Emergency department outcomes for emergent diagnoses during the first year of the COVID-19 pandemic: A Canadian population-based study

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

Author contributions:
KG, CLA, LC, ML, SF, BB, SLM were involved in study conceptualization. KG, CLA, RS, BB, SLM were involved in creating the data analysis plan. WL conducted the analysis. All authors contributed to data interpretation. KG and SLM prepared the first draft of the manuscript and all authors edited and provided critical feedback to the final manuscript and approved the final manuscript.

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The authors report no conflicts of interest.

ABSTRACT

Background: The indirect effects of acute care avoidance for emergent issues during the beginning of the COVID-19 pandemic have not been explored. We aimed to examine markers of greater illness acuity on emergency department (ED) presentation in patients with non-COVID related emergent diagnoses, and associated outcomes.

Methods: Retrospective study using administrative data from Ontario. We selected four emergent diagnoses: appendicitis, ectopic pregnancy, renal failure, diabetic ketoacidosis. A non-emergent diagnosis (cellulitis) was used as a control. Primary outcome of interest was hospital admission. Secondary outcomes were: arrival by ambulance, surgical intervention (for appendicitis and ectopic pregnancy), subsequent return hospital admission, and 30-day mortality. Outcomes during the first year of the pandemic (Mar 15–Dec 31, 2020) were compared to a control period (Mar 15–Dec 31, 2018 and 2019). We conducted multivariable regression to examine outcomes in patients with each diagnosis during the pandemic compared to control period.

Results: ED visits for all conditions initially decreased. During the study period, patients across all diagnoses were more likely to arrive to ED via ambulance. There was increased odds of surgery among patients with an ectopic pregnancy (OR: 1.28, 95% CI: 1.04-1.55) but not appendicitis. Patients with renal failure had an 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).

Interpretation: ED volumes for all conditions declined following onset of the pandemic, but returned to baseline. Among patients with renal failure, there was increase in hospitalization and mortality, suggesting delays to care may have may contributed to worse outcomes for these patients. For other emergent diagnoses, there were no differences in outcomes.

INTRODUCTION

On March 11, 2020, the World Health Organization declared COVID-19 a global pandemic.[1] While 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 (ED) volumes across Canada decreased by up to 50%.[2-4] Delays or avoidance of the ED for acute, emergent medical conditions could result in significant downstream detrimental effects, including patient morbidity and mortality. For instance, prior to the pandemic, patients with acute coronary syndrome and stroke with delays to definitive care had worse outcomes compared to those who did not.[5-6]

For patients with an emergent condition, there are relatively few alternative care options other than an ED. During the pandemic, to avoid an ED, patients may have been inclined to contact primary care clinics first, to determine if an ED visit was necessary. During the COVID-19 pandemic, there were reports of reduced in-person physician visits, and an 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/imaging. Therefore, while virtual care may be sufficient for many conditions, we hypothesize that even if such care could be arranged in a timely way, it likely still resulted in significant delays to definitive care for certain time-sensitive, emergent conditions. Therefore, the primary objective of this study was to use population-level data in a universal health care system to examine a marker of higher patient acuity on presentation, hospital admission from the ED, among patients with four emergent, non-COVID related surgical and medical diagnoses during the first year of the pandemic compared to a historical control period. Secondary objectives were to examine other markers of patient acuity, such as

arrival by ambulance, and worse associated outcomes (surgery, return hospital admissions after ED or hospital discharge, and 30-day mortality).

METHODS

Study Design and Setting

This was a retrospective cohort study of population-based health data from 2018-2020 in Ontario, Canada. Patient information was obtained from province-wide administrative health databases held at ICES.

Data Sources

Information regarding ED visits were obtained from the Canadian Institutes of Health Information National Ambulatory Care Reporting System (CIHI-NACRS). NACRS contains abstracted data on ED visits in Ontario. CIHI's Discharge Abstract Database (DAD) contains information on acute care hospitalizations and in-patient surgical procedures in the province. Ontario Mental Health Reporting System was used to identify hospital episodes of care. The Ontario Health Insurance Plan (OHIP) database contains physician billings for medically-necessary care. The Same Day Surgery (SDS) database was used to identify surgery and other procedures. The Registered Persons Database contains mortality information for Ontario residents, including out-of-hospital deaths. These databases were also used to obtain demographics and comorbidities. Patients were linked to the databases using unique, encoded identifiers, and analyzed at ICES. See *eMethods* in the *Supplement* for further description of databases.

Study Participants

Using NACRS, we identified patients 18 years and older with a valid OHIP number seen in an ED with one of four pre-selected, time-sensitive (emergent) diagnoses (appendicitis, ectopic pregnancy, renal failure/hyperkalemia, and diabetic ketoacidosis (DKA)) during the first year of the pandemic (March 15–Dec 31, 2020). These conditions were chosen because they are time-sensitive diagnoses (with potentially severe outcomes if missed), that were not expected to change substantially in prevalence during the pandemic. Some patients with these diagnoses may be managed as outpatients (i.e. appendicitis with outpatient antibiotics, non-ruptured ectopic pregnancy via misoprostol) if they meet certain clinical criteria, including earlier presentation for care. The impact of these pandemic on emergency department visits for these conditions have also not been well explored in the literature. A fifth diagnosis, cellulitis, was included as it could be examined as a 'control' condition, as it is typically not emergent and can be managed as an outpatient with oral antibiotics if the patient is systemically well. Diagnoses were identified using the ED discharge diagnosis in NACRS, which uses the 10th version of the *International Statistical Classification of Diseases and Related Health Problems* (ICD-10) codes. See *eMethods* in the *Supplement* for ICD-10 codes to identify each diagnosis. Only the first ED visit for each diagnosis during the study period was included. We excluded patients who left the ED without being seen or left against medical advice.

Outcome Variables

The primary outcome was hospital admission from the ED: if a greater proportion of patients presenting with the diagnosis in question were admitted to hospital, we considered that a marker of higher acuity and severity on ED presentation. Secondary outcomes of interest

included: arrival to ED by ambulance, surgical intervention (for appendicitis and ectopic pregnancy), return hospital admissions within 30 days of ED or hospital discharge, and 30-day mortality.

Exposure Variables

The main exposure variable was the time period the ED visit occurred: during the first year of the pandemic (March 15–Dec 31, 2020) compared to a historical control period, which was the same time period in 2018 and 2019 (March 15 – Dec 31, 2018 and March 15 - Dec 31, 2019).

Covariates

Covariates included in the statistical models were chosen *a priori,* and included demographics (age, sex, rural residence, income quintile), comorbidities (John Hopkin's Adjusted Diagnostic Group [ADG] score, asthma, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, cancer, diabetes, hypertension stroke, liver failure, renal failure), and ED characteristics (day of ED visit, time of ED visit, and hospital type. See *eMethods* in the *Supplement* for covariate definitions.

Data Analysis

First, we examined the frequency of ED visits during the study time periods. We graphically plotted monthly ED 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 to those seen during the control period. We used a cut-off

for standardized differences of < 0.10 to indicate that patients in the two time periods were similar.[9] We used multivariable logistic regression models to examine the adjusted associations of the covariables above with the following outcomes: hospital admission, ambulance arrival, surgery, and 30-day mortality. These models were created for each diagnostic group (i.e. the diagnostic conditions were examined individually, in relation to outcomes), and odds ratios (OR) with 95% confidence intervals (CI) were calculated. Cox proportional-hazards models were used to examine repeat hospital admission within 30-day of ED or hospital discharge by diagnostic group, with censoring for death or at 30-days. Results were reported as hazard ratios (HR) with 95% CIs.

RESULTS

There was an initial reduction in monthly ED visits for all four emergent diagnoses, and the control diagnosis. The decrease in volumes for all diagnoses appeared to be novel compared to 2018 and 2019. See Figure 1a-e for monthly ED visits for each diagnosis. For all diagnostic groups, visits appeared to return to baseline by September 2020.

Baseline characteristics of patients with each diagnosis did not vary between the control and the pandemic period (Tables 1a-e). In adjusted analyses, across all diagnoses, ED patients seen during the pandemic study period had increased odds of arrival via ambulance compared to the control period. See table 2 for outcomes among patients with each diagnosis.

For patients with an ED 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 to the control period, while there was a trend toward adjusted

increased return hospitalizations within 30 days of ED or hospital discharge (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 diagnosed with an ectopic pregnancy, there was an increased adjusted odds of surgery compared to the control period (OR: 1.28, 95% CI: 1.04-1.55). There were too few deaths within 30 days to analyze. There were no differences in hospital admission or return hospitalization for these patients.

Among patients with renal failure/hyperkalemia, there was an increased adjusted odds of hospital admission on ED presentation (OR: 1.14, 95% CI: 1.04-1.24) and 30-day mortality (OR: 1.17, 95% CI: 1.04-1.31) during the study period compared to the control period. For patients with DKA and cellulitis, there were no differences in outcomes other than arrival by ambulance.

DISCUSSION

In this population-based study, we found an initial reduction in the volume of ED visits at the start of the pandemic for all four of the emergent diagnoses examined, similar to reports of *overall* reduced ED volumes globally.[10-15] We found that patients with renal failure had a higher association of being admitted to hospital when they presented to an ED, but also to die in the short-term period. These patients had the largest decline in ED volumes early on in the pandemic, which may have been associated with higher admission rates and mortality when they presented, possibly due to delays in treatment. These patients are typically older (66% of the patients in this group were over 65 years old, in stark contrast to other groups) and have far more frequent healthcare interactions per year,[16,17] 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 ED, with fewer support systems or resources, compared to younger

cohorts. While early on, it was identified that patients with chronic kidney disease or who develop renal failure and have COVID have worse outcomes,[18] the majority of patients in our study (98%) with renal failure/hyperkalemia were not positive for COVID, therefore, this is likely not the reason for worse outcomes in this population. Future studies examining 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 mortality have continued ease of access to timely acute medical care.

Patients with an ectopic pregnancy were more likely to be treated surgically during the pandemic. This may indicate more patients presenting outside the window of opportunity for medical management, or an increased risk of ruptured ectopic, necessitating surgical management. There have been several reports of increased rates of ruptured ectopic pregnancy during the pandemic in other regions.[19-21] 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.[10] This observed difference may be related to the different time periods examined 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, adhesions, etc.; however, long-term studies are needed in order to accurately anticipate potential complications.

Patients with appendicitis seen during the pandemic period had a trend toward increased return hospitalizations after 30-days, but no change in surgical intervention at the time of ED diagnosis. The increased return hospitalization could potentially reflect higher frequency of ruptured appendicitis.

Similar to our control group of cellulitis, there were no significant differences in hospital admission, mortality, or repeat hospital admissions during the first year of the pandemic for patients diagnosed with DKA. This suggests that short-term outcomes were not affected by the reduced ED volumes in the first few weeks of the pandemic. Alternatively, it is possible that there were patients with DKA who didn't 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 vs the pre-pandemic control periods (i.e. conservative bias). Alternatively, the results may demonstrate that our 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 influx of patients COVID.

For all comers, there have been many reasons proposed to explain the decrease in ED usage during the pandemic, including actual reductions in acute pathology, reduced ED usage, and over-usage of the ED prior to the pandemic.[10,22] Our study focused solely on time-sensitive emergent conditions and found smaller reductions in ED volumes at the beginning of the pandemic for most, compared to what has been reported in many other studies (with reports of up to 65% reductions in ED volume). This likely reflects that patients with these emergent conditions had reduced ability to access timely definitive treatment elsewhere, and inability to delay treatment for long. The latter may be reflected in the higher odds of ambulance use 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 simply trying to delay going to an ED as long as possible, in hopes the symptoms would resolve.

Limitations

There are several limitations with this study. We only included patients who presented to the ED, so we cannot draw conclusions about those who did not seek medical attention or died at home. If a substantial proportion in the pandemic period died at home without ED contact, 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 ED via ambulance they may be seen faster, and potentially avoid contracting COVID. Some of the decrease in ED visits for each disease could be related to pandemic behaviors and being more precautious; this might lead to a healthier cohort in the pandemic period, and again, bias results toward the null. Our study used administrative data and there may be potential misclassification bias if there were coding errors used; however, many of these variables have been validated, with good agreement between chart reviews and databases for mandatory variables[23] and the main ED diagnosis for various diseases.[24-26] This study was retrospective, there may be residual differences between groups due to unmeasured confounders between the time periods examined.

CONCLUSION

The volume of ED visits for emergent diagnoses examined initially declined during the first year of the COVID-19 pandemic. The pandemic period was associated with an increased odds of hospitalization and early mortality for patients with renal failure, an increase in surgeries for women with an ectopic pregnancy, and a trend towards re-hospitalization in patients with appendicitis. For other outcomes, and in patients with DKA, there were no significant differences

between the pandemic and prior time periods, suggesting 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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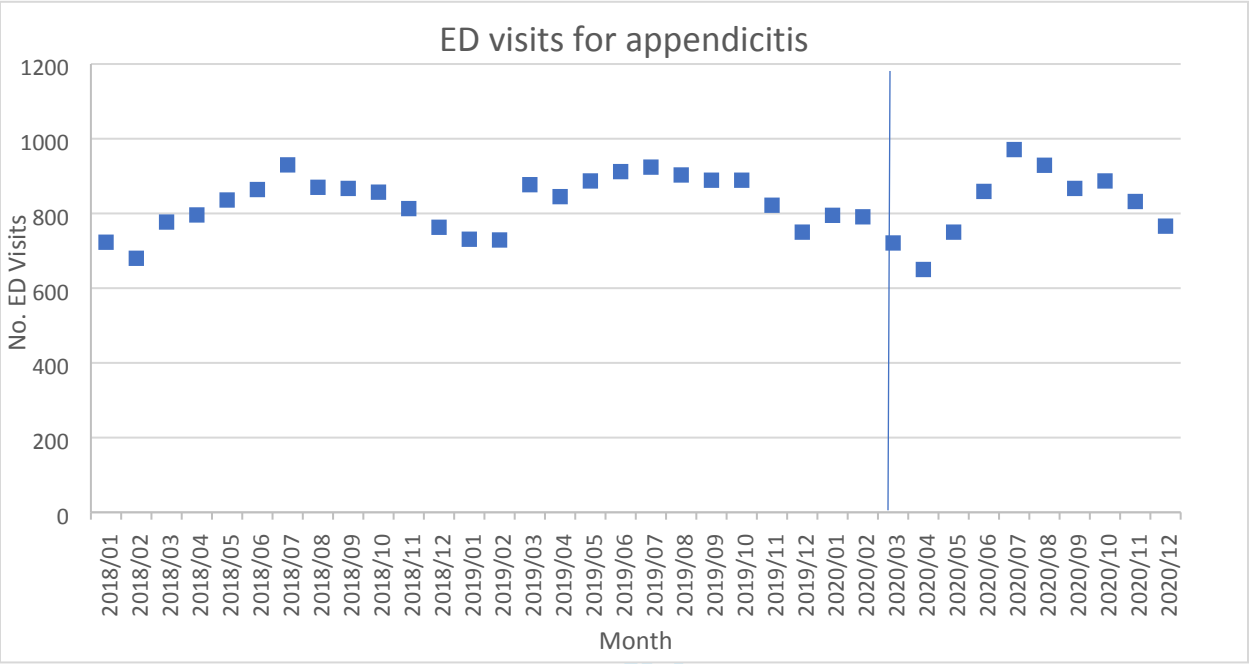
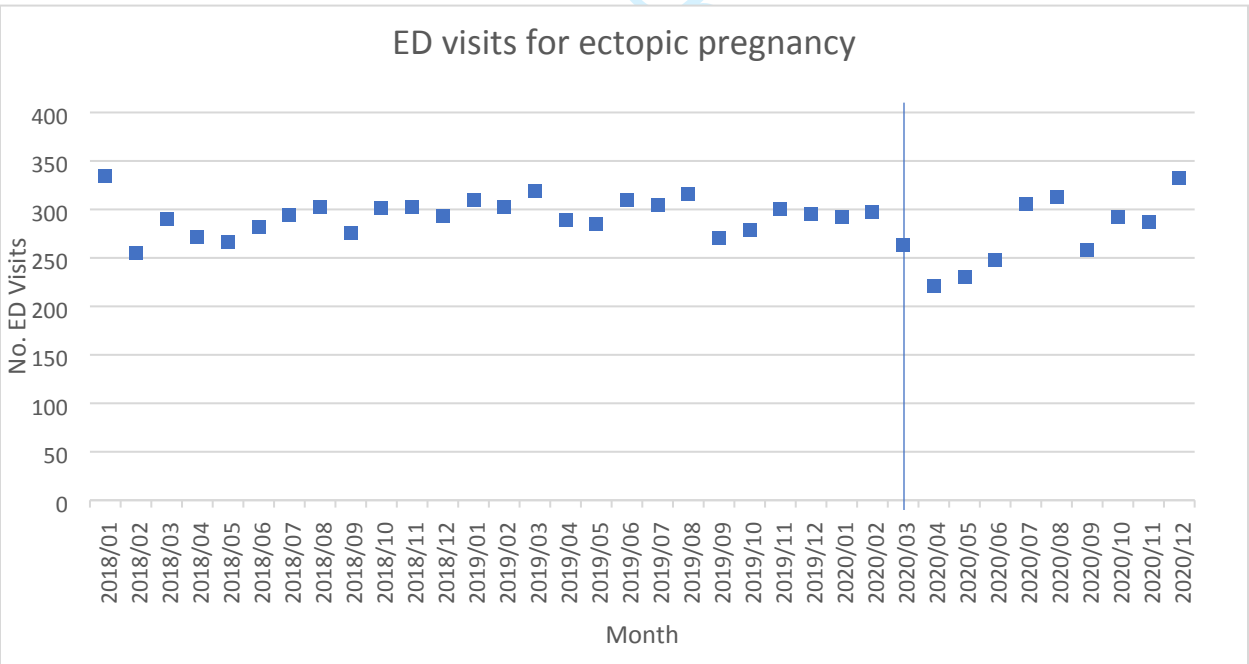
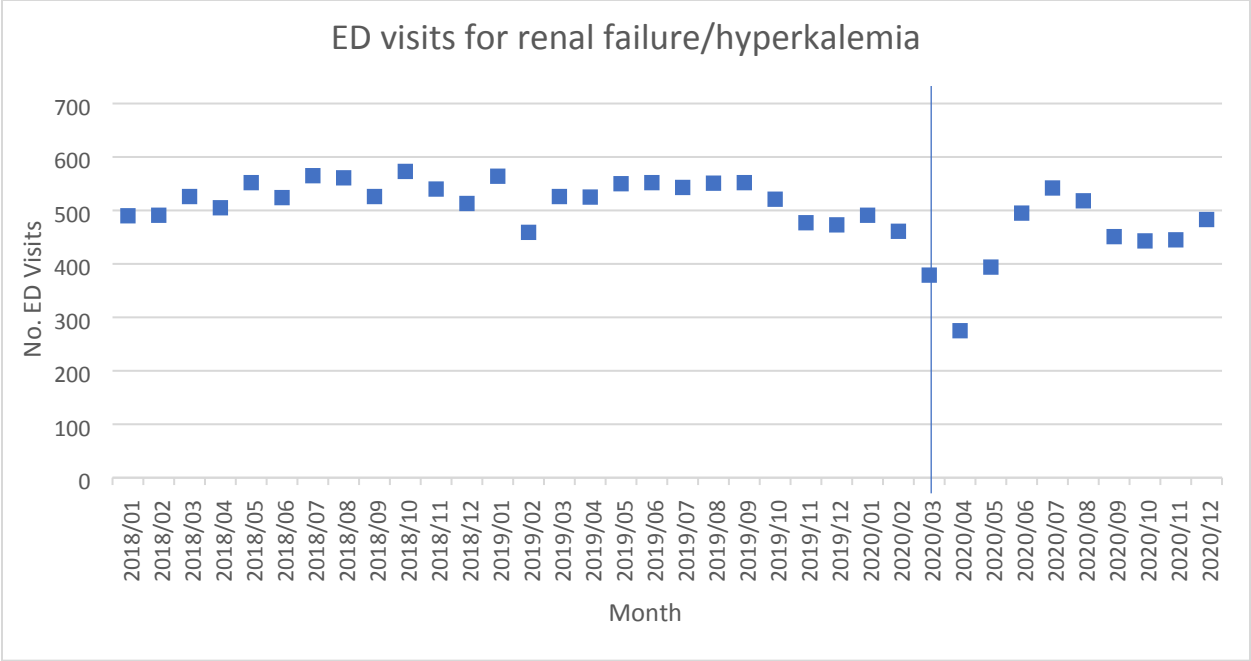
Figure 1 a- e: Monthly ED visits for each emergency diagnosis






ED visits for renal failure/hyperkalemia
No. ED Visits
0
100
200
300
400
500
600
700
2018/01
2018/02
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2018/06
2018/07
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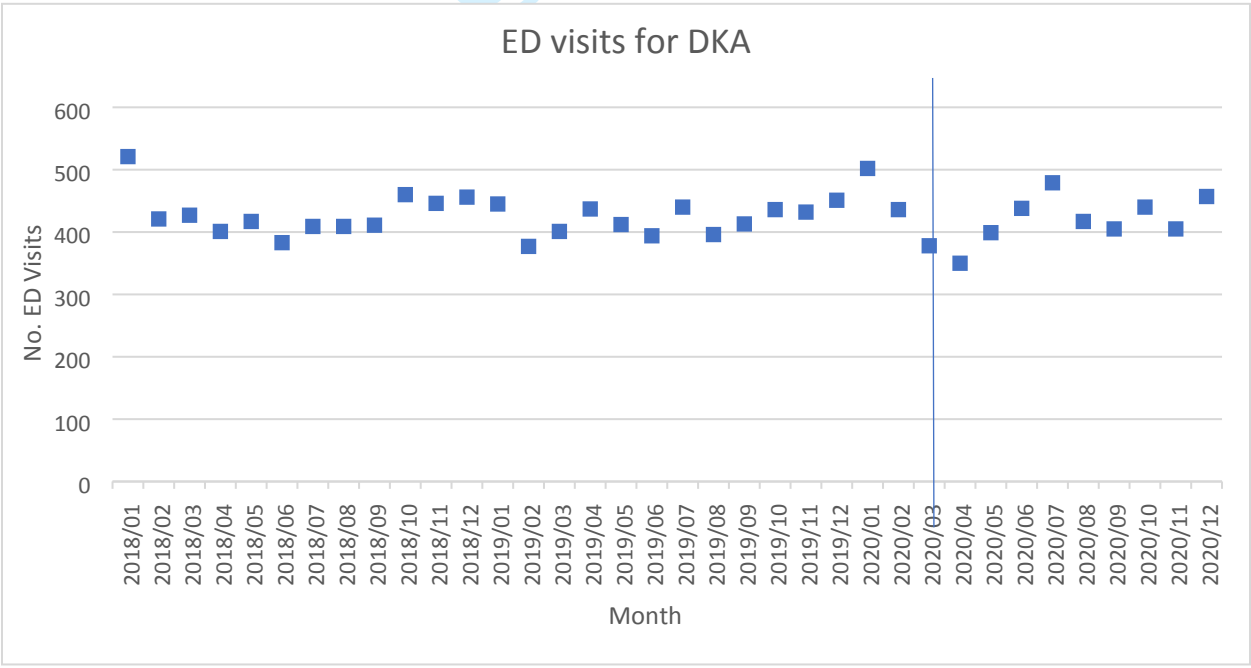
2020/12
Month


ED visits for DKA
No. ED Visits
0
100
200
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400
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2018/01
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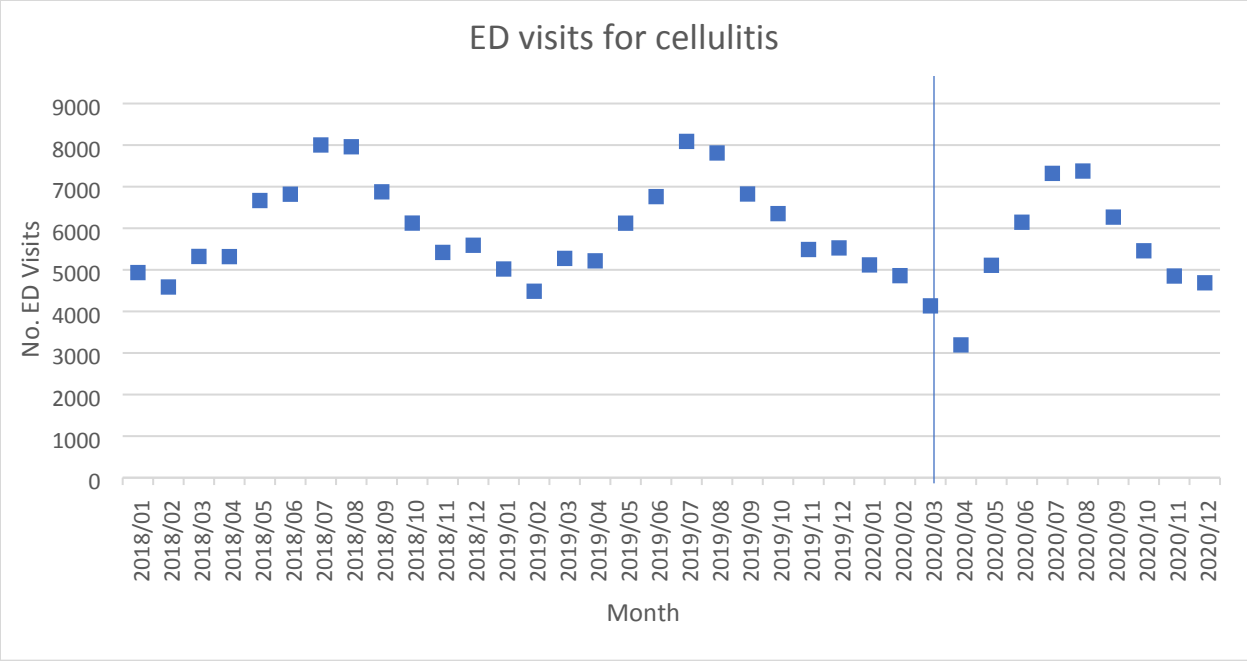

Table 1a: Baseline characteristics for patients with appendicitis

Variable, n (%)		Total	2020	2018 & 2019	Standardized Difference
		N=23,962	**N=7,771**	**N=16,191**	
Demographics					
Age	18-64	20,835 (87.0%)	6,711 (86.4%)	14,124 (87.2%)	0.03
	65+	3,127 (13.0%)	1,060 (13.6%)	2,067 (12.8%)	0.03
Sex	Female	12,238 (51.1%)	3,944 (50.8%)	8,294 (51.2%)	0.01
Rural	Urban	22,460 (94.6%)	7,266 (94.4%)	15,194 (94.6%)	0.01
	Rural	1,293 (5.4%)	430 (5.6%)	863 (5.4%)	0.01
Income Quintile	1 (high)	4,645 (19.4%)	1,489 (19.2%)	3,156 (19.6%)	0.01
	2	4,777 (20.0%)	1,513 (19.5%)	3,264 (20.2%)	0.02
	3	4,647 (19.5%)	1,525 (19.7%)	3,122 (19.3%)	0.01
	4	4,879 (20.4%)	1,562 (20.2%)	3,317 (20.6%)	0.01
	5 (low)	4,942 (20.7%)	1,661 (21.4%)	3,281 (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		1,472 (6.1%)	476 (6.1%)	996 (6.2%)	0
Congestive heart failure		407 (1.7%)	135 (1.7%)	272 (1.7%)	0
Diabetes mellitus		2,135 (8.9%)	693 (8.9%)	1,442 (8.9%)	0
Hypertension		4,785 (20.0%)	1,517 (19.5%)	3,268 (20.2%)	0.02
Asthma		4,205 (17.5%)	1,334 (17.2%)	2,871 (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%)	5,818 (74.9%)	12,181 (75.2%)	0.01
Time of ED visit	Day [08:00-16:59]	13,284 (55.4%)	4,314 (55.5%)	8,970 (55.4%)	0
	Evening [17:00-23:59]	6,223 (26.0%)	2,057 (26.5%)	4,166 (25.7%)	0.02
	Night [00:00-07:59]	4,455 (18.6%)	1,400 (18.0%)	3,055 (18.9%)	0.02
Hospital Type	Community	18,084 (75.5%)	5,881 (75.7%)	12,203 (75.4%)	0.01
	Small	661 (2.8%)	213 (2.7%)	448 (2.8%)	0
	Teaching	5,217 (21.8%)	1,677 (21.6%)	3,540 (21.9%)	0.01

ADG: adjusted diagnostic groups; ED: emergency department; SD: standardized difference; IQR: interquartile range

Table 1b: Baseline characteristics for patients with ectopic pregnancy

Variable, n (%)		Total	2020	2018 & 2019	Standardized Difference
		N=7,776	**N=2,490**	**N=5,286**	
Demographics					
Age	18-64	7,776 (100.0%)	2,490 (100.0%)	5,286 (100.0%)	.
Sex	Female	7,776 (100.0%)	2,490 (100.0%)	5,286 (100.0%)	.
Rural	Urban	7,258 (94.2%)	2,321 (94.2%)	4,937 (94.1%)	0
	Rural	450 (5.8%)	142 (5.8%)	308 (5.9%)	0
Income Quintile	1 (high)	1,977 (25.5%)	632 (25.4%)	1,345 (25.5%)	0
	2	1,710 (22.0%)	558 (22.4%)	1,152 (21.8%)	0.02
	3	1,562 (20.1%)	532 (21.4%)	1,030 (19.5%)	0.05
	4	1,428 (18.4%)	438 (17.6%)	990 (18.7%)	0.03
	5 (low)	1,091 (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	7,776 (100.0%)	2,490 (100.0%)	5,286 (100.0%)	.
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		1,485 (19.1%)	450 (18.1%)	1,035 (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)	1	6,007 (77.3%)	1,921 (77.1%)	4,086 (77.3%)	0
Time of ED visit	Day [08:00-16:59]	4,868 (62.6%)	1,604 (64.4%)	3,264 (61.7%)	0.06
	Evening [17:00-23:59]	2,217 (28.5%)	687 (27.6%)	1,530 (28.9%)	0.03
	Night [00:00-07:59]	691 (8.9%)	199 (8.0%)	492 (9.3%)	0.05
Hospital Type	Community	5,934 (76.3%)	1,919 (77.1%)	4,015 (76.0%)	0.03
	Small	237 (3.0%)	89 (3.6%)	148 (2.8%)	0.04
	Teaching	1,605 (20.6%)	482 (19.4%)	1,123 (21.2%)	0.05

*some cells have been suppressed to prevent back calculation of low cell volumes
ADG: adjusted diagnostic groups; ED: emergency department; SD: standardized difference; IQR: interquartile range

Table 1c: Baseline characteristics for patients with renal failure/hyperkalemia

Variable, n (%)		Total	2020	2018 & 2019	Standardized Difference
		N=13,502	**N=3,942**	**N=9,560**	
Demographics					
Age	18-64	4,565 (33.8%)	1,330 (33.7%)	3,235 (33.8%)	0
	65+	8,937 (66.2%)	2,612 (66.3%)	6,325 (66.2%)	0
Sex	Female	6,128 (45.4%)	1,757 (44.6%)	4,371 (45.7%)	0.02
Rural	Urban	11,571 (88.4%)	3,343 (87.5%)	8,228 (88.7%)	0.04
	Rural	1,520 (11.6%)	476 (12.5%)	1,044 (11.3%)	0.04
Income Quintile	1 (high)	3,923 (29.2%)	1,092 (27.8%)	2,831 (29.7%)	0.04
	2	2,955 (22.0%)	925 (23.5%)	2,030 (21.3%)	0.05
	3	2,547 (18.9%)	745 (19.0%)	1,802 (18.9%)	0
	4	2,162 (16.1%)	614 (15.6%)	1,548 (16.3%)	0.02
	5 (low)	1,861 (13.8%)	552 (14.1%)	1,309 (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		4,067 (30.1%)	1,152 (29.2%)	2,915 (30.5%)	0.03
Chronic obstructive pulmonary disease		4,136 (30.6%)	1,187 (30.1%)	2,949 (30.8%)	0.02
Congestive heart failure		4,671 (34.6%)	1,372 (34.8%)	3,299 (34.5%)	0.01
Diabetes mellitus		8,883 (65.8%)	2,605 (66.1%)	6,278 (65.7%)	0.01
Hypertension		11,526 (85.4%)	3,340 (84.7%)	8,186 (85.6%)	0.03
Asthma		2,534 (18.8%)	718 (18.2%)	1,816 (19.0%)	0.02
Cancer		1,413 (10.5%)	409 (10.4%)	1,004 (10.5%)	0
Stroke		1,303 (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		7,250 (53.7%)	2,133 (54.1%)	5,117 (53.5%)	0.01
ED Characteristics					
Weekday ED visit (Monday to Friday)		10,642 (78.8%)	3,142 (79.7%)	7,500 (78.5%)	0.03
Time of ED visit	Day [08:00-16:59]	8,382 (62.1%)	2,445 (62.0%)	5,937 (62.1%)	0
	Evening [17:00-23:59]	3,818 (28.3%)	1,104 (28.0%)	2,714 (28.4%)	0.01
	Night [00:00-07:59]	1,302 (9.6%)	393 (10.0%)	909 (9.5%)	0.02
Hospital Type	Community	9,608 (71.2%)	2,833 (71.9%)	6,775 (70.9%)	0.02
	Small	1,022 (7.6%)	319 (8.1%)	703 (7.4%)	0.03
	Teaching	2,872 (21.3%)	790 (20.0%)	2,082 (21.8%)	0.04

ADG: adjusted diagnostic groups; ED: emergency department; SD: standardized difference; IQR: interquartile range

Table 1d: Baseline characteristics for patients with diabetic ketoacidosis

Variable, n (%)		Total	2020	2018 & 2019	Standardized Difference
		N=9,957	**N=3,376**	**N=6,581**	
Demographics					
Age	18-64	7,668 (77.0%)	2,571 (76.2%)	5,097 (77.5%)	0.03
	65+	2,289 (23.0%)	805 (23.8%)	1,484 (22.5%)	0.03
Sex	Female	4,679 (47.0%)	1,505 (44.6%)	3,174 (48.2%)	0.07
Rural	Urban	8,844 (91.2%)	3,010 (91.7%)	5,834 (90.9%)	0.03
	Rural	854 (8.8%)	271 (8.3%)	583 (9.1%)	0.03
Income Quintile	1 (high)	3,109 (31.4%)	1,061 (31.5%)	2,048 (31.3%)	0.01
	2	2,216 (22.4%)	777 (23.1%)	1,439 (22.0%)	0.03
	3	1,780 (18.0%)	588 (17.5%)	1,192 (18.2%)	0.02
	4	1,567 (15.8%)	528 (15.7%)	1,039 (15.9%)	0
	5 (low)	1,240 (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		1,201 (12.1%)	404 (12.0%)	797 (12.1%)	0
Chronic obstructive pulmonary disease		1,325 (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		8,750 (87.9%)	2,850 (84.4%)	5,900 (89.7%)	0.16
Hypertension		4,504 (45.2%)	1,525 (45.2%)	2,979 (45.3%)	0
Asthma		2,137 (21.5%)	714 (21.1%)	1,423 (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		1,210 (12.2%)	404 (12.0%)	806 (12.2%)	0.01
ED Characteristics					
Weekday ED visit (Monday to Friday)		7,225 (72.6%)	2,449 (72.5%)	4,776 (72.6%)	0
Time of ED visit	Day [08:00-16:59]	5,207 (52.3%)	1,777 (52.6%)	3,430 (52.1%)	0.01
	Evening [17:00-23:59]	3,129 (31.4%)	1,065 (31.5%)	2,064 (31.4%)	0
	Night [00:00-07:59]	1,621 (16.3%)	534 (15.8%)	1,087 (16.5%)	0.02
Hospital Type	Community	6,933 (69.6%)	2,370 (70.2%)	4,563 (69.3%)	0.02
	Small	630 (6.3%)	209 (6.2%)	421 (6.4%)	0.01
	Teaching	2,394 (24.0%)	797 (23.6%)	1,597 (24.3%)	0.02

ADG: adjusted diagnostic groups; ED: emergency department; SD: standardized difference; IQR: interquartile range

Table 1e: Baseline characteristics for patients with cellulitis

Variable, n (%)		Total	2020	2018 & 2019	Standardized Difference
		N=160,788	**N=47,886**	**N=112,902**	
Demographics					
Age	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%)	6,991 (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%)	8,949 (18.8%)	21,622 (19.2%)	0.01
	4	28,181 (17.6%)	8,358 (17.5%)	19,823 (17.6%)	0
	5 (low)	26,060 (16.3%)	7,689 (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%)	5,140 (10.7%)	12,509 (11.1%)	0.01
Chronic obstructive pulmonary disease		29,535 (18.4%)	8,871 (18.5%)	20,664 (18.3%)	0.01
Congestive heart failure		15,741 (9.8%)	4,641 (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		7,304 (4.5%)	2,098 (4.4%)	5,206 (4.6%)	0.01
Stroke		5,131 (3.2%)	1,456 (3.0%)	3,675 (3.3%)	0.01
Liver failure		2,020 (1.3%)	646 (1.3%)	1,374 (1.2%)	0.01
Renal Failure		9,188 (5.7%)	2,692 (5.6%)	6,496 (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%)	4,667 (9.7%)	11,446 (10.1%)	0.01
Hospital Type*	Community	-	-	-	0
	Paeds	-	-	-	
	Small	-	-	-	0.01
	Teaching	-	-	-	0

ADG: adjusted diagnostic groups; ED: emergency department; SD: standardized difference; IQR: interquartile range
*cells suppressed to prevent back calculation

Table 2: Outcomes during the pandemic period compared to control period for patients

Outcome	Appendicitis Adjusted* OR or HR (95% CI)	Ectopic Pregnancy Adjusted$^{\infty}$ OR or HR (95% CI)	Renal Failure Adjusted* OR or HR (95% CI)	DKA Adjusted* OR or HR (95% CI)	Cellulitis Adjusted* OR or HR (95% CI)
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 days	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-day mortality	Too few outcomes	Too few outcomes	1.17 (1.04-1.31)	1.15 (0.91-1.46)	1.03 (0.91-1.16)

*adjusted for covariables listed in Table 1a,c,d,e;

$^{\infty}$ adjusted for covariables listed in Table 1b, except coronary artery disease, chronic obstructive pulmonary disease, congestive heart failure, cancer, stroke, liver failure, renal failure

Reference category is historical control time period

CI: confidence interval; HR: hazard ratio; OR: odds ratio

Supplementary Material

Methods. Additional information regarding data sources and covariates
Table e1: ICD-10 codes to identify emergent diagnoses
Table e2: Validated algorithms for comorbidities
Table e3: Codes to identify other comorbidities/covariates

METHODS:

Data Sources

ED visits were identified from the Canadian Institutes of Health Information National Ambulatory Care Reporting System (CIHI-NACRS). NACRS is an administrative database that contains anonymized, abstracted data on all ED patient visits in the province of Ontario; it contains over 300 data points on every ED visit. Reporting to NACRS is mandatory in Ontario. Data in NACRS are reviewed and errors and/or missing data are identified, and returned to the submitting hospital as necessary for resubmission; therefore, missing data for mandatory variables in NACRS is very low.

Study Participants

The main discharge diagnosis in NACRS, which uses ICD-10 codes, was used to identify patients with the diagnoses of interest**.** See Table e1 for the ICD-10 codes used to identify each of the fiver emergent diagnoses.

Covariates

Where available, validated algorithms were used to identify patient risk factors and comorbidities in the linked databases. See Table e2 for previously validated algorithms to identify comorbidities with ICES data. Where validated algorithms were not available, the patient was considered to have a past medical history of the disease in question if they had, within the 5 years prior to the ED visit, one diagnosis in the DAD, or two outpatient diagnoses in the OHIP databases, or two main diagnoses in NACRS, or one each from NACRS and the OHIP database. This approach is a similar strategy used in many of the validated algorithms. See Table e3 for codes to identify other comorbidities. To identify patients with a history of cancer, the Ontario Cancer Registry (OCR) was used. The OCR is a registry that contain all the diagnosed cases of cancer (expect squamous and basal cell carcinoma) in the province. To examine rurality, the Rural Index of Ontario (RIO) score was used. The RIO score is a continuous score calculated by Statistics Canada, and is assigned to each patient based on postal code.[5] The score incorporates: population density, distance to basic referral centre, and distance to advanced referral centre. A higher RIO score is indicative of a more rural area, with scores greater than 40 considered to be rural based on funding models by the Ministry of Health and Long Term Care. The John Hopkins Adjusted Clinical Group (ACG) case-mix system is a measure of patient acuity/comorbidity. Diagnoses are assigned to one of 32 diagnostic cluster (Adjusted Diagnostic Groups (ADG); patients with the greatest number of high-risk clusters are generally sickest and require the most health care resources. In an ambulatory cohort, the ADG score is similar in principle to the use of Charlson Comorbidity Index in studies of hospitalized patients.

Table e1: ICD-10 codes in the main discharge diagnosis in CIHI-NACRS to identify emergent diagnoses

Diagnosis	ICD-10 Code	Description
Acute appendicitis	K35	Acute appendicitis
	K350	Acute appendicitis with generalized peritonitis
	K351	Acute appendicitis with peritoneal abscess
	K352	Acute appendicitis with generalized peritonitis
	K353	Acute appendicitis with localized peritonitis
	K358	Acute appendicitis, other and unspecified
	K359	Acute appendicitis, unspecified
Ectopic pregnancy	O00	Ectopic Pregnancy
	O000	Abdominal pregnancy
	O001	Tubal pregnancy
	O002	Ovarian pregnancy
	O008	Other ectopic pregnancy
	O009	Ectopic pregnancy, unspecified
Hyperkalemia	E875	Hyperkalaemia
Acute Renal Failure	E102, E112, E132, E142, I12, I13, N01.*, N03.*, N05.*, N08.*, N18.*, N19.*, N25.* with dialysis OHIP: R849, R850, G323, G325, G326, G330, G331, G860, G333, G083, G091, G085, G295, G082, G090, G092, G093, G094, G861, G862, G863, G864, G865, G866, G294, G095, G096 CCP: 51.95, 66.98 CCI: 1PZ21HQBR, 1PZ21HPD4	
DKA	E10.0*	Type 1 diabetes mellitus with coma
	E10.1*	Type 1 diabetes mellitus with ketoacidosis
	E11.0*	Type 2 diabetes mellitus with coma
	E11.1*	Type 2 diabetes mellitus with ketoacidosis
	E13.0*	Other specified diabetes mellitus with coma
	E13.1*	Other specified diabetes mellitus with ketoacidosis
	E14.0*	Unspecified diabetes mellitus with coma
	E14.1*	Unspecified diabetes mellitus with ketoacidosis
Cellulitis	L03*	Cellulitis

Table e2: Validated algorithms for comorbidities

Comorbidity	Sensitivity %	Specificity %	Reference
CAD	88.8	92.8	1
CHF	84.8	97.0	2
COPD	57.5	95.4	3
Diabetes	86.0	97.0	5
Hypertension	73.0	95.0	6

CAD: coronary artery disease; CHF: congestive heart failure; COPD: chronic pulmonary obstructive disease

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Table e3. Codes to identify other comorbidities/covariates

Comorbidity	ICD-10 DX10CODE	OHIP DXCODE
Cancer (last 5 years)	OCR	OCR
Renal Failure	N01.*, N03.*, N05.*, N18.*, N19.*,	585, 584
Liver Failure	K70.4, K72.1, K72.9, K76.6, K76.7,	571
Stroke	I63.*, I64.*, H34.*	436, 437
CAD	I20.*, I21.*, I22.*, I23.*, I24.*, I25.*	410, 412, 413

OCR: Ontario Cancer Registry; ALR: Activity Level Reporting database; NDFP = New Drug Funding Program database