CANADIAN JOURNAL of EMERGENCY NURSING
JOURNAL CANADIEN des INFIRMIÈRES D'URGENCE
THE OFFICIAL JOURNAL OF THE NATIONAL EMERGENCY NURSES' ASSOCIATION
www.NENA.ca www.CJEN.ca

From triage to treatment: A population-level descriptive retrospective time-series analysis of emergency department visits in Alberta during the COVID-19 pandemic

Christopher Picard,[1] Carmel L. Montgomery,[1] Efrem M. Violato,[2] Matthew J. Douma,[3] and Colleen M. Norris[1]

[1] Faculty of Nursing, University of Alberta, Edmonton, AB, Canada
[2] Centre for Advanced Medical Simulation, Northern Alberta Institute of Technology, Edmonton, AB, Canada
[3] School of Nursing, Midwifery and Health Systems, University College Dublin, Dublin, Ireland

Corresponding Author: Christopher Picard, Faculty of Nursing, University of Alberta, 3-131 Edmonton Clinic, Health Academy, 11405-87 Avenue, Edmonton, AB T6G 1C9
Email: picard@ualberta.ca; Telephone: 780-492-4567; Fax: 780-492-2551

Abstract

Background: The COVID-19 pandemic has had a significant impact on healthcare systems worldwide, leading to changes in presentation types, service utilization, and admission rates to emergency departments (ED). This study examines changes in ED visit patterns and triage misclassifications during the pandemic in Alberta, Canada.

Methods: We conducted a retrospective population-level time-series analysis of all patients who presented to 12 EDs in the Edmonton Alberta Zone between March 3, 2019, and March 3, 2022. Routinely collected electronic health record data were analyzed and with primary categories of reporting including Canadian Triage Acuity Scale (CTAS), age, Canadian Emergency Department Information System (CEDIS) presenting complaint, admission status, triage misclassifications, and time markers for patient care.

Results: Included were 1.24 million cases from 12 hospitals. When we compare the patterns of presentation with the pre-pandemic period, we found a relative increase of 12.5% in EMS volumes, a 43.2% relative reduction in the proportion of patients presenting to tertiary EDs, 17.2% relative reduction in the number of patients under the age of 18, and a global increase in acuity with the highest relative increase 19.7% coming from patients in the highest acuity level: CTAS 1. Complaint distributions during these periods demonstrated that mental health, substance use, and environmental complaints experienced 15.5%, 22.4%, and 26.7% relative increases in volume, respectively; pediatric specific complaints experienced a 56.5% relative reduction. By the end of the study period, patients spent an average of 59 minutes longer in the ED compared to the pre-pandemic period. The proportion of patients triaged using Epic, an electronic documentation system, increased from 7.8% of all patients triaged in the pre-pandemic period to over 66.1% during the pandemic, and there was a 22.9% and 24.2% relative reduction in high-risk triage misclassifications (22.9%) and pain related triage misclassifications (24.2%) by the end of the period compared with before the pandemic.

Conclusion: Our study adds to the pandemic-related emergency care knowledge base by describing ED visit

ISSN: 2293-3921 (print) | ISSN: 2563-2655 (online) | https://doi.org/10.29173/cjen226
Print publisher: Pappin Communications http://pappin.com | Online publisher: University of Alberta www.library.ualberta.ca/publishing/open-journals

trends, changes in presenting complaint categories, and time markers for patient care over a big-data pre- and post-pandemic dataset. Nursing-specific ED quality indicators that have not been previously described over a three-year duration between March 3rd, 2019, and March 3rd, 2022, are also presented. Our study findings have significant implications for healthcare professionals and policymakers in understanding both the impact of the pandemic on ED care delivery as well as future pandemic and post-pandemic ED operations.

Keywords: COVID-19, triage, length of stay, patient safety, emergency department

Background

As of May 2023, there have been more than 4.6 million cases and 50,000 deaths in Canada attributed to COVID-19 (World Health Organization, 2020). Internationally, the effects of COVID-19 on healthcare systems have been examined for changes in Emergency Department (ED) presentation types, service utilization, and admission rates, and showed that there were significant reductions in overall ED presentation volumes, and specific reductions in pediatric, surgical, and cardiac presentations with a concurrent increase in overall acuity (Pujolar et al., 2022). To complicate matters, there has been significant regional variability in the rates of COVID-19 transmission and pandemic-related health system effects (Karaivanov et al., 2021). In Alberta, previous studies have shown a COVID-19 related increase in Emergency Medical Services (EMS) call volume acuity with a concurrent decrease in the rates at which they transfer patients to the ED (Lane et al., 2021), a decrease in ED visits resulting in medical/surgical admissions (Rennert-May et al., 2021), and a reduction in intensive care unit (ICU) admissions and duration of stay (Bagshaw et al., 2022).

Unfortunately, most studies examining the effects of COVID-19 on presentation volumes examine only relatively short intervals, between March 2019 and June 2020 (Bagshaw et al., 2022; Rennert-May et al., 2021), or fixed periods during successive years (i.e., December–June 2017–2020; Lane et al., 2021) and, as a result, may either miss or exaggerate the changes in patient volumes attributed to COVID-19 compared with other external factors, such as seasonal variations. Additionally, there is a notable paucity of literature examining how the pandemic affected ED nursing practice in general and triage nursing specifically.

The objectives of our study were to examine ED visit trends over a prolonged and continuous period, describing presenting complaint categories (versus admission codes), considering multiple time markers for patient care (i.e., time to care space, time to physician assessment, and total length of stay), and examine previously unexplored factors that may have been affected by COVID-19, namely triage misclassification rates.

Methods

We performed a population-level study using a retrospective time-series analysis to describe changes in the patterns of ED visits prior to and during the COVID-19 pandemic to explore points that have not been previously described.

Setting and populations

This retrospective cohort study of all Edmonton (Alberta) ED visits examined the records of patients who presented to EDs between March 3, 2019, and March 3, 2022. The Edmonton Zone services 1.5 million people, the median population age in the area is 37.8 years (Statistics Canada, 2021), and health services are delivered by 14 hospitals, 12 emergency departments, and 32,600 healthcare workers (Alberta Health Services, 2016b).

Data collection

Any patients seen during the study period, at all sites in the catchment area, were included in our analysis. The administrative ED healthcare data that we examined included the hospital's location and triage documentation system. The patient data we collected included age, sex, number of previous visits, arrival date and time, and means of arrival at the ED. These data were merged with information gathered during triage, including the patient's triage acuity score, presenting complaint category, and vital signs. Finally, treatment time markers, such as the time from triage to bed, physician, and/or admission, and the ED visit discharge outcome (e.g., admitted, transferred, discharged, or died) from each of the 12 EDs that reported visit level data into the regional database were collected (Picard et al., 2023a). Environmental data for the study period were downloaded from the Government of Canada historical database for the downtown (Edmonton Blatchford) weather station (Government of Canada, 2023).

Categories

Site level information

Site-level visit characteristics included the type of ED, triage documentation system used, and COVID-19 wave. ED types were categorized into three categories: urban/academic, regional/community, urgent care using previously defined groupings (Rowe et al., 2020). During the study time period, hospitals in the zone used one of two triage documentation systems – either the Emergency Department Information System (EDIS) [HAS Solutions, Australia] or Epic electronic documentation system [Epic, United States].

There were significant regional differences in the volume of patients seen during each wave of the COVID-19 pandemic (Cameron-Blake et al., 2021), as well as heterogeneity in how COVID-19 waves were defined in the literature, particularly after the third wave. Methods used vary, but can include infection rates (Ayala et al., 2021), or viral reproduction rates (Zhang et al., 2021). Similar to previous studies (Hohl et al., 2022; Xiong et al., 2022) we defined a wave as a period of sustained acceleration followed by a period of sustained deceleration in cases using the World Health Organization (WHO) dashboard for Canada (2020). We allocated patients to the first wave if they presented between March 1 and September 30, 2020 (213 days), to the second wave if they presented between October 1, 2020, and March 31, 2021 (181 days), and to the third wave if they presented between April 1, 2021, and July 31, 2021 (121 days). COVID periods were well defined for waves one through three. However, the remaining were less well understood and were grouped more broadly in fixed intervals to match the preceding periods with Waves 4 and 5 being defined as August 1, 2021, to November 30, 2021 (121 days); and December 1, 2021, to March 31, 2022 (120 days). The pre-pandemic period examined was March 1, 2019, to February 29, 2020 (365 days).

Patient information variables

Patient-level data included the patients' means of arrival, number of previous visits to that specific ED, sex, and age. We categorized ED arrival mode into two means of arrival including arrival by EMS, which included both air and ground ambulance, and not by EMS, which included self-presentations or those escorted by law enforcement. Data collected from the administrative database included the number of visits a patient had in the preceding 90 and 365 days, the sex (the default reflects a patient's legal documentation, but this can be adjusted by the triage nurse for a response of male, female, or "x"), and age in years. Cases with a questionable age, for example significantly higher than 100 (e.g., 908 years), were assumed to be entered incorrectly. As it was not possible to determine the correct age, the missing cases represented a small proportion of the overall data set (percent = .09%, n = 1,206), and census data reports only 285 people in the Edmonton Zone being ≥100 years (Statistics Canada, 2021), all cases with an age greater than 100 years were dropped.

Information gathered during triage

During triage, nurses assigned an acuity score and categorized the reason for the visit based on an assessment interview with the patient that included measurement of their vital signs. Acuity was recorded using the five-point Canadian Triage Acuity Scale (CTAS) tool (Beveridge et al., 1998), which is used by more than 95% of Canadian EDs (Rowe et al., 2006). Presenting complaint codes were categorized using the Canadian Emergency Department Information System (CEDIS) presenting complaint list, which groups ED-specific International Classification of Disease (ICD) codes into body system complaint categories (Grafstein et al., 2003; Innes et al., 2001). The CTAS and CEDIS are used as clinical decision-support tools by nurses (Picard & Kleib, 2020) and include assessments, such as vital signs, pain, and mechanism of injury, as inputs. Routinely collected vital signs included heart rate, respiratory rate, blood pressure, oxygen saturation, blood glucose level, Glasgow Coma Scale (GCS), and pain level (using a 0–10 numeric pain scale). By comparing acuity and presenting complaint data to vital signs, we also determined when triage nurses deviated from recommended acuity scores and calculated "variance rates."

Because triage data are used for benchmarking and funding decisions (Grafstein et al., 2008) it is important that the data accurately reflect a patient's condition. It is essential to ensure that triage nurses are assigning appropriate triage scores and presenting complaint codes in a consistent and reliable manner. Triage variances were defined by comparing a patient's triage vital signs to CTAS-specified modifiers and according to the definitions used for an ongoing Edmonton Zone triage quality improvement project (Cotton et al., 2021; Picard et al., 2023a). CTAS data were examined for three major groups of misclassifications: i) low acuity misclassifications, patients assigned a CTAS 5 who should have been assigned a higher acuity level; ii) high acuity misclassifications, patients assigned a CTAS score 3–5 who should have been assigned CTAS 1 or 2; iii) and pain misclassifications, patients who presented to the ED with a primary complaint of pain, yet did not receive a pain assessment. Raw misclassifications were counted as present or absent and summed in instances of multiple misclassifications.

Information about the visit

Data used to describe the visit included the amount of time spent during each phase of the visit, and the outcome of the visit. The time markers we used to track the progression of a patient's care included the times from triage to a care space, physician assessment, admission, or discharge (Ospina et al., 2007). These reported data elements have been collected and analyzed in the Edmonton Zone previously (Bullard et al., 2009). Times are represented in hours, minutes, seconds (HH:MM:SS). The maximum time possible, as recorded in the data set, was 23:59:59. The potential outcomes for a visit included admission (to any service), transfer (to another facility), leaving before completion of therapy (at any stage of therapy), discharge, or other, which included duplicate visits and other registration issues.

Data Analysis and Reporting

The data were analyzed using descriptive statistics and frequency analysis, including time-series analysis. An exploratory data analysis approach employing machine learning methods (Hong et al., 2020), also was used to determine if any important patterns emerged in the data. The primary outcome variables were pain misclassification, sum of high-risk vital sign misclassifications and the sum of low-risk vital sign misclassifications. Predictor variables included COVID waves, and other relevant demographic and ED measures.

An exploratory approach was used to determine any important relationships in the data between COVID-19 waves and misclassifications. An omnibus Chi-square test was run for pain misclassification, sum of high-risk vital sign misclassification and sum of low-risk misclassifications, to determine if any differences existed in misclassification rates across COVID-19 waves, and for all predictors (Tables 1–6). Due to the large sample size and the subsequent high likelihood of detecting an effect along with the small values of the regression coefficients, a Machine Learning model for Classification using logistic regression and Decision Trees was implemented to determine the value of COVID-19 waves as a predictor of pain and high-risk and low-risk misclassification. The "Tidymodels" package in R (Kuhn & Wickham, 2020) was used to conduct all analyses. Samples, bootstrapped 50 times, were used for the omnibus testing, a 70/30 test training split was used for the machine learning models, and significance levels for all tests were set at $p < 0.05$.

Data reporting followed the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) Statement guidelines for observational studies (von Elm et al., 2007; Supplement 1). Ethics approval and data-sharing agreements were secured through the University of Alberta Research Ethics Boards (REB) approval (Pro00100158).

Results

Site and zone level changes

In this study, we analyzed a total of 1.24 million ED visits from 12 hospitals including two urban/academic centres, nine regional/community hospitals, and one urgent care centre. When we examined the zone-level changes in patient presentations, we determined that 33.81% (*n* = 419,979) of visits occurred in the pre-pandemic interval. There was a reduction in both the mean number of monthly ED visits and the number of patients transported to the ED by EMS; proportionally, however, the number of patients arriving by EMS rose to 19.47% during Wave 1 (*n* = 36,158) and peaked at 20.87% (*n* = 36,410) during Wave 2 and saw a relative increase of 12.54% when compared to the pre-pandemic period (Table 1). There was a 43.19% relative reduction (16.69% absolute) in the number of patients presenting to urban/academic EDs at the end of the period compared with the pre-pandemic period.

The proportion of patients who left before the completion of treatment varied across the study period. In the pre-pandemic period, 9.15% (*n* = 38,455) of patients left before treatment completion. This rate decreased during Wave 1 to 7.68% (*n* = 14,263) patients and further decreased to 7.48% (*n* = 13,058) patients in

Table 1

Site-Level Visit Characteristics by COVID-19 Wave

Variable	COVID Wave						Overall
	0	1	2	3	4	5	
Total Number of Visits (%)	419,979 (33.81)	185,701 (14.95)	174,496 (14.05)	157,614 (12.69)	157,393 (12.67)	147,166 (11.85)	1,242,349 (100)
Months in Period, N	12	7	6	4	4	4	37
Visits per Month, Mean (SD)	35,020 (1,511.29)	26,545 (3,626.45)	29,107 (3.908.71)	39,465 (3,080.06)	39,413 (1,846.33)	36,839 (2034.12)	33,610 (5,389.21)
Arrived by EMS							
No, N (%)	349,001 (83.10)	149,543 (80.53)	138,086 (79.13)	126,455 (80.23)	125,783 (79.92)	117,181 (79.63)	1,006,049 (80.98)
Yes, N (%)	70,978 (16.90)	36,158 (19.47)	36,410 (20.87)	31,159 (19.77)	31,610 (20.08)	29,985 (20.37)	236,300 (19.02)
Disposition							
Admit, N (%)	39,415 (9.38)	13,781 (7.42)	12,957 (7.42)	10,915 (6.91)	11,028 (7.00)	9,723 (6.60)	97,819 (7.87)
Transfer, N (%)	13,054 (3.11)	7,202 (3.88)	6,305 (3.61)	4,964 (3.14)	4,600 (2.92)	4,510 (3.06)	40,635 (3.27)
Died, N (%)	453 (0.11)	258 (0.14)	319 (0.18)	180 (0.11)	215 (0.14)	224 (0.15)	1649 (0.13)
Left Prior to Completion, N (%)	38,455 (9.15)	14,263 (7.68)	13,058 (7.48)	16,654 (10.55)	15,793 (10.02)	15,649 (10.62)	113,872 (9.16)
Other, N (%)	444 (0.11)	173 (0.09)	97 (0.06)	113 (0.07)	101 (0.06)	92 (0.06)	1020 (0.08)
Discharged, N (%)	328,336 (78.13)	150,053 (80.75)	141,701 (81.14)	124,849 (79.09)	125,753 (79.77)	116,979 (79.39)	987,671 (79.42)
Missing, N (%)	81 (0.02)	84 (0.05)	202 (0.12)	186 (0.12)	162 (0.10)	179 (0.12)	894 (0.07)
ED/UCC Ttype							
Tertiary, N (%)	162,388 (38.64)	38,217 (20.57)	30,643 (17.55)	23,079 (14.62)	22,897 (14.52)	22,852 (15.51)	300,076 (21.95)
Community/ Suburban, N (%)	257,850 (61.35)	147,597 (79.43)	143,996 (82.46)	134,782 (85.38)	134,755 (85.48)	124,504 (84.49)	943,484 (69.02)

Note. SD = standard deviation; EMS = emergency medical services; ED = emergency department; UCC = urgent care centre

Wave 2. However, in Wave 3, the rate increased substantially to 10.55% (n = 16,654) patients. Similarly, the rates in Waves 4 and 5 remained elevated at 10.02% (n = 15,793 patients) and 10.62% (n = 15,649 patients), respectively. Admission rates observed pre-pandemic were 9.38% (n = 39,415) were at their lowest 6.60% (n = 9,723) during the fifth wave, their highest during the pandemic Wave 1, 7.42% (n = 13,781) and wave 2, 7.42% (n = 12,957). Compared with the pre-pandemic period, we found a 16.09% decrease in the relative admission rates (absolute increase of 1.51%; Table 1).

Our analysis of all-cause mortality in the ED revealed noticeable differences between the pre-pandemic period and each wave of the pandemic. In the pre-pandemic period, 0.11% (n = 453) of patients died in the ED. During Wave 1 of the pandemic, the percentage of patients who died increased to 0.14% (n = 258 deaths). This trend continued in Wave 2 (0.18%, n = 319 deaths). However, in Wave 3 the percentage of deaths returned to the pre-pandemic level (0.11%, n = 180). In Waves 4 and 5, the mortality rates increased slightly again to 0.14% (n = 215) and 0.15% (n = 224) deaths, respectively. Despite the relatively small numbers of patients dying in the ED, there was a large increase in the death rate (relative increase of 18.18%, absolute increase of 0.02%) compared with the pre-pandemic period (Table 1).

The median ED LOS for all patients increased for all time intervals: triage to bed, time to initial physician assessment, and time from assessment to discharge (Table 2). The median time from triage to placement in a care space nearly doubled from the pre-pandemic period to Wave 5 (32 to 63 minutes). The time to initial assessment also increased from just under one and a half hours to just over two hours (85 versus 122 minutes) between the pre-pandemic period and Wave 5. The increases in time from physician assessment to discharge were somewhat more modest, with patients spending an additional 19 minutes during this phase of care (133 versus 152 minutes). The net effect of these prolonged times is that patients spend an average of 59 minutes longer in the ED (Table 2).

Patient-level changes

At a patient level, we did not see any differences in the sex of the patients being admitted between COVID-19 waves; overall,

Table 2

*Descriptive Statistics for Time Markers by COVID-19 Wave**

Time Variable	0		1		2		3		4		5		Overall**	
	Time	Change (%)	Time	Change (%)	Time	Change (%)	Time	Change (%)	Time	Change (%)	Time	Change (%)	Time	Change (%)
Triage to Bed														
1st Qu.	0:10:00	na	0:11:00	1.10	0:13:00	1.10	0:16:00	1.10	0:14:55	1.10	0:18:17	1.10	0:13:52	1.39
Median	0:30:00	na	0:32:00	1.07	0:36:00	1.13	0:55:00	1.53	0:51:00	0.93	1:03:43	1.25	0:44:37	1.49
3rd Qu.	1:29:00	na	1:33:00	1.04	1:35:37	1.03	2:10:06	1.36	2:09:00	0.99	2:33:00	1.19	1:54:57	1.29
N (%)	339,781 (34.24)	na	141,077 (14.22)	na	137,845 (13.89)	0.98	126,732 (12.77)	0.92	127,529 (12.85)	1.01	119,419 (12.03)	0.94	992,383 (100)	2.92
Triage to Physician														
1st Qu.	0:42:00	na	0:41:00	0.98	0:41:00	1.10	0:56:27	1.10	0:53:26	1.10	1:00:00	1.10	0:48:59	1.17
Median	1:25:00	na	1:24:00	0.99	1:23:41	1.00	1:52:00	1.34	1:49:00	0.97	2:02:03	1.12	1:39:17	1.17
3rd Qu.	2:35:28	na	2:34:00	0.99	2:30:51	0.98	3:09:22	1.26	3:08:07	0.99	3:29:00	1.11	2:54:28	1.12
N (%)	339262 (34.48)	na	140,689 (14.30)	na	136,110 (13.83)	0.97	124,658 (12.67)	0.92	125,489 (12.76)	1.01	117,631 (11.96)	0.94	983,839 (100)	na
Physician To Discharge														
1st Qu.	0:53:00	na	1:00:00	1.13	1:17:28	1.10	1:10:20	1.10	1:08:15	1.10	1:07:54	1.10	1:06:10	1.25
Median	2:13:00	na	2:23:00	1.08	2:47:27	1.17	2:38:41	0.95	2:35:08	0.98	2:35:16	1.00	2:32:05	1.14
3rd Qu.	4:33:00	na	4:44:00	1.04	5:17:39	1.12	5:08:31	0.97	5:02:34	0.98	5:05:00	1.01	4:58:27	1.09
N (%)	328,506 (34.26)	na	134,446 (14.02)	na	133,960 (13.97)	1.00	122,636 (12.79)	0.92	123,483 (12.88)	1.01	115,843 (12.08)	0.94	958,874 (100)	na

Note. *Hours:Minutes:Seconds; **change percentage is calculated as overall/interval 0 (pre-pandemic); Qu = quarter

51.1% of patients (n = 635,256) were female. The mean age in the cohort was 40.5 years (SD=24.0, n = 1,242,349); we did not find changes in the mean age of patients between COVID-19 waves, but did note a 17.2% relative reduction (4.1%, absolute) in the number of patients under the age of 18 presenting to the ED, compared with the pre-pandemic interval. The mean number of visits by patients in the preceding 90 and 365 days remained unchanged throughout the study periods (Table 3). When we examined the triage acuity of patients, we found that CTAS 2, 3 and 4 patients accounted for 95.8% of the visits (20.8%, n = 253,395; 54.4%, n = 676,203; 20.6%, n = 256,258; respectively). We also noticed a global increase in acuity with the highest relative increase (19.7%) coming from patients with the highest acuity level: CTAS 1 (Table 4).

We identified an overall reduction in the number of ED visits during the study period. We also identified that the proportion of patients presenting for each complaint category was generally stable, both between waves and when compared with the pre-pandemic period, with the exception being for visits related to substance use, mental health concerns, environmental exposure, trauma, respiratory issues, ear related problems, and pediatric specific complaints.

From an absolute count perspective, the largest overall increase in presenting complaints for ED patients were for substance use and mental health ED visits. Both Waves 1 and 2 experienced 17% wave-over-wave increases in the number of patients seen in the ED for mental health-related concerns. There were modest decreases in the proportion of mental health patients in Waves

Table 3

Patient Characteristics by COVID Wave

Variable	COVID Wave 0	1	2	3	4	5	Overall
Gender							
Female (%)	212,298 (50.52)	93,462 (50.30)	90,542 (51.85)	81,324 (51.52)	81,033 (51.40)	76,597 (51.98)	635,256 (51.08)
Male (%)	207,926 (49.48)	92,324 (49.69)	84,077 (48.14)	76,495 (48.46)	76,579 (48.57)	70,724 (48.00)	608,125 (48.90)
Non-binary (%)	0 (0.00)	3 (0.00)	4 (0.00)	3 (0.00)	2 (0.00)	2 (0.00)	14 (0.00)
NA* (%)	14 (0.00)	25 (0.01)	16 (0.01)	39 (0.02)	38 (0.02)	33 (0.02)	165 (0.01)
Age							
Med (IQR)	37.0 (19.0;58.0)	39.0 (24.0;60.0)	40.0 (26.0;60.0)	40.0 (25.0;60.0)	38.0 (22.0;58.0)	38.0 (22.0;58.0)	38.0 (22.0;59.0)
Mean (SD)	39.1 (24.9)	41.8 (23.4)	42.8 (22.9)	41.9 (23.2)	40.1 (23.8)	39.6 (24.0)	40.5 (24.0)
0–18 years (%)	101,062 (24.06)	31,822 (17.14)	25,916 (14.85)	26,189 (16.62)	31,468 (19.99)	31,029 (21.08)	247,486 (19.92)
19–36 years (%)	106,982 (25.47)	52,462 (28.25)	49,755 (28.51)	44,633 (28.32)	44,417 (28.22)	39,793 (27.04)	338,042 (27.21)
37–54 years (%)	87,719 (20.89)	43,249 (23.29)	43,182 (24.75)	38,086 (24.16)	35,846 (22.77)	34,220 (23.25)	282,302 (22.72)
55–72 years (%)	75,859 (18.06)	36,067 (19.42)	34,417 (19.72)	30,171 (19.14)	28,077 (17.84)	26,307 (17.88)	230,898 (18.59)
>72 years (%)	48,357 (11.51)	22,101 (11.90)	21,226 (12.16)	18,535 (11.76)	17,585 (11.17)	15,817 (10.75)	143,621 (11.56)
Number of previous visits by patients in the preceding							
90 days, Mean (SD)	1.1 (3.5)	1.1 (2.6)	1.4 (3.1)	1.5 (3.8)	1.5 (3.2)	1.6 (3.9)	1.3 (3.4)
365 days, Mean (SD)	2.9 (10.0)	2.6 (7.9)	2.6 (7.6)	2.5 (7.9)	2.7 (8.5)	3.1 (10.7)	2.8 (9.0)

Note. *Other No gender indicated, i.e., empty data cell; Med = median; IQR = interquartile range; SD = standard deviation

Table 4

Triage Acuity Assignment by Wave

CTAS level	COVID Wave 0 n, (%)	0 Change (%)	1 n, (%)	1 Change (%)	2 n, (%)	2 Change (%)	3 n, (%)	3 Change (%)	4 n, (%)	4 Change (%)	5 n, (%)	5 Change (%)	Overall n, (%)	Overall Change* (%)
1 (%)	2,981 (0.71)	na	1,426 (0.77)	1.08	1,504 (0.86)	1.12	1,652 (1.05)	1.22	1,619 (1.03)	0.98	1,396 (0.95)	0.92	10,578 (0.85)	1.20
2 (%)	79,729 (18.98)	na	35,808 (19.28)	1.02	39,217 (22.47)	1.17	35,627 (22.6)	1.01	35,314 (22.44)	0.99	32,700 (22.22)	0.99	258,395 (20.8)	1.10
3 (%)	224,412 (53.43)	na	99,997 (53.85)	1.01	96,712 (55.42)	1.03	85,527 (54.26)	0.98	86,869 (55.19)	1.02	82,686 (56.19)	1.02	676,203 (54.43)	1.02
4 (%)	99,523 (23.7)	na	42,420 (22.84)	0.96	31,320 (17.95)	0.79	29,160 (18.5)	1.03	28,274 (17.96)	0.97	25,561 (17.37)	0.97	256,258 (20.63)	0.87
5 (%)	13,084 (3.12)	na	5,809 (3.13)	1.00	4,678 (2.68)	0.86	4,379 (2.78)	1.04	4,250 (2.7)	0.97	3,796 (2.58)	0.96	35,996 (2.9)	0.93
NA** (%)	250 (0.06)	na	241 (0.13)	2.17	1,065 (0.61)	4.69	1,269 (0.81)	1.33	1,067 (0.68)	0.84	1,027 (0.7)	1.03	4,919 (0.4)	6.67
Total (%)	419,979 (33.81)	na	185,701 (14.95)	0.44	174,496 (14.05)	0.94	157,614 (12.69)	0.90	157,393 (12.67)	1.00	147,166 (11.85)	0.94	1,242,349 (100)	na

Note. *Total change is calculated as the change from pre-pandemic (period zero) to the total; **No CTAS Level indicated, i.e., empty data cell; CTAS = Canadian Triage Acuity Scale

3, 4, and 5 (10%, 1%, and 4%, respectively), but the overall proportion of patients being cared for in the ED was 16% higher than during the pre-pandemic period. There were large increases for environmental presentations (heat- and cold-related injuries and illnesses) during Waves 2 and 5 (similar calendar times) with Wave 5 showing a 64% higher proportion of patients in this group. These fluctuations are expected given that the mean daily low temperatures were 4.40 deg C ($p = 0.002$) colder in Wave 5 (M=-13.04 SD=9.48, $n = 115$) compared with Wave 2 (M=-8.64, SD=8.36, $n = 181$), and more than twice as many days with a mean temperature below -20C (26.1%, $n = 30/115$; 12.2%, $n = 22/181$). When we compare the distribution of visits with the pre-pandemic period, we noted that mental health, substance use, and environmental complaints experienced 15.5%, 22.4%, and 26.7% relative (0.51%, 0.5%, and 1% absolute) increases, respectively, from their pre-pandemic periods (Table 5).

Non-sustained reductions were observed among trauma presentations. There were 1,061 fewer patients, a 23.3% relative reduction (0.5% absolute), and reduction in trauma presentations between Waves 1 ($n = 3,821$) and 2 ($n = 3,016$). There were significant drops in respiratory presentations. During Wave 1, there was a 23.7% relative reduction, with an additional 8.2% reduction in Wave two. During the 13 months of Waves 1 and 2, there were 16,598 fewer respiratory presentations compared with the preceding 12-month period. The proportion of patients seen increased sharply in Wave 4 (34.4%), but still resulted in a global reduction in the number of patients in the study period who presented with respiratory complaints compared with the pre-pandemic period, a persistent drop of 12.4% (Table 5).

There were also 2,182 fewer ear-related presentations in the 13 months of Waves 1 and 2 than in the preceding 12-month interval. Despite increases in the numbers of presentations for ear complaints during Waves 3 to 5, there was a persistent 20.2% relative reduction in patients presenting for ear complaints in the study period compared with the pre-pandemic period.

The most dramatic reduction in presenting complaints during the study period was for pediatric-specific CEDIS complaints. This category was the only category with continual reductions in volume throughout all study period intervals. The most dramatic reductions in volumes for pediatric specific complaints occurred in the first two waves, which saw 199 patients present in the 13-month interval compared to 960 in the preceding 12-month interval, a 56.5% overall reduction compared with the pre-pandemic period (Table 5).

Nurse-level changes

When we examined the practice of triage nurses in assessing patients throughout the pandemic, we found there was a transition from triage using the EDIS clinical documentation system to the Epic electronic health record. The proportion of patients

Table 5

CEDIS Presenting Complaints by COVID Wave

	0		1		2		3		4		5		Total	
CEDIS Group	n, (%)	Change (%)	n, (%)	Change (%)	n, (%)	Change (%)	n, (%)	Change (%)	n, (%)	Change (%)	n, (%)	Change (%)	n, (%)	Change (%)
ORTHO	65,333 (15.56)	na	30,114 (16.22)	1.04	26,518 (15.2)	0.94	26,043 (16.52)	1.09	24,903 (15.82)	0.96	22,738 (15.45)	0.98	195,649 (15.75)	1.01
GI	61,866 (14.73)	na	26,778 (14.42)	0.98	27,243 (15.61)	1.08	22,680 (14.39)	0.92	23,027 (14.63)	1.02	22,842 (15.52)	1.06	184,436 (14.85)	1.01
CVS	45,933 (10.94)	na	21,360 (11.5)	1.05	22,670 (12.99)	1.13	19,282 (12.23)	0.94	18,641 (11.84)	0.97	17,709 (12.03)	1.02	145,595 (11.72)	1.07
Skin	44,001 (10.48)	na	22,034 (11.87)	1.13	16,276 (9.33)	0.79	16,449 (10.44)	1.12	14,759 (9.38)	0.90	11,259 (7.65)	0.82	124,778 (10.04)	0.96
RESP	44,610 (10.62)	na	15,033 (8.1)	0.76	12,979 (7.44)	0.92	11,708 (7.43)	1.00	15,745 (10)	1.35	15,469 (10.51)	1.05	115,544 (9.3)	0.88
NEURO	35,979 (8.57)	na	15,216 (8.19)	0.96	15,200 (8.71)	1.06	13,291 (8.43)	0.97	12,791 (8.13)	0.96	12,772 (8.68)	1.07	105,249 (8.47)	0.99
GEN	34,190 (8.14)	na	12,350 (6.65)	0.82	13,587 (7.79)	1.17	12,842 (8.15)	1.05	13,000 (8.26)	1.01	12,727 (8.65)	1.05	98,696 (7.94)	0.98
GU	18,595 (4.43)	na	8,859 (4.77)	1.08	8,068 (4.62)	0.97	6,697 (4.25)	0.92	6,359 (4.04)	0.95	5,825 (3.96)	0.98	54,403 (4.38)	0.99
MH	13,760 (3.28)	na	7,106 (3.83)	1.17	7,820 (4.48)	1.17	6,384 (4.05)	0.90	6,276 (3.99)	0.99	5,707 (3.88)	0.97	47,053 (3.79)	1.16
ENT - T	13,062 (3.11)	na	6,172 (3.32)	1.07	5,186 (2.97)	0.89	4,426 (2.81)	0.95	4,599 (2.92)	1.04	4,350 (2.96)	1.01	37,795 (3.04)	0.98
SUB	9,583 (2.28)	na	5,514 (2.97)	1.30	5,161 (2.96)	1.00	5,146 (3.26)	1.10	4,956 (3.15)	0.97	4,329 (2.94)	0.93	34,689 (2.79)	1.22
OB-GYN	8,411 (2)	na	4,049 (2.18)	1.09	4,447 (2.55)	1.17	3,611 (2.29)	0.90	3,602 (2.29)	1.00	3,266 (2.22)	0.97	27,386 (2.2)	1.10
Trauma	7,243 (1.72)	na	3,821 (2.06)	1.20	2,760 (1.58)	0.77	2,964 (1.88)	1.19	3,171 (2.01)	1.07	2,617 (1.78)	0.89	22,576 (1.82)	1.06
OPTHO	7,598 (1.81)	na	3,823 (2.06)	1.14	3,016 (1.73)	0.84	2,788 (1.77)	1.02	2,361 (1.5)	0.85	1,984 (1.35)	0.90	21,570 (1.74)	0.96
ENT – E	4,797 (1.14)	na	1,436 (0.77)	0.68	1,179 (0.68)	0.88	1,198 (0.76)	1.12	1,340 (0.85)	1.12	1,311 (0.89)	1.05	11,261 (0.91)	0.80
ENT – N	3,310 (0.79)	na	1,496 (0.81)	1.03	1,531 (0.88)	1.09	1,249 (0.79)	0.90	1,224 (0.78)	0.99	1,190 (0.81)	1.04	10,000 (0.8)	1.01
ENVIR	647 (0.15)	na	266 (0.14)	0.93	428 (0.25)	1.79	187 (0.12)	0.48	188 (0.12)	1.00	605 (0.41)	3.42	2,321 (0.19)	1.27
BLANK	101 (0.02)	na	108 (0.06)	3.00	394 (0.23)	3.83	641 (0.41)	1.78	431 (0.27)	0.66	451 (0.31)	1.15	2,126 (0.17)	8.50
PEDS	960 (0.23)	na	166 (0.09)	0.39	33 (0.02)	0.22	28 (0.02)	1.00	20 (0.01)	0.50	15 (0.01)	1.00	1,222 (0.1)	0.43
Total	419,979	na	185,701	na	174,496	na	157,614	na	157,393	na	147,166	na	1,242,349.00	na

Note. ORTHO = orthopedics; GI = gastrointestinal; CVS = cyclic vomiting syndrome; RESP = respiratory; NEURO = neurological; GEN = general; GU = genitourinary; MH = mental health; ENT-T = ear, nose, and throat – throat; SUB = substance use; OB-GYN = obstetrics and gynecology; OPTHO = ophthamology; ENT–E = ear, nose, and throat – ear; ENT–N = ear, nose, and throat – nose; ENVIR = environmental; PEDS = pediatrics triaged using Epic increased from 7.8% of all patients triaged in the pre-pandemic period to more than 66.1% of all patients by Wave 5. In total, 38.0% of patients in the study were triaged using the Epic electronic health record system. Over this time, we also witnessed a decrease in all triage misclassification categories. There were 22.9% and 24.2% relative reductions in high-risk misclassifications and pain-related misclassifications. Although the absolute reduction in high-risk triage misclassifications (patients incorrectly NOT assigned a CTAS 1 or 2) was nominal (0.3%), there was a large absolute reduction in pain misclassifications (patients presenting with pain who did not receive a pain assessment; 3.8%) across the sample, which is a remarkable 6.8% absolute reduction in pain misclassifications between the pre-pandemic and Wave 5. There was also a modest decrease in low-risk triage misclassifications (patients incorrectly assigned a CTAS-5), which declined by a 9.2% relative, or 0.2% absolute reduction (Table 6).

Significant differences across waves were found for pain misclassification $\chi2$ (5) = 11,523, $p < .001$. Pairwise comparisons indicated the only non-significant differences were between Waves 2–3, $p = .41$, though the difference between Waves 3–5, $p = .0449$, and 4–5, $p = .03$, were only marginally significant, all other comparisons being significant at $p < .001$. Significant differences existed for high-risk misclassification χ^2 (5) = 542.73, $p < .001$. Pairwise comparison indicated most contrasts by wave were significant at $p < .001$, except for Waves 2–5, $p = .03$. The non-significant differences were between Waves 2–3, $p = .98$, Waves 2–4, $p < .16$, Waves 3–4, $p = .6$, Waves 3–5, $p = .12$, wave 4–5, $p = .98$. Significant differences across waves were found for low-risk misclassification χ^2 (5) = 257.6, $p < .001$. Pairwise comparisons indicated most contrasts by wave were significant at $p < .005$, or $p < .001$. The non-significant differences were between Waves 0–1, $p = .52$, 0–3, $p = .31$, Waves 2–3, $p = .83$, Waves 2–4, $p = .49$, and Waves 2–5, $p = .21$, and finally between Waves 4–5, $p = .99$.

Table 6

Frequency of Triage Errors by COVID Wave

Variable	COVID-19 Wave 0	1	2	3	4	5	Overall
High-Risk Vital Sign Errors							
No (%)	415,654 (98.91)	184,214 (99.14)	173,373 (99.28)	156,776 (99.31)	156,623 (99.35)	146,446 (99.38)	1,233,086 (99.15)
Yes (%)	4,584 (1.09)	1,600 (0.86)	1,266 (0.72)	1,085 (0.69)	1,029 (0.65)	910 (0.62)	10,474 (0.84)
Low-Risk Vital Sign Errors							
No (%)	413,335 (98.36)	182,631 (98.29)	172,248 (98.63)	155,695 (98.63)	155,665 (98.74)	145,451 (98.71)	1,225,025 (98.50)
Yes (%)	6,903 (1.64)	3,183 (1.71)	2,391 (1.37)	2,166 (1.37)	1,987 (1.26)	1,905 (1.29)	18,535 (1.49)
CEDIS Primary Pain							
No (%)	313,034 (74.54)	137,122 (73.84)	125,340 (71.83)	115,589 (73.34)	117,192 (74.46)	109,077 (74.12)	917,354 (73.84)
Yes (%)	106,945 (25.46)	48,579 (26.16)	49,156 (28.17)	42,025 (26.66)	40,201 (25.54)	38,089 (25.88)	324,995 (26.16)
Pain Error							
No (%)	354,292 (84.36)	160,858 (86.62)	158,758 (90.98)	142,973 (90.71)	144,061 (91.53)	134,119 (91.13)	1,095,061 (88.14)
Yes (%)	65,687 (15.64)	24,843 (13.38)	15,738 (9.02)	14,641 (9.29)	13,332 (8.47)	13,047 (8.87)	147,288 (11.86)
Signed off with No Vitals							
No (%)	411,097 (97.89)	182,258 (98.15)	171,462 (98.26)	154,956 (98.31)	154,937 (98.44)	144,963 (98.50)	1,219,673 (98.17)
Yes (%)	8,820 (0.02)	3,419 (0.04)	2,891 (0.04)	2,404 (0.04)	2,302 (0.04)	2,022 (0.05)	21,858 (0.01)
Triage system used							
EDIS (%)	387,247 (92.21)	144,115 (77.61)	71,508 (40.98)	58,932 (37.39)	58,001 (36.85)	49,919 (33.92)	769,722 (61.96)
EPIC (%)	32,732 (7.79)	41,586 (22.39)	102,988 (59.02)	98,682 (62.61)	99,392 (63.15)	97,247 (66.08)	472,627 (38.04)

Note. CEDIS = Canadian Emergency Department Information System; EDIS = emergency department information system; EPIC = an electronic documentation system

A logistic regression model where each COVID wave was entered at the same time produced co-efficient estimates with each wave having a significant effect except for the sum of low-risk misclassification in Wwave 1 (Table 7). A follow-up Machine Learning analysis using Logistic Regression and Decision Trees was conducted for each outcome variable to determine the predictive ability of COVID waves for misclassification rates and the relative strength of each COVID wave as a predictor of triage misclassification. Across all three outcome variables and both methods, no models were produced that performed adequately. All models performed at chance with poor classification (Table 8). For pain, high-risk, and low-risk misclassification, it is unlikely that the time period of COVID-19 waves alone affected rates.

A significant model effect was found for each outcome variable across all predictors, pain χ^2 (41) = 1,210,091, p < .001, sum of high-risk χ^2 (41) = 77,8071.1, p < .001, and sum of low-risk χ^2 (41) = 1,557,481, p < .001 misclassification. To investigate potential predictors of misclassification a logistic regression model where all predictors were entered was used to identify any potential influential predictors for each type of misclassification. A follow-up Machine Learning analysis for the expanded model using logistic regression and Decision Trees was conducted. The logistic regression model showed marginal improvement for probable error (PE) and standard error (SE) over the COVID-19 wave-only model, however, the results indicated the model was not an adequate predictor of misclassification. Better performance was obtained for the Decision Tree model for Single Loss Expectancy (SLE) where a greater accuracy was obtained with a low false negative rate. Age, centre, and triage to physician appeared to be the most important significant predictors of low-risk acuity misclassification (Supplement 2–4). Though these variables may be important for understanding misclassifications based on the exploratory approach, this is not a predictive/explanatory model for misclassification and only points towards future investigation.

Discussion

At a system level, the pandemic resulted in a regional redistribution of patients with a significantly higher proportion presenting

Table 7

Logistic Regression Coefficients by COVID Wave for Each Outcome Variable

	Pain Error[a]			Sum High Risk Vital[a]			Sum Low Risk Vital[a]		
	Coefficient Estimate	SE*	*p*	Coefficient Estimate	SE*	*p*	Coefficient Estimate	SE*	*p*
Intercept**	-1.70	.004	< .001	-4.50	0.02	< .001	-4.33	0.02	< .001
Wave 1	-0.19	.008	< .001	-0.25	0.03	< .001	0.04	0.03	.27
Wave 2	-0.76	.01	< .001	-0.45	0.04	< .001	-0.1	0.03	.003
Wave 3	-0.79	.01	< .001	-0.51	0.04	< .001	-0.08	0.03	.03
Wave 4	-0.88	.01	< .001	-0.55	0.04	< .001	-0.16	0.03	< .001
Wave 5	-0.83	.01	< .001	-0.59	0.04	< .001	-0.21	0.03	< .001

Note. [a]Bootstrapping was performed to obtain coefficient estimates and SE, with 50 bootstrapped samples; *Standard Error;
** Wave 0 (pre-COVID data) was used as the reference category

Table 8

Predictive Accuracy for COVID Wave Logistic Regression and Decision Tree Models Across Outcome Variables

	Pain Error		Sum High Risk Vital		Sum Low Risk Vital	
Measure	**ACC**	**ROC-AUC**	**ACC**	**ROC-AUC**	**ACC**	**ROC-AUC**
Logistic Regression	.88	.58	.88	.6	.98	.53
Decision Tree	.88	.5	.99	.5	.95	.5

Confusion Matrix

		Truth		Truth		Truth	
Logistic Regression	Prediction	No	Yes	No	Yes	No	Yes
	No	328,868	44,201	369,916	3,152	367,502	5,566
	Yes	0	0	0	0	0	0
		Truth		Truth		Truth	
Decision Tree	Prediction	No	Yes	No	Yes	No	Yes
	No	328,868	44,201	369,916	3,152	367,502	5,566
	Yes	0	0	0	0	0	0

Note. ACC = accuracy; ROC-AUC = receiver operator curve – area under the curve by EMS and presenting to regional/community sites. This increased proportion of patients presenting to non-urban/academic sites was not associated with a proportional increase in patient transfer rates (a surrogate metric for needing care in an alternate location). There were markers that suggested patient acuity increased, including an increased proportion of CTAS 1 and 2 cases, and an increased number of within-ED deaths. The increases in acuity and mortality, especially in light of the transition away from urban/academic hospitals, should be investigated to determine if the changing patterns of destination hospital were associated with worse outcomes.

At a patient level, when comparing pre-pandemic with pandemic periods, we found there was no change in the mean age of patients, nor in the rates of females who presented to the ED. When we grouped patients by age category, however, we observed a noteworthy reduction in the number of patients under the age of 18 who presented to the ED. There was also noteworthy inconsistency in how sex and gender data were collected at triage. Anecdotally, gender data are typically collected by triage nurses using photo identification. In Alberta, gender-affirming licenses were introduced in 2018 and were not available to people under the age of 18 (Government of Alberta, 2016; Clancy, 2018). As a result, there is a high likelihood that not all patients would have had identification that corresponds with their gender, and that the data field is much more likely to represent sex than gender. The differences in sex and gender as constructs is an important issue in epidemiologic research (Bauer, 2023). Our research has shown that these two constructs each impact not only COVID-19-related outcomes (Tadiri, et al., 2020), but also hypertension (Azizi et al., 2022), coronary artery disease (Norris et al., 2017), and cardiovascular health (Azizi et al., 2021), to name a few. Given the extremely limited sample of non-binary patients collected in our study, urgent research is needed to address this apparent data collection deficit.

The overall presenting complaint patterns remained mostly stable when the absolute percentages of patients were considered. However, we observed large reductions in respiratory complaints and a marked increase in the number of presentations related to environmental exposures, mental health, and substance use problems. Although the increases were modest, they highlight the need to support the most vulnerable and marginalized patients susceptible to these complaints and suggest that specific presentations (those associated with mental health, substance use, or environmental exposures) may be unable to seek care outside of the ED.

The zone-level change in documentation system and move from EDIS as the primary means of electronic triage data capture to Epic was associated with a decrease in all markers of triage misclassification. The transition from EDIS to Epic may have impacted the distribution of the sub-grouped CEDIS complaints that fall within each category, as well as the pain misclassification rate. Although these were not explored in this study, the unstructured triage narratives included in the Edmonton Zone Triage dataset have been previously used for quality improvement and epidemiologic research (Picard, et al., 2023b) and future work to ensure that the categorical assignments of pain and presenting complaint should be performed to ensure they are congruent with the narrative assessment. The markers of patient flow times to bed, physician initial assessment, and disposition all increased. We cannot determine if this is primarily attributable to the system pressures, such as the need for additional screening and isolation, the transition to a new electronic health record system, or the additional workup required to discharge a proportionally higher number of patients despite their increased acuity.

Our findings are congruent with previous work that has demonstrated increased rates of patients presenting for mental health and substance use issues. We add contextual data to these data by demonstrating that although there was a significant relative increase for these presentations, the absolute changes were nominal, particularly when they were considered with respect to the overall number of presentations to the ED.

Our study builds on previous work in Alberta, but unlike most previous studies that examined the Calgary area, it examines the Edmonton area. This is of particular benefit from a provincial perspective, with both major metro areas now assessed. The combined studies populations of Edmonton and Calgary (1.5 million and 1.2 million) represent 61.4% of the population of Alberta (Alberta Health Services, 2016a, 2016b; Statistics Canada, 2021). These findings can be helpful to guide future pandemic responses.

Strengths and Limitations

The strength of this study comes primarily from its design as a prolonged population-level study of a highly populous health zone that represents diverse communities. Most pandemic-related studies examined brief windows of time and limited COVID-19 waves. Studies that examine these periods captured the most volatile period of the pandemic and associated differences may have overestimated effects and the expected outcomes. Our study examined the effects of COVID-19 and its distinct waves of positive cases over the first three years of the pandemic. This perspective of multiple hospital types across a variety of communities not only allows policy and decision-makers to contextualize the absolute differences, but also may offer insight into how long the acute changes in presentation patterns can be expected to last.

The primary limitation of this study is the grouping of patients according to wave of COVID-19 infection. These groupings led to some baseline imbalances in groups and may have distorted changes in presentation patterns that may otherwise have been evident; this weakness is tempered by the proportional examination of patterns and the robust sample size.

The other limitation in this study is attributable to the data collected. We are limited in our analysis of the presenting complaint categories by changes in the data collection methods that arose from the transition between electronic health records during the reporting period. This transition prevented us from examining patterns of consultations and trauma due to increasing missing and incomplete data. The irregular reporting of the trauma data is somewhat tempered by the fact that there was not a proportionate increase in trauma-related CEDIS primary presenting complaints.

Conclusion

We have identified that there were changes in the patterns of urban/academic versus regional/community ED visit volumes and temporary changes in presenting complaint patterns. We offer insight into the duration of change, the level of reduction in the number of patients presenting to urban/academic centres and the increase in the use of regional/community hospital EDs. There was a clinically significant increase in the overall LOS and acuity, combined factors that could significantly impact the safety of an already stretched ED system. Importantly, the increase seen in presentations related to environmental exposures, mental health, and substance use problems during the COVID pandemic suggests that there may be ongoing support/resources addressing these issues post-pandemic. Future studies must consider analyses of presenting complaints and associated disease patterns during the pandemic.

Implications for Emergency Nursing Practice

1. There may be a relationship between newer electronic health record-supported triage systems and triage misclassification rates.
2. There was an increase in overall acuity among patients presenting to the ED between 2020–2023.
3. There has been an increase in overall ED LOS, which needs additional investigation.
4. Pandemics may increase the rates at which patients present for environmental exposure, mental health, and substance use concerns.

About the Authors

Christopher Picard is working as a Clinical Nurse Specialist in Trauma. He is a PhD student in the faculty of Nursing at the University of Alberta. His research focus is on resuscitation care, artificial intelligence, and triage.

Carmel Montgomery, PhD, RN, has been an assistant professor in the Faculty of Nursing at the University of Alberta since 2021. She completed her PhD with the Department of Critical Care Medicine at the University of Alberta following several years of working as a staff nurse in the Intensive Care Unit, palliative home care, quality improvement, and patient safety.

Efrem Violato, PhD, is a Research Associate at the Centre for Advanced Medical Simulation at the Northern Alberta Institute of Technology with a focus on research methods & design, and assessment.

Matthew J. Douma, MN, RN, is a resuscitation scientist, a PhD candidate at University College Dublin, editor of CJEN and a recovering emergency nurse.

Colleen M. Norris, MN, BScN, RN, FAHA, FCAHS, is a professor and the Associate dean of Research in the Faculty of Nursing at the University of Alberta. She is the Cavarzan Chair in Women's Health Research and an adjunct professor with the Faculty of Medicine and School of Public Health at the UA. Dr. Norris' research addresses the sex and gender factors that affect women's health from the post-reproductive stage to end of life care, with a focus on Women's Heart Health.

Conflict of Interest Statement

None declared.

Contributions of the authorship team & CRedIT author statement

All authors contributed to the design of this manuscript. CP, MJD and CMN initiated the project. The data collection and analyses were performed by CP and EV. The manuscript was drafted by CTP and MJD. CM and CMN supervised this project. All authors contributed to the manuscript. All authors have all read, refined and approved the final manuscript.

Source(s) of Funding: *Funding was provided by the National Emergency Nurses Association (NENA).*

REFERENCES

Alberta Health Services. (2016a). *Mapping out healthcare in your community: Calgary zone*. Calgary Zone Map and Brochure. https://www.albertahealthservices.ca/assets/zone/ahs-zn-calgary-map-brochure.pdf

Alberta Health Services. (2016b). *Mapping out healthcare in your community: Edmonton zone*. Edmonton Zone Map and Brochure. https://www.albertahealthservices.ca/assets/zone/ahs-zn-edmonton-map-brochure.pdf

Ayala, A., Villalobos Dintrans, P., Elorrieta, F., Castillo, C., Vargas, C., & Maddaleno, M. (2021). Identification of COVID-19 waves: Considerations for research and policy. *International Journal of Environmental Research and Public Health*, *18*(21), 11058. https://doi.org/10.3390/ijerph182111058

Azizi, A., Alipour, P., Raparelli, V., Norris, C. M., & Pilote, L. (2022). The role of sex and gender in hypertension. *Journal of Human Hypertension*. https://doi.org/10.1038/s41371-022-00789-4

Azizi, Z., Gisinger, T., Bender, U., Deischinger, C., Raparelli, V., Norris, C. M., Kublickiene, K., Herrero, M. T., Emam, K. E., Kautzky-Willer, A., Pilote, L., & GOING-FWD Investigators. (2021) Sex, gender, and cardiovascular health in Canadian and Austrian populations. *Canadian Journal of Cardiology, 37*(8), 1240–1247. https://doi.org/10.1016/j.cjca.2021.03.019.

Bagshaw, S. M., Zuege, D. J., Stelfox, H. T., Opgenorth, D., Wasylak, T., Fraser, N., Nguyen, T. X., & Critical Care Strategic Clinical Network, Alberta Health Services, Alberta, Canada. (2022). Association between pandemic coronavirus disease 2019 public health measures and reduction in critical care utilization across ICUs in Alberta, Canada. *Critical Care Medicine*, *50*(3), 353–362. https://doi.org/10.1097/CCM.0000000000005275

Bauer, G. R. (2023). Sex and gender multidimensionality in epidemiologic research. *American Journal of Epidemiology*, *192*(1), 122–132. https://doi.org/10.1093/aje/kwac173

Beveridge, R., John, S., Clarke, B., John, S., Janes, L., John, S., Savage, N., Thompson, J., Dodd, G., Murray, M., Ontario, B., Jordan, C. N., Warren, D., & Vadeboncoeur, A. (1998). *Implementation Guidelines for The Canadian Emergency Department Triage & Acuity Scale (CTAS),* 32.

Bullard, M. J., Villa-Roel, C., Bond, K., Vester, M., Holroyd, B. R., & Rowe, B. H. (2009). Tracking emergency department overcrowding in a tertiary care academic institution. *Healthcare*

Quarterly (Toronto, Ont.), *12*(3), 99–106. https://doi.org/10.12927/hcq.2013.20884

Cameron-Blake, E., Breton, C., Sim, P., Tatlow, H., Hale, T., Wood, A., Smith, J., Sawatsky, J., Parsons, K. T., & Tyson, K. (2021). *Variation in the Canadian provincial and territorial responses to COVID-19* (BSG-WP-2020/032). Blavatnik School of Government Working Paper. https://centre.irpp.org/2021/03/variation-in-the-canadian-provincial-and-territorial-responses-to-covid-19/

Clancy, C. (2018, June 08). Third sex option for government IDs rolled out by Alberta NDO. *Edmonton Journal*. https://edmontonjournal.com/news/politics/x-marks-the-spot-as-alberta-ndp-rolls-out-third-gender-marker-on-id-documents

Cotton, R., Drew, R., Douma, M., O'Dochartaigh, D., Keddie, C., Muncaster, K., & Picard, C. (2021). An analysis of individual and department triage variances to identify, quantify, and improve markers of triage nurse accuracy. *Canadian Journal of Emergency Nursing*, *44*(2). https://doi.org/10.29173/cjen130

Government of Alberta. (2016). Bill 29: Vital statistics and life events modernization act. 1st Reading Nov. 8, 2016, 29th Legislature, 2nd session. https://www.assembly.ab.ca/assembly-business/bills/bill?billinfoid=11662&from=bills

Government of Canada. (2023). *Daily climate data: Edmonton Blatchford Alberta, Environment and Climate Change Canada - Meteorological Service of Canada*. https://climate.weather.gc.ca/climate_data/hourly_data_e.html

Grafstein, E., Bullard, M. J., Warren, D., Unger, B., & CTAS National Working Group. (2008). Revision of the Canadian Emergency Department Information System (CEDIS) Presenting complaint list (version 1.1). *CJEM*, *10*(2), 151–173. https://doi.org/10.1017/s1481803500009878

Grafstein, E., Unger, B., Bullard, M., & Innes, G. (2003). Canadian Emergency Department Information System (CEDIS) Presenting complaint list (version 1.0). *CJEM*, *5*(1), 27–34. https://doi.org/10.1017/s1481803500008071

Hohl, C. M., Rosychuk, R. J., Hau, J. P., Hayward, J., Landes, M., Yan, J. W., Ting, D. K., Welsford, M., Archambault, P. M., Mercier, E., Chandra, K., Davis, P., Vaillancourt, S., Leeies, M., Small, S., Morrison, L. J., & Canadian COVID-19 Rapid Response Network (CCEDRRN) investigators for the Network of Canadian Emergency Researchers, for the Canadian Critical Care Trials Group. (2022). Treatments, resource utilization, and outcomes of COVID-19 patients presenting to emergency departments across pandemic waves: An observational study by the Canadian COVID-19 Emergency Department Rapid Response Network (CCEDRRN). *CJEM*, *24*(4), 397–407. https://doi.org/10.1007/s43678-022-00275-3

Hong, M., Jacobucci, R., & Lubke, G. (2020). Deductive data mining. *Psychological Methods*, *25*(6), 691–707. https://doi.org/10.1037/met0000252

Innes, G., Murray, M., & Grafstein, E. (2001). A consensus-based process to define standard national data elements for a Canadian emergency department information system. *CJEM*, *3*(4), 277–284. https://doi.org/10.1017/s1481803500005777

Karaivanov, A., Lu, S. E., Shigeoka, H., Chen, C., & Pamplona, S. (2021). Face masks, public policies and slowing the spread of COVID-19: Evidence from Canada. *Journal of Health Economics*, *78*, 102475. https://doi.org/10.1016/j.jhealeco.2021.102475

Lane, D. J., Blanchard, I. E., Buick, J. E., Shaw, M., & McRae, A. D. (2021). Changes in presentation, presenting severity and disposition among patients accessing emergency services during the first months of the COVID-19 pandemic in Calgary, Alberta: A descriptive study. *CMAJ Open*, *9*(2), E592–E601. https://doi.org/10.9778/cmajo.20200313

Norris, C. M., Johnson, N. L., Hardwicke-Brown, E., McEwan, M., Pelltier, R., Pilote, L. (2017). The contribution of gender to apparent sex differences in health status among patients with coronary artery disease. *Journal of Women's Health, 50-57*. http://doi.org/10.1089/jwh.2016.5744

Ospina, M. B., Bond, K., Schull, M., Innes, G., Blitz, S., & Rowe, B. H. (2007). Key indicators of overcrowding in Canadian emergency departments: A Delphi study. *CJEM*, *9*(5), 339–346. https://doi.org/10.1017/s1481803500015281

Picard, C., Cotton, R., Ware, M., Hill, A., Bell, B., Bouffard, L., O'Dochartaigh, D., Dyjur, D., Montgomery, C., Douma, M. J., & Norris, C. M. (2023a). Edmonton Zone triage project (EZ Triage): Validation of an automated triage audit system. *Canadian Journal of Emergency Nursing*, *46*(1). https://doi.org/10.29173/cjen223

Picard, C., & Kleib, M. (2020). Advancing emergency nurses' leadership and practice through informatics: The unharnessed power of nurses' data. *Canadian Journal of Emergency Nursing*, *43*(3). https://doi.org/10.29173/cjen37

Picard, C., Kleib, M., Norris, C. M., O'Rourke, H. M., Montgomery, C., Douma, M. J. (2023b). The use and structure of emergency nurses' triage narrative data: Scoping review. *JMIR Nursing, 6, e41331*. https://doi.org/10.2196/41331

Pujolar, G., Oliver-Anglès, A., Vargas, I., & Vázquez, M.-L. (2022). Changes in access to health services during the COVID-19 pandemic: A scoping review. *International Journal of Environmental Research and Public Health*, *19*(3), 1749. https://doi.org/10.3390/ijerph19031749

Rennert-May, E., Leal, J., Thanh, N. X., Lang, E., Dowling, S., Manns, B., Wasylak, T., & Ronksley, P. E. (2021). The impact of COVID-19 on hospital admissions and emergency department visits: A population-based study. *PloS One*, *16*(6), e0252441. https://doi.org/10.1371/journal.pone.0252441

Rowe, B. H., Bond, K., Ospina, M. B., Blitz, S., Schull, M., Sinclair, D., & Bullard, M. (2006). Data collection on patients in emergency departments in Canada. *CJEM*, *8*(6), 417–424. https://doi.org/10.1017/s1481803500014226

Rowe, B. H., McRae, A., & Rosychuk, R. J. (2020). Temporal trends in emergency department volumes and crowding metrics in a western Canadian province: A population-based, administrative data study. *BMC Health Services Research*, *20*(1), 356. https://doi.org/10.1186/s12913-020-05196-4

Statistics Canada. (2021). *Census of population: Geographic level health regions*. https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/details/download-telecharger.cfm?Lang=E

Tadiri, C. P., Gisinger, T., Kautzky-Willer, A., Kublickiene, K., Trinidad-Herrero, T., Raparelli, V., Pilote, L., & Norris, C. M. (2020). The influence of sex and gender domains on COVID-19 cases and mortality. *Canadian Medical Association Journal. 192*(36), 1041–1045. https://doi.org/10.1503/cmaj.200971

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., Vandenbroucke, J. P., & STROBE Initiative. (2007). Strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. *BMJ (Clinical Research Ed.)*, *335*(7624), 806–808. https://doi.org/10.1136/bmj.39335.541782.AD

World Health Organization. (2020). *Coronavirus disease (COVID-19) Canada dashboard with vaccination data*. https://covid19.who.int

Xiong, X., Wai, A. K. C., Wong, J. Y. H., Tang, E. H. M., Chu, O. C. K., Wong, C. K. H., & Rainer, T. H. (2022). Impact of varying wave periods of COVID-19 on in-hospital mortality and length of stay for admission through emergency department: A territory-wide observational cohort study. *Influenza and Other Respiratory Viruses*, *16*(2), 193–203. https://doi.org/10.1111/irv.12919

Zhang, S. X., Arroyo Marioli, F., Gao, R., & Wang, S. (2021). A second wave? What do people mean by COVID waves? A working definition of epidemic waves. *Risk Management and Healthcare Policy*, *14*, 3775–3782. https://doi.org/10.2147/RMHP.S326051