ED visit				
Day (08:00–16:59)	95 050 (59.1)	29 088 (60.7)	65 962 (58.4)	0.05
Evening (17:00–23:59)	49 625 (30.9)	14 131 (29.5)	35 494 (31.4)	0.04
Night (00:00–07:59)	16 113 (10.0)	4667 (9.7)	11 446 (10.1)	0.01
Hospital type				
Community	–	–	–	0
Pediatric	–	–	–	
Small	–	–	–	0.01
Teaching	–	–	–	0
Outcomes				
Ambulance arrival	13 063 (8.1)	4337 (9.1)	8726 (7.7)	0.05
Hospital admission	11 851 (6.9)	3552 (7.4)	8299 (7.4)	0
Hospital admission within 30 d of discharge	9819 (6.1)	2870 (6.0)	6949 (6.2)	0.01
30-d mortality	1208 (0.8)	364 (0.8)	844 (0.7)	0

Note: ADG = adjusted diagnostic groups, ED = emergency department, IQR = interquartile range, SD = standardized difference.
*Unless indicated otherwise. Some cells suppressed to prevent back calculation.

Table 6: Patient outcomes during the pandemic period compared with control period

Outcome	Adjusted OR or HR (95% CI)*				
	Appendicitis†	Ectopic pregnancy‡	Renal failure†	Diabetic ketoacidosis†	Cellulitis†
Ambulance arrival	1.47 (1.35–1.61)	1.41 (1.16–1.71)	1.22 (1.11–1.33)	1.27 (1.17–1.38)	1.19 (1.15–1.25)
Hospital admission	0.98 (0.89–1.07)	1.06 (0.96–1.17)	1.14 (1.04–1.24)	1.11 (0.97–1.27)	1.01 (0.95–1.07)
Surgery	0.97 (0.90–1.05)	1.27 (1.04–1.55)	–	–	–
Hospital admission within 30 d of discharge	1.13 (1.00–1.24)	0.92 (0.79–1.08)	0.92 (0.84–1.00)	1.05 (0.93–1.18)	0.97 (0.93–1.01)
30-d mortality§	–	–	1.17 (1.04–1.31)	1.15 (0.91–1.46)	1.03 (0.91–1.16)

Note: CI = confidence interval, HR = hazard ratio, OR = odds ratio.
*Odds ratios were calculated for ambulance arrival, hospital admission, surgery and 30-day mortality; hazard ratios were calculated for hospital admission within 30 days of discharge from the emergency department or hospital.
†Adjusted for demographics, comorbidities and emergency department characteristics.
‡Adjusted for demographics, comorbidities and emergency department characteristics, except coronary artery disease, chronic obstructive pulmonary disease, congestive heart failure, cancer, stroke, liver failure, renal failure
§For appendicitis and ectopic pregnancy, too few outcomes overall or in 1 category to run model.

the pandemic for patients with diabetic ketoacidosis. This suggests that short-term outcomes were not affected by the reduced volumes in emergency department visits in the first few weeks of the pandemic. It is possible that there were patients with diabetic ketoacidosis who did not seek care at all and died without being included in our cohort, which would bias the cohort to a less sick population in the pandemic period, potentially minimizing differences between outcomes across study periods (i.e., conservative bias). Alternately, the results may demonstrate that the Ontario health care system was able to care for these patients in the first year of the pandemic without short-term adverse events during a time where the health care system's focus was on COVID-19 and ensuring hospital capacity to care for the subsequent influx of patients.

Many reasons have been proposed to explain the decrease in emergency department usage at the onset of the pandemic, including actual reductions in acute pathology, reduced emergency department usage and overusage of the emergency department before the pandemic.[13,24] Our study focused solely on time-sensitive emergent conditions and found smaller reductions in emergency department volumes at the beginning of the pandemic for most, compared with what has been reported in many other studies (with reports of up to 65% reductions in emergency department visits).[17] This likely reflects that patients with these emergent conditions had reduced ability to access timely, definitive treatment elsewhere, and an inability to delay treatment for long. The latter may be reflected in the higher odds of arrival by ambulance for these patients during the pandemic, which may be a marker of higher acuity and could reflect disease progression secondary to patient attempts to delay seeking care elsewhere or at an emergency department as long as possible, in hopes that the symptoms would resolve.

Given our finding that patients with renal failure had increased admissions to hospital and mortality during the early pandemic period, future studies evaluating this patient population are needed to explore why these patients had worse outcomes during the pandemic. In future pandemics, we need to ensure patients with a high baseline morbidity and risk of death have continued ease of access to timely acute medical care. Future studies also need to examine longer-term outcomes among patients presenting to the emergency department during the COVID-19 pandemic.

Limitations

We included only patients who presented to the emergency department, so we cannot draw conclusions about those who did not seek medical attention or who died at home. If a substantial proportion died at home without emergency department contact during the pandemic period, our study would have missed these patients and introduced a conservative bias to our results, as it would make the study cohort appear healthier than they were. An alternative reason for higher odds of ambulance arrival may be related to patient perceptions that if they presented to an emergency department via ambulance they may be seen faster, and potentially avoid contracting SARS-CoV-2. Some of the reductions in emergency department visits for each disease could be related to pandemic behaviours and being more cautious; this might lead to a healthier cohort in the pandemic period and, again, bias results toward the null. It is possible that physician thresholds to admit patients to hospital changed during the pandemic. However, we did not find any significant differences in hospital admissions for any of the cohorts except patients with renal failure or hyperkalemia. This finding could be related to changes in physician behaviours during the early pandemic, resulting in sicker patients not being admitted to maintain health care capacity. We did not include any measures of disease severity; therefore, we cannot comment on whether patients seen during the pandemic were presenting with more severe disease during the pandemic period. Some of our results may be overly conservative and conceal the effects of

acute care avoidance early on in the pandemic owing to reduced volumes because we looked at a longer period of time during the pandemic, over which volumes initially declined then returned to baseline. Our study used administrative data and there may be potential misclassification bias if there were coding errors; however, many of these variables have been validated, with good agreement between chart reviews and databases for mandatory variables[25] and the main diagnosis in the emergency department for various diseases.[26–28] Given that this study was retrospective, there may be residual differences between groups from unmeasured confounders between the time periods. The retrospective and observational nature of our study design means that causal inferences cannot be made based on the results of this study. We conducted multiple analyses and did not adjust for multiple comparisons; as such, there is the possibility for type I errors. Finally, given that this study was conducted in Ontario, the findings may not be generalizable to other regions or countries.

Conclusion

The pandemic period was associated with an increased odds of ambulance arrival for all diagnostic categories, along with increased hospital admissions and 30-day mortality for patients with renal failure, an increase in surgeries for patients with ectopic pregnancies and a trend toward hospital readmissions among patients with appendicitis. For other outcomes, and among patients with diabetic ketoacidosis, there were no significant differences between the pandemic and prepandemic periods, suggesting that the health care system in Ontario was able to care for many of these patients effectively during the beginning of the pandemic.

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Funding: This study received support from the Ontario Health Data Platform, a province of Ontario initiative to support Ontario's ongoing response to COVID-19 and its related impact.

Disclaimer: This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health (MOH) and the Ministry of Long-Term Care (MLTC). This document used data adapted from the Statistics Canada Postal Code^{OM} Conversion File, which is based on data licensed from Canada Post Corporation, and/or data adapted from the Ontario Ministry of Health Postal Code Conversion File, which contains data copied under license from Canada Post Corporation and Statistics Canada. Parts of this material are based on data and/or information compiled and provided by the Ontario Ministry of Health, MLTC, the Canadian Institute for Health Information (CIHI) and Ontario Health. The analyses, conclusions, opinions and statements expressed herein are solely those of the authors and do not reflect those of the funding or data sources; no endorsement is intended or should be inferred. This study was supported by the Ontario Health Data Platform (OHDP), a Province of Ontario initiative to support Ontario's ongoing response to COVID-19 and its related impacts. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by the OHDP, its partners, or the Province of Ontario is intended or should be inferred.

Data sharing: The data set from this study is held securely in coded form at ICES. Although data sharing agreements prohibit ICES from making the data set 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 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 and are therefore either inaccessible or may require modification.

Supplemental information: For reviewer comments and the original submission of this manuscript, please see www.cmajopen.ca/content/11/5/E969/suppl/DC1.