The epidemiology of burn injuries in a Canadian population during the COVID-19 pandemic

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Abstract

Purpose:

To investigate the changes in the epidemiology of burn injuries in a Canadian population during the COVID-19 pandemic.

Methods:

Data from the Canadian Institute for Health Information were used to evaluate differences in burn ED visits from before to during the COVID-19 pandemic. Logistic regression models estimated the odds of a severe burn occurrence.

Results:

During the pandemic, there were significant decreases in ED visits for burns. Distributions of factors associated with burns had little to no change. Period, age, gender, income, month, and daytime were significantly associated with severe burns during the pandemic.

Conclusions:

The study found large reductions in the number of ED visits during the pandemic, but no evidence of changes in the epidemiology of burns or patterns in the patient populations.

Keywords:

Burn, injury, epidemiology, demographic, COVID-19, pandemic, pattern, severe burns

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List of Acronyms

CA	Census area
CIHI	Canadian Institute for Health Information
DAD	Discharge Abstract Database
ED	Emergency department
ICD-10	International Classification of Disease version-10
MOHLTC	Ministry of Health and Long-Term Care
NACRS	National Ambulatory Care Reporting System
OHIP	Ontario Health Insurance Plan
OR	Odds ratio
Q1	Income Quintile 1
Q2	Income Quintile 2
Q3	Income Quintile 3
Q4	Income Quintile 4
Q5	Income Quintile 5
REF	Reference variable
SES	Socioeconomic status
TBSA	Total body surface area

1 Introduction

1.1 Background

Since late 2019, the SARS-CoV-2 virus has been the dominant global health issue (1). By the end of 2021, more than 250 million COVID-19 cases and 5 million deaths were recorded due to the SARS-CoV-2 virus (2). Despite the efforts of governments to prevent further spread of the virus, cases continued to increase, leading to immense human and financial costs on healthcare systems around the world. In Canada, the cost of treating a single COVID-19 patient totalled $23 000, with the total cost of treating all cases nearing $1 billion (3).

Rapid transmission of the virus lead to strained healthcare systems (4-6). In Canada, various levels of government enacted country-wide social lockdowns. Restrictions included reduced international travel, endorsements of working from home and restrictions of public services (7-9). Public health guidelines encouraged indoor mask wearing, frequent hand-washing, avoiding use of public amenities, and quarantine after virus exposure. These were all individual components of community-wide health protection plans across the country (10).

During the lockdowns, public emergency departments (ED) saw a significant decrease in visits (11). The Canadian Institute for Health Information (CIHI) reported a 55% drop in ED visits, following the initiation of lockdowns. Reduced ED visits decreased wait times (11), while fewer surgical admissions were observed in Calgary (12), Ottawa (13) and the north-east region of the United States (14). In the United States, acute injuries saw the largest reductions in health service use (14). In Ottawa, despite the decrease in overall ED visits, there was an increase in the proportion of severe injuries (13).

Burns are common unintentional injuries, especially in pediatric populations (15, 16). Burns are injuries to human tissue from thermal sources and can place a major burden on patients (17, 18). These injuries may cause extreme morbidity, leading to significant decrements in mental and physical health (19). On a global scale, increased risk of burns is associated with lower socioeconomic status (SES) (17, 19-21), and being in infanthood, childhood or late adulthood (15, 17, 19-23). However, significant decreases in morbidity and mortality rates have been observed in the 21st century (22, 23) due to better burn safety regulations, installation of smoke detectors, and improved health management systems (19, 24).

While ED visits decreased during the lockdowns (11), the effect of the pandemic on burn injury patterns in the general population is unknown within Canada. In other countries, contradictory results based on the population and country have been found. For example, during the pandemic lockdowns, some increases in burn ED visits were found in USA, and Italy (25, 26), while decreased visits were found in Turkey, Spain and Japan (27-29). In addition, nearly all existing literature does not include the examination of factors related to the occurrence of severe burn injuries. Novel modelling of factors associated with severe burns may provide important insight into factors associated with these severe injuries.

1.2 Objective

The effect of lockdown orders on burn epidemiology during the COVID-19 pandemic remains unknown within Canada. The objective of the study is to investigate the epidemiology of burn injuries in a Canadian population from before to during the COVID-19 pandemic. This information may help healthcare systems understand the impact of the pandemic on burn injuries and anticipate the impact of potential lockdowns. These results will also provide health professionals with relevant information to determine which patient populations are at most risk of burn injuries and severe burn injuries during a socially restricted time frame.

2 Methods

2.1 Study Design

We performed a retrospective, population-based secondary analysis of data for the province of Ontario. Data were collected from the National Ambulatory Care Reporting System (NACRS) and the Discharge Abstract Database (DAD), both of which are published by CIHI. The NACRS and DAD databases provide acute care data through hospitalization and ED reporting. Information is provided on visit and patient characteristics, clinical measures and administrative data related to health care system use across Canada (30, 31). CIHI uses the International Classification of Diseases codes (ICD-10) to identify specified diagnoses and the use of health services. CIHI's data quality mandate (32) ensures data are high quality, unbiased, relevant and reliable to aid stakeholders in making informed decisions to improve health care services.

2.2 Population and Setting

The study was based on the entire population of Ontario, and included those who used the publicly funded healthcare system for burn injuries. The province of Ontario is the most populated in Canada, home to a diverse population of 14 million inhabitants (33). Approximately, 90% of the population resides in a larger urban census area (CA). Most residents live in southeastern Ontario, concentrated in some of Canada's largest CA's, including Ottawa, Hamilton, and the Toronto region (34). The Ontario healthcare system is operated by the Ministry of Health and Long-Term Care (MOHLTC), and further managed through smaller administrative units, such as the Ontario Health Regions, Public Health Units, and municipal or regional governments (35). Through the *Connecting Care Act, 2019*, the provincial government created an agency, known as Ontario Health (OH), which oversees the coordination, modernization and improvement of the provincial healthcare system (36). Ontario has a publicly funded healthcare system, in which residents' medical expenses are covered through the Ontario Health Insurance Plan (OHIP). For non-medical emergencies and routine health procedures, patients may seek primary care with family-based medical professionals. There are also many non-public and private care centres where patients can receive treatment. Many of these family or private clinics do not share visit data with CIHI, and therefore are not captured within the NACRS or DAD. For urgent care, residents can visit an ED or contact the emergency 9-1-1 phone number (37).

The study included patient data from the NACRS and DAD. Burn records were retrieved through ICD-10 codes T20-T32 and L55. All codes involving V, W, X, and Y were considered for causes of injury. The "pandemic" time period considered burn visits reported on or between March 1, 2020, and August 31, 2020. The "pre-pandemic" time period considered reported burn visits on parallel dates in 2019. Additional full-year summaries collected health services data for the full calendar years in 2019 and 2020. Patients were excluded if their visit occurred outside of the time periods. The study population was representative of the overall Ontario population residing within the province. No specific demographic variables were used as exclusion criteria. Due to the nature of ICD-10 codes retrieved, self-inflicted burn injury visits were not captured in the study.

2.3 Variables

The outcome variable was the count of patient visits to public EDs for burn injuries. This was assessed through absolute counts of patient visits to the ED and the reported number of individual burn injuries each patient had sustained. The number of burn visits and cases were assessed for each exposure variable across all time periods.

Several measures were considered as potential exposure variables. Age was categorized into the following groups, <1 year, 1 year, 2-4 years, 5-9 years, 10-14 years, 15-19 years, 20-29 years, 30-39 years, 40-49 years, 50-64 years and 65 years and older. Sex was included as male or female. Region of living was reported as urban or rural/remote. Income was reported using Statistics Canada standard income quintiles, Q1, Q2, Q3, Q4, and Q5. The lowest earning income was represented by Q1, the highest earning by Q5. Month of injury corresponds to visit date for all twelve calendar months. In some analyses, there is a reference to pandemic time periods. These are months of the initial lockdown, from March, up to and including August. Time of day was split into four categories. First was early morning for any visits between 00:00 and 5:59. Morning corresponded to 6:00 to 11:59. Afternoon were visits between 12:00 and 17:59. Evening/night were visits between 18:00 and 23:59. Ambulance use was reported as used or not used. Visit disposition was reported as death, discharge home, voluntary leave or transfer. Transfers may include transfers to inpatient care, inpatient care, acute or non-acute facilities, intra-facility movement, ambulatory care, residential care, group living and correctional facilities. However, in the CIHI databases, there was no differentiation for different transfer types. For burn variables, mechanism was denoted as scald, contact, electrical, fire/flame/smoke, radiation, sunburn, uncertain etiology and other. Burn site was reported as head/neck, eye, trunk, upper limbs, hand and wrist, lower limbs, foot and ankle, respiratory, internal, and multi-unspecified sites. Burn depth was reported as first-, second- or third-degree, with an additional 'unclassified' category.

All third-degree burns were categorized as severe burns for the purposes of the logistic regression modelling. Burns may be classified into major, and minor based on injury depth and total body surface area (TBSA) (18). Depth refers to skin layers damaged by a burn injury. First-degree burns affect only the epidermis and are referred to as superficial burns. Second-degree burns may be referred to as superficial partial-thickness burns or deep partial-thickness burns. Full-thickness or third-degree burns injure the dermis skin layer, destroying nerves and require surgical treatment (18). TBSA refers to the total outer body surface area damaged by burns and is typically presented as a percentage. While some researchers identify TBSA as an ideal severity marker (18), we were unable to analyze TBSA due to the method of reporting, and thus used third-degree burns as our severity indicator.

2.4 Statistical Analyses

Descriptive statistics provided an overview of patient injury data for all time periods. Data includes all burn visits in 2019 and 2020. A second analysis restricted the time period to March to August of 2019 (pre-pandemic) and 2020 (pandemic) to determine differences in the pre-pandemic and pandemic time frames. Primary comparative analysis strategies were chi-square tests as appropriate. These tests assessed the relationship between the time frames (6-month pandemic or pre-pandemic) and each of the included exposure variables. Age standardized rates for burn ED visits were calculated for full-year data and parallel pandemic month data in 2019 and 2020.

Logistic regression models were used to determine the odds of a severe burn injury. The outcome variable was the presence of a third-degree burn, with 1, denoting the patient experiencing at least one third-degree burn anywhere on their body, and 0 represented absence of third-degree burns. First, a univariate model was built, using only the period variable (pandemic and non-pandemic), including all pooled data from January 2019 to August 2020. Then, a second pooled data model was built, which adjusted for several exposure variables in addition to the pandemic variable. This adjusted model included potential exposure variables with their reference groups as follows: age (20-29 years), sex (female), region (urban), income (Q5), period (pre-pandemic), month (March), daytime (afternoon), and ambulance use (not used).

A third model was built using data from the initial pandemic lockdown period. This was restricted to data from March 2020 to August 2020, and included all previously mentioned variables except pandemic period, and the exclusion of months outside the pandemic. This set of models allowed for direct and indirect comparisons of factors associated with severe burns across the periods. Additional models were also created and are available in the appendix. Results include ORs and 95% confidence intervals. Statistical significance was determined at the 5% (two-sided) significance level. Data were analyzed using SAS version 9.4 (Cary, NC).

3 Results

3.1 Full year summaries

In total, 39,315 patients with burn injuries used the public health care system in Ontario in 2019 and 2020. The total number of patient visits was 21,693 in 2019 and decreased by 18.8% to 17,622 in 2020 (Table 1). Additional full year summaries on burn visits in 2018 and 2019 are provided in the appendix for reference (Table A10).

In both years, 20–29-year-olds were the most frequently burned, peaking at 4,219 (19.4%) visits in 2019 and 3,217 (18.3%) in 2020, representing an approximate 23.8% decrease. Despite slight changes in proportions, the age distributions repeated similar patterns in each year. These patterns include the 10-14 year cohort having the lowest burn counts, and the peak count reported at 20-29 years. A decrease in burn counts was observed for the 65+ year group (Table 1, Figure B1).

When considering age rates, both years followed similar distributions. The highest rates were reported for the 1-year age group, 900.8 per 100,000 per year in 2019 and 740.7 per 100,000 per year in 2020 (Table 2, Figure B2). The next highest rates were the <1 year age group, 402.9 in 2019, 324.0 in 2020, and the 2-4 year age group, 257.7 in 2019 and 210.6 in 2020. The lowest rates were observed in the 65+ age group, 78.9 in 2019 and 65.28 in 2020 (Table 2).

Males and urban areas reported the most frequent visits by sex and region. In 2019 and 2020, males made up 11,451 and 9,642 of burn cases, an approximate decrease of 15.8%. Urban burns made up 17,726 to 14,426 of the region-based visits. Health services utilization was more frequently reported for lower income quintiles. The two lowest income quintiles, 1 and 2, comprised of 46.7% (10,115 total) of visits in 2019 and 46.2% (8,140 total) in 2020. The highest income quintile accounted for 3,381 visits in 2019 and 2,714 cases in 2020 (Table 1).

A monthly trend showed more visits in the summer months of June, July and August. The three months surpassed 2,000 cases each in 2019. In 2020, July reached 2,233 cases, followed by 1,951 in August and 1,890 in June, while the lowest count in 2020 was found in April at 810 (Table 1). For daily time trends, reported burn visits increased from the early morning to afternoon, but showed a slight decrease into the evening/night hours (Table 1).

From pre-pandemic to the pandemic, there was slight increase in the proportion of patients that used any form of ambulance as transportation to an ED visit. For disposition, the number of burn deaths increased from 50 in 2019 to 63 in 2020. Decreases were noted for home discharges, from 19,646 in 2019 to 16,046 in 2020, for voluntary leaves, from 882 in 2019 to 457 in 2020, and for transfers, from 1,115 to 1,056 (Table 1).

Table 1

Full year descriptive summaries of all demographic variables for burn injury patients in 2019 and 2020.

Variables		**2019** n=21693	**2020** n=17622
Age	< 1 year	516 (2.4%)	415 (2.4%)
	1 year	1193 (5.5%)	981 (5.6%)
	2-4 years	1090 (5.0%)	891 (5.1%)
	5-9 years	774 (3.6%)	664 (3.8%)
	10-14 years	746 (3.4%)	552 (3.1%)
	15-19 years	1633 (7.5%)	1228 (7.0%)
	20-29 years	4219 (19.4%)	3217 (18.3%)
	30-39 years	3081 (14.2%)	2680 (15.2%)
	40-49 years	2655 (12.2%)	2216 (12.6%)
	50-64 years	3704 (17.1%)	3056 (17.3%)
	65+ years	2082 (9.6%)	1722 (9.8%)
Sex	Female	10242 (47.2%)	7980 (45.3%)
	Male	11451 (52.8%)	9642 (54.7%)
Region	Rural/Remote	3967 (18.3%)	3196 (18.1%)
	Urban	17726 (81.7%)	14426 (81.9%)
Income Quintile	1 – low income	5548 (25.6%)	4441 (25.2%)
	2	4567 (21.1%)	3699 (21.0%)
	3	4247 (19.6%)	3506 (19.9%)
	4	3950 (18.2%)	3262 (18.5%)

	5 – high income	3381 (15.6%)	2714 (15.4%)
Month of Injury	January	1429 (6.6%)	1390 (7.9%)
	February	1390 (6.4%)	1363 (7.7%)
	March	1548 (7.1%)	1049 (6.0%)
	April	1605 (7.4%)	810 (4.6%)
	May	1843 (8.5%)	1523 (8.6%)
	June	2103 (9.7%)	1890 (10.7%)
	July	2952 (13.6%)	2233 (12.7%)
	August	2301 (10.6%)	1951 (11.1%)
	September	1791 (8.3%)	1526 (8.7%)
	October	1727 (8.0%)	1411 (8.0%)
	November	1497 (6.9%)	1261 (7.2%)
	December	1507 (6.9%)	1215 (6.9%)
Daytime	Early Morning	1890 (8.7%)	1594 (9.0%)
	Morning	4867 (22.4%)	3893 (22.1%)
	Afternoon	7415 (34.2%)	6360 (36.1%)
	Evening/Night	7521 (34.7%)	5775 (32.8%)
Ambulance Use *	Any Type	2359 (10.9%)	2317 (13.1%)
	None/Walk-In	19334 (89.1%)	15305 (86.9%)
Disposition **	Death	50 (0.2%)	63 (0.4%)
	Discharge Home	19646 (90.6%)	16046 (91.1%)
	Leave	882 (4.1%)	457 (2.6%)
	Transfer	1115 (5.1%)	1056 (6.0%)

*: Any type ambulance use involved patients transported to an ED or hospital by ground, air, or water

**: Disposition transfer includes patient movement to day surgery, to the ED, to clinics, intra-facility movement, movement to inpatient, residential care or correctional facility.

Table 2

Age ED visit rates for each cohort (per 100,000 per year), full year summaries in 2019 and 2020.

	Year	
Age Cohort	**2019**	**2020**
<1	402.9	324.0
1	900.8	740.7
2-4	257.7	210.6
5-9	101.3	86.9
10-14	92.8	68.7
15-19	203.8	153.2
20-29	225.5	171.9
30-39	159.7	138.9
40-49	148.8	124.2
50-64	125.6	103.7
65+	78.9	65.3
Total Age-Standardized Rate	**152.5**	**123.9**

Specific to burn injury measures, the number of cases were not equal to the number of patient visits as each patient could experience more than one burn. Scalding was the most common mechanism at 7,261 in 2019 and decreased by 18.6% to 5,911 in 2020, while the least frequent were radiation at 90 in 2019 and 54 in 2020, and electrical at 195 in 2019 and 157 in 2020. The largest proportion of mechanisms were unknown etiologies at 54.5% in 2019 and 43.0% in 2020 (Table 3).

Nearly half of all burns were classified as an unspecified degree. Excluding unspecified, second-degree burns were the highest reported depth across both years, 9,135 in 2019 and down 11.0% to 8,134 in 2020. Third-degree burns decreased by 10.6%, from 1,050 to 939. Full details regarding burn injury sites are included in Table 3.

Table 3

Full year descriptive summaries of all burn-specific injury variables for 2019 and 2020.

Burn Injury Variables		**2019**	**2020**
Burn Mechanism	Radiation	90 (0.2%)	54 (0.1%)
	Electrical	195 (0.5%)	157 (0.4%)
	Sunburn	1340 (3.3%)	919 (2.2%)
	Smoke/Fire/Flame	2668 (6.5%)	2605 (6.4%)
	Contact	3720 (9.1%)	2797 (6.8%)
	Scald	7261 (17.8%)	5911 (14.5%)
	Other	2849 (7.0%)	2389 (5.8%)
	Uncertain Etiology	22284 (54.5%)	17577 (43.0%)
Burn Depth	1st Degree	2862 (11.3%)	2155 (10.1%)
	2nd Degree	9135 (36.1%)	8134 (38.0%)
	3rd Degree	1050 (4.2%)	939 (4.4%)
	Unspecified	12234 (48.4%)	10175 (47.5%)
Burn Site	Head	1971 (9.4%)	1668 (9.5%)
	Eye	1571 (7.5%)	1241 (7.1%)
	Trunk	2115 (10.1%)	1968 (11.2%)
	Upper Limbs	2863 (13.7%)	2384 (13.6%)
	Hand & Wrist	6927 (33.1%)	5349 (30.5%)
	Lower Limbs	2527 (12.1%)	2280 (13.0%)
	Foot & Ankle	1731 (8.3%)	1508 (8.6%)
	Respiratory	96 (0.5%)	82 (0.5%)
	Internal	247 (1.2%)	197 (1.1%)
	Multi-Unspecified	864 (4.1%)	838 (4.8%)

3.2 Comparisons during initial pandemic period (March-August)

Following the full-year summaries, chi-square tests were used to compare the 2019 and 2020 6-month COVID-19 pandemic periods of March to August. This 6-month period represented the initial lockdown period in 2020 in Ontario, Canada. The parallel time frame in 2019 was used for comparison. In 2019, 12,352 total ED visits for burns were reported, with 9,456 in 2020, representing a decrease of 23.4% ($p=0.0479$). A decrease in the number of visits was observed for each age cohort, from 2019 to 2020.

Decreases were noted in adult age groups. For example, 20-29 years, decreased by 28.1% from 2,488 to 1,790, and the 40-49 year cohort, decreased by 21.9% from 1,460 to 1,140 (Table 4).

Age-standardized visit rates were also calculated for the initial pandemic period. Similar patterns in the full year summaries were observed for the 6-month period comparisons (Table 5). The overall standardized rate in 2019 was 86.8 per 100,000, which was higher than the 2020 rate of 66.5 per 100,000. The highest rates were reported for the less than 10-year age cohorts in both 6-month periods (Figure C3).

The number of male ED visits in the 2020 6-month period decreased to 5,291 by 20.9% from 6,692 in 2019. The number of female visits decreased from 5,660 by 26.4% to 4,165 (p=0.0090) (Table 4). No evidence of significant differences were found for the distribution of region (p=0.3861) or income (p=0.1317). Although there were no statistically significant changes in the distribution of ED burn visits, the number of urban and regional patients both decreased, rural from 2,289 to 1,709 (25.3%) and urban from 10,063 to 7,747 (23.0%), respectively. For SES, lower income was associated with higher numbers of ED visits (Table 4). Every SES quintile observed decreases from 2019 to 2020, with similar distributions of categories.

Monthly counts decreased from 2019 to 2020. Similar to the full year summaries, the highest ED visit count was reported for July, 2,952 and 2,233 in 2019 and 2020, respectively. April also had the lowest count for 2020 at 810, a decrease of 49.5% from 1,605. For daily patterns, all times observed decreased visits from 2019 to 2020. Notable decreases were identified for morning, and evening/night (p<0.0001). Additional details regarding the time and patient arrival characteristics are included in Table 4.

Table 4

Direct comparisons of patient variables during the initial pandemic period of March to August 2020 to the parallel period in 2019.

		Year		
Variables		**2019** n=12352	**2020** n=9456	**p-value**
Age	<1	243 (2.0%)	186 (2.0%)	**0.0479**
	1	581 (4.7%)	443 (4.7%)	
	2-4	568 (4.6%)	467 (4.9%)	
	5-9	490 (4.0%)	393 (4.2%)	
	10-14	479 (3.9%)	327 (3.5%)	
	15-19	1006 (8.1%)	707 (7.5%)	
	20-29	2488 (20.1%)	1790 (18.9%)	
	30-39	1766 (14.3%)	1475 (15.6%)	
	40-49	1460 (11.8%)	1140 (12.1%)	
	50-64	2122 (17.2%)	1664 (17.6%)	
	65+	1149 (9.3%)	864 (9.1%)	
Sex	Female	5660 (45.8%)	4165 (44.0%)	**0.0090**
	Male	6692 (54.2%)	5291 (56.0%)	
Region	Rural/Remote	2289 (18.5%)	1709 (18.1%)	0.3861
	Urban	10063 (81.5%)	7747 (81.9%)	
Income	1 – low income	3161 (25.6%)	2356 (24.9%)	0.1317
	2	2613 (21.2%)	1981 (20.9%)	
	3	2424 (19.6%)	1833 (19.4%)	
	4	2221 (18.0%)	1832 (19.4%)	
	5 – high income	1933 (15.6%)	1454 (15.4%)	
Month	March	1548 (12.5%)	1049 (11.1%)	**<0.0001**
	April	1605 (13.0%)	810 (8.6%)	
	May	1843 (14.9%)	1523 (16.1%)	
	June	2103 (17.0%)	1890 (20.0%)	
	July	2952 (23.9%)	2233 (23.6%)	
	August	2301 (18.6%)	1951 (20.6%)	
Daytime	Early Morning	1112 (9.0%)	882 (9.3%)	**<0.0001**
	Morning	2744 (22.2%)	1978 (20.9%)	
	Afternoon	4163 (33.7%)	3468 (36.7%)	
	Evening/Night	4333 (35.1%)	3128 (33.1%)	
Ambulance *	Any Type	1295 (10.5%)	1201 (12.7%)	**<0.0001**
	None/Walk-In	11057 (89.5%)	8255 (87.3%)	
Disposition **	Death	28 (0.2%)	28 (0.3%)	**<0.0001**
	Leave	523 (4.2%)	222 (2.3%)	

	Transfer	601 (4.9%)	544 (5.8%)
	Home Discharge	11200 (90.7%)	8662 (91.6%)

Note: REF denotes the reference category. Statistically significant associations are highlighted in bold-face.

*: Any type ambulance use involved patients transported to an ED or hospital by ground, air, or water.

**: Disposition transfers refer to patient movement to day surgery, to the ED, to clinics, intra-facility movement, movement to inpatient, residential care or correctional facility.

Table 5

Age ED visit rates for each cohort (per 100,000 per year), March to August, 6-month period summaries in 2019 and 2020.

	Year	
Age Cohort	**2019**	**2020**
<1	189.7	145.2
1	438.7	334.5
2-4	134.3	110.4
5-9	64.1	51.4
10-14	59.6	40.7
15-19	125.5	88.2
20-29	133.0	95.7
30-39	91.5	76.5
40-49	81.8	63.9
50-64	72.0	56.4
65+	43.6	32.8
Total Age-Standardized Rate	**86.8**	**66.5**

All three burn variables found significant differences associated with the lockdown. The epidemiology of mechanisms was similar in the 6-month period to the full-year summaries. The most frequent mechanisms were scalding at 3,659 in 2019 and 2,809 in 2020. However, the second most common mechanism was contact in 2019 at 2,036 and fire/flame/smoke at 1,480 in 2020 (Table 6). All burn degrees observed decreases from 2019 to 2020. First-degree burns decreased by 28.8%, from 1,759 to 1,252, second-degree burns decreased by 17.7%, from 5,284 to 4,351, and third-degree burns decreased by 16.5%, from 600 to 501 (p=0.0025). Every burn site had a decrease from the pre-pandemic to pandemic period ($p<0.0001$). Some notable decreases include upper limbs by 22.8%, from 1,636 to 1,263, and hand and wrist by 29.8%, from 3,596 to 2,523 (Table 6).

Table 6

Direct comparisons of patient burn-specific injury variables during the March to August, 6-month initial pandemic period in 2020 to the parallel monthly time period in 2019.

		Year		
Burn Injury Variables		**2019**	**2020**	**p-value**
Burn Mechanism	Radiation	58 (0.3%)	31 (0.2%)	**<0.0001**
	Electrical	103 (0.5%)	69 (0.4%)	
	Sunburn	1268 (5.6%)	873 (5.2%)	
	Fire	1667 (7.4%)	1480 (8.7%)	
	Contact	2036 (9.0%)	1404 (8.3%)	
	Scald	3659 (16.2%)	2809 (16.6%)	
	Other	1614 (7.2%)	1332 (7.9%)	
	Unknown Etiology	12136 (53.8%)	8938 (52.8%)	
Burn Depth	1st Degree	1759 (13.1%)	1252 (11.8%)	**0.0025**
	2nd Degree	5284 (39.5%)	4351 (40.9%)	
	3rd Degree	600 (4.5%)	501 (4.7%)	
	Unspecified Degree	7493 (56.0%)	5787 (54.4%)	
Burn Site	Head	1094 (7.9%)	821 (7.5%)	**<0.0001**
	Eye	860 (6.2%)	655 (5.9%)	
	Trunk	1190 (8.6%)	1035 (9.4%)	
	Upper Limbs	1636 (11.8%)	1263 (11.5%)	
	Hand & Wrist	3596 (25.9%)	2523 (22.9%)	
	Lower Limbs	1509 (10.9%)	1319 (12.0%)	
	Foot & Ankle	904 (6.5%)	800 (7.3%)	
	Respiratory	46 (0.3%)	40 (0.4%)	
	Internal	126 (0.9%)	95 (0.9%)	
	Multi-Unspecified	2907 (21.0%)	2467 (22.4%)	

Note: Statistically significant associations are highlighted in bold-face.

3.3 Modelling severe burns during the 2020 pandemic

Preliminary exploratory analysis examined the impact of the pandemic period on severe burns. The univariate model found no evidence of a statistically significant relationship (OR=1.12, 0.99-1.27) between the pandemic period and severe burn ED visits (Table 7). The subsequent fully-adjusted multivariable logistic regression model included exposures associated with experiencing a severe burn ED visit from January 2019 to August 2020 (Table 8). However, after adjusting for potential confounding effects, the pandemic showed a statistically significant effect OR = 1.19 (1.04-1.35). The fully adjusted model also revealed some interesting associations. Age cohorts with a significant association of an ED visit included, 5-9 years (OR=1.73, 1.29-2.33), 30-39 years (OR=1.22, 1.00-1.47), 40-49 years (OR=1.51, 1.25-1.83), 50-64 years (OR=1.68, 1.43-1.98), and 65+ years (OR=2.67, 2.23-3.18). For sex, male patients (OR=1.79, 1.58-2.02), and for income, Q1 (OR=1.26, 1.11-1.44) had increased ORs of experiencing a severe burn ED visit. Burn injuries during the pandemic were significantly related to increased severity (OR=1.19, 1.04-1.35). No significant differences were found for the regional variable. March was selected as the reference group to represent the initial pandemic in 2020. Four months were significant compared to March. April (OR=1.30, 1.06-1.60), and November (OR=1.41, 1.09-1.83) had increased odds, while June (OR=0.69, 0.56-0.86) and July (OR=0.83, 0.69-0.99) had reduced ORs. Severe burns most frequently occurred in the afternoon, and thus was used as the reference group. Early morning had higher odds (OR=1.65, 1.39-1.97) than afternoon (Table 8).

Given the significance of the pandemic period in the pooled 2019 and 2020 model (Table 8), an additional model was built, using data strictly from the initial COVID-19 pandemic, March 2020 to August 2020 (Table 9). Significant age cohorts, sex, income, and daytime were similar to the pooled model. Unique to the pandemic model, ED visits with patients originating from rural regions showed a protective effect (OR=0.74, 0.57-0.97). Additionally, April was the only month found to be significant (OR=1.42, 1.02-1.96) (Table 9).

Table 7

Univariate logistic modelling of experiencing an ED visit for a severe burn from January 2019 to August 2020.

			Odds Ratio (95% Confidence Interval)	
Variables		**Estimate**	**Lower**	**Upper**
Period	Pre-pandemic	REF		
	Pandemic	1.12	0.99	1.27

Note: REF denotes the reference category. Statistically significant associations are highlighted in bold-face.

Table 8

Multivariable logistic regression using pooled data from January 2019 to August 2020 to model the odds ratios of experiencing an ED visit for a severe burn.

			Odds Ratio (95% Confidence Interval)	
Variables		**Estimate**	**Lower**	**Upper**
Period	Pre-pandemic	REF		
	Pandemic	**1.19**	**1.04**	**1.35**
Age	20-29 years	REF		
	<1 year	1.06	0.67	1.69
	1 year	1.13	0.82	1.56
	2-4 years	1.28	0.95	1.73
	5-9 years	**1.73**	**1.29**	**2.33**
	10-14 years	1.14	0.78	1.67
	15-19 years	0.83	0.61	1.12
	30-39 years	**1.22**	**1.00**	**1.47**
	40-49 years	**1.51**	**1.25**	**1.83**
	50-64 years	**1.68**	**1.43**	**1.98**
	65+ years	**2.67**	**2.23**	**3.18**
Sex	Female	REF		
	Male	**1.79**	**1.58**	**2.02**
Income	5 – highest income	REF		
	1 – lowest income	**1.26**	**1.11**	**1.44**
	2	1.09	0.94	1.27
	3	1.00	0.80	1.22
	4	1.02	0.85	1.21
Region	Urban	REF		
	Rural	0.88	0.76	1.03
Month	March	REF		
	January	0.88	0.69	1.11
	February	0.99	0.77	1.27
	April	**1.30**	**1.06**	**1.60**
	May	0.96	0.78	1.20
	June	**0.69**	**0.56**	**0.86**
	July	**0.83**	**0.69**	**0.99**
	August	1.05	0.87	1.26
	September	0.99	0.73	1.35
	October	0.99	0.71	1.39
	November	**1.41**	**1.09**	**1.83**
	December	1.04	0.77	1.40
Daytime	Afternoon	REF		
	Early Morning	**1.65**	**1.39**	**1.97**

Morning	1.11	0.96	1.28
Evening/Night	0.84	0.73	0.96

Note: REF denotes the reference category. Statistically significant associations are highlighted in bold-face.

Table 9

Multivariable logistic regression for the pandemic using data from March 2020 to August 2020 to model the odds ratios of experiencing an ED visit for a severe burn.

			Odds Ratio (95% Confidence Interval)	
Variables		**Estimate**	**Lower**	**Upper**
Age	20-29 years	REF		
	<1 year	1.56	0.82	2.96
	1 year	0.68	0.36	1.29
	2-4 years	1.27	0.73	2.21
	5-9 years	**2.36**	**1.51**	**3.68**
	10-14 years	1.28	0.69	2.39
	15-19 years	0.61	0.34	1.08
	30-39 years	**1.48**	**1.06**	**1.98**
	40-49 years	**1.94**	**1.42**	**2.64**
	50-64 years	**1.94**	**1.47**	**2.56**
	65+ years	**3.93**	**2.96**	**5.22**
Sex	Female	REF		
	Male	**1.85**	**1.51**	**2.27**
Income	5 – highest income	REF		
	1 – lowest income	**1.44**	**1.18**	**1.77**
	2	0.93	0.71	1.23
	3	0.89	0.64	1.24
	4	0.91	0.69	1.19
Region	Urban	REF		
	Rural	**0.74**	**0.57**	**0.97**
Month	March	REF		
	April	**1.42**	**1.02**	**1.96**
	May	0.96	0.69	1.34
	June	0.77	0.57	1.03
	July	1.10	0.86	1.40
	August	1.14	0.87	1.50
Daytime	Afternoon	REF		
	Early Morning	**1.81**	**1.38**	**2.37**
	Morning	1.24	0.99	1.55
	Evening/Night	1.25	0.98	1.59

Note: REF denotes the reference category. Statistically significant associations are highlighted in bold-face.

4 Discussion

4.1 Full year summaries, 6-month period comparisons and previous literature

This study highlighted pandemic-related changes in the epidemiology of burn injury patients in the Ontario healthcare system. Overall, there were large decreases in the absolute number of ED visits for burns and individual burn cases during the pandemic. Despite the changes in visit and case counts, distributions followed similar patterns in both full-year, and 6-month pandemic comparisons. The modelling of severe burns provided a novel insight into demographic and exposure factors associated with experiencing a severe burn during the pandemic period.

Previous literature found a decrease in the rate of pandemic-related burn injury mortality and morbidity (15, 23, 38). Although findings in the current study support this, the decreases observed in magnitude were much greater than the year-by-year changes noted earlier (21). In this study, the overall count and age-adjusted rate of burn ED visits decreased during the pandemic for all age groups. Despite these decreases, the proportion of visits by age group remained similar for full-year and March to August comparisons. It is understood the pandemic led to a decrease in patient visits to the ED, but the age-distribution of visits did not change. While the 6-month comparison may have shown a significant p-value, these changes may not be of clinical relevance.

Early literature on pandemic burn epidemiology showed a general decrease in burn patients compared to previous years. In the UK, burn visit counts (39, 40) and burn rates decreased during the pandemic (41). In Spain, adult burn visits decreased by 36%, despite pediatric visits increasing by 20% (27). Decreased counts for adult and pediatric burn visits were noticed in various other countries (28, 29, 42, 43, 44). Literature for adolescent and adult populations (26, 29, 45), found no significant changes for burn ED visit rates and risk, however, presented burn injuries were found to be more severe. In Canada, the trend of fewer but more severe burn visits was echoed in Toronto (46). Further literature found increased pediatric ED visit or rates during the pandemic period (25-27, 41, 45, 47). This contradicts our study and one by Sethuraman et al. (48), where all pediatric age groups observed decreases following the start of the COVID-19 pandemic. However, the drop in ED visits was expected following the start of the pandemic, as large decreases in visits for all age groups had been noted by CIHI (11).

The youngest children in cohorts, <1, 1 and 2-4 also had the highest age ED visit rates. The lowest rates occurred in the late childhood and teenage years, followed by a slight increase at 15-19 and 20-29 age groups. From early adulthood to the 65+ age group, there was a gradual decrease in ED visit rates. The pandemic rate distributions were similar to distributions for previous literature in Canada (21). Age-standardized rates in 2013, found the youngest age groups with the highest burn injury rates, and the lowest rates in teenage years and early adulthood.

Men were more affected by burns than women, consistent with literature from USA (49), Brazil (50), the UK (51). Some contradictory literature noted increased female burn patients. With more time spent at home, many women experienced scald burns due to increased time spent on household roles in cooking and cleaning (28, 45). Men have consistently reported more burn ED visits in the Canadian healthcare system, before (24), and during the pandemic (46), which was consistent with our findings.

The SES and regional variables did not show many statistically significant relationships in our results. There were large decreases in patient visit count from 2019 to 2020. In Ontario, the number of burn visits where patients were determined to be in lower income quintiles was higher. Analogous to findings from March to August 2020, previous literature found 49% and 20% of the reported patients belonged to the two lowest earning quintiles and rural areas, respectively (22). Historically, children and households from lower SES experienced higher risk of burn morbidity and mortality (15, 17). The role of regional residence is not well-understood. Some previous literature has found higher rates of rural-based burns, citing lack of sprinkler systems and smoke alarms (52). Other reasons include, rural residences lacking electrical power and relying on flammable materials to generate warmth (22). However, this rationale cannot be applied, as the vast number of urban-based burns may be attributed to the densely populated cities throughout Ontario. A future study should investigate the association of SES and regional indicators on burn epidemiology in Ontario and Canada.

The burn mechanism, burn depth, and burn site variables all showed significant differences for their 6-month comparisons across 2019 and 2020. However, this result should be interpreted with caution, as changes were minimal overall and statistical significance was likely a function of large sample sizes. The burn specific variables mirrored the demographic variables, with decreased individual burn counts year-over-year and parallel proportional distributions. In 2020, scalding, flame and contact burns remained the most frequent mechanisms, supportive of earlier burn literature (28, 29, 50, 51), including Canada (21, 46).

The most frequent burn sites were hand and wrist, upper limbs, and lower limbs. Overall, several studies found the same bodily regions among the highest reported burn sites (28, 47, 50, 53, 54). When burn sites and mechanisms are considered together, an epidemiological pattern can be inferred. Scalding remained as the peak mechanism count with hand and wrist, and upper limbs as the highest sites. While at home, more time was spent on activities involving use of hot water or fluids, such as cooking, cleaning and washing. These sorts of activities involve primary use of the hands and upper limbs, are also reflected in these ED visit counts.

ED visits for all degrees of burn depth observed decreases from 2019 to 2020, with second-degree or partial thickness burns remaining the most frequently reported (47, 53). Historically, over half of burn visits in Canadian children were graded as second-degree (24). Although higher degree is not always a direct marker of severity, it can confirm the requirement for advanced or surgical treatment. First-degree burns or superficial burns affect only the epidermis, and therefore require minor treatment at home

(55). First-degree burn patients may have remained at home and not risked COVID-19 infection in a public healthcare centre. Second- and third-degree burns progressively become deeper and require more advanced or professional treatment (55). As a result, second- and third-degree burns may not have seen large decreases in case counts compared to first-degree burns.

Overall, every variable measured in the study exhibited a decrease in the number of ED burn visits or individual cases during the pandemic, but no drastic changes to the distributions were observed. This is consistent in the full-year summaries and the 6-month comparisons, as the decrease in pandemic ED visits was expected (11) and likely attributed to the initial fear of COVID-19. In the Survey on Access to Health Care and Pharmaceuticals During the Pandemic, 30% of Canadians delayed healthcare visits for fear of contracting the virus (56). Many residents in North America also avoided healthcare workers where possible (57), likely reducing patient visits and burn counts. Patients may have only visited the ED when suffering from more severe burns, which was also noted in Canada (46). In Europe, the rise in pediatric burn injuries was likely attributed to the increased time spent at home. More home time, in conjunction with parental teleworking status, and burnout lead to increased pediatric burns (27, 47). Although similar conditions arose in Canada, pediatric burns did not increase, a finding supported by literature from Montreal (58).

4.2 Modelling of severe burns during the 2020 pandemic

To our knowledge, no literature exists which involved a direct modelling of the pandemic time frame to severe burn injuries. However, previous literature has shown an increased severity of reported burn ED visits (26, 29, 44, 46, 49) during the COVID-19 pandemic. Our models showed that adults, 30 years and older had increased odds of severe burns. The 5-9 year cohort was the only pediatric cohort with higher odds of severe burn injuries. Increased time spent at home with parents working, factors such as being in the vicinity of heat-related activities and children having thinner skin than adults may lead to the increased risk (27, 59). Moreover, adult groups also include the primary working population, who also complete daily responsibilities such as cooking, cleaning, leaving the house for errands, and job-related tasks (27). These activities may increase the odds of experiencing contact burns, scalds and other potential burns, and thus the risk of a severe burn and a following ED visit. In comparison to females, males had a significant OR for a severe burn ED visit. These findings were consistent across all models and aligns with previous literature. Males historically have been higher risk populations for being burned (22, 24), and would translate into higher risk for severe burn ED visits. In all models, Q1 was significant for severe burn ED visits. These findings are consistent with previous literature (60) and were expected, as patients of lower SES tend to have reduced access to primary care and utilize the ED more frequently than individuals of higher SES (61). Further research may benefit from understanding the relationship between these two variables.

4.3 Strengths

Using a population-based approach allowed for a more comprehensive understanding of burn injuries in Ontario. This allowed for a better representation of the overall provincial population. The use of a novel approach in modelling severe burns during the pandemic provides unique insight into burn epidemiology. The modelling of severe burns helps understand necessary and susceptible patient populations that use the ED. These types of burns also require more resources and intensive medical care. Understanding what demographic factors are associated may help with resource planning and public health messaging to reduce potential risk in Ontario.

4.4 Limitations

The results of this study should be interpreted with caution. The design was a secondary analysis of data, and emphasizes associations, not causal relationships for any variables. Further, the majority of the Ontario population is centralized in the South-East portion of the province, mainly Toronto and the surrounding CAs. The study results would be skewed towards these more densely populated areas and less generalizable to more rural communities.

Another limitation of the study is a potential underreporting of lower severity burn injuries. Some studies reported patients were less likely to travel to EDs or other medical centres to treat minor burn injuries due to the risk of contracting COVID-19 (41, 56, 57). Thus, patients with severe and painful burn injuries were more likely present at the ED. However, given the secondary aim of this study is to aid medical centres in preparing and planning for future social restrictions, this information may help medical centres understand why more severe burn injuries are more likely to present at the ED.

Finally, multiple testing is an additional limitation in the study. There is an increased risk of achieving a false positive result due to the multiple models built and multiple subgroups considered in these analyses.

4.5 Conclusion

Overall, the year-by-year summary found large decreases from 2019 to the 2020 pandemic of burn ED visits. However, ED visit patterns did not drastically change. Demographic changes to ED visits found more older burn patients, male patients, visits occurring in the summer months, patients using ambulatory transport and visits with transfers to other care or discharged home. Specific to burn characteristics, more flame burns, fewer contact and fewer scald visits were observed. There were lower proportions of first-degree burn visits, and increased proportions of foot and ankle, trunk and lower limb burn sites. Consistent exposure variables associated with severe burn ED visits include occurring during the initial pandemic, being an adult or older adult, being in the 5-9 year cohort, being among the lowest SES quintile, being male and occurring in the early morning. The complex relationship of exposure and demographic characteristics may help us understand those at risk of burns and the most frequently burned sub-populations. Overall, despite large decreases in case or patient counts, the results suggest the epidemiology of burn ED visit patterns did not change during the pandemic. This is also supported by the consistent significant exposure variables derived from the logistic models. Healthcare system stakeholders and organizers should understand which patient groups are susceptible and aim to implement strategies to reduce odds for burn injuries.

References

1. Centers for Disease Control and Prevention. (2021, October 21). COVID-19 – Frequently Asked Questions. https://www.cdc.gov/coronavirus/2019-ncov/faq.html
2. World Health Organization. (2021). Coronavirus disease (COVID-19) pandemic. https://www.who.int/emergencies/diseases/novel-coronavirus-2019
3. Canadian Institute of Health Information. (2021, September 9). COVID-19 hospital stays cost 3 times more than a stay for heart attack. https://www.cihi.ca/en/covid-19-hospital-stays-cost-3-times-more-than-a-stay-for-heart-attack
4. Christie, A., Brooks, J. T., Hicks, L. A., Sauber-Schatz, E. K., Yoder, J. S., & Honein, M. A. (2021). Guidance for implementing COVID-19 prevention strategies in the context of varying community transmission levels and vaccination coverage. Morbidity and Mortality Weekly Report, 70(30), 1044-1047. https://doi.org/10.15585/mmwr.mm7030e2
5. Zhang, R., Li, Y., Zhang, A. L., & Molina, M. J. (2020). Identifying airborne transmission as the dominant route for the spread of COVID-19. Earth, Atmospheric and Planetary Sciences, 117(26), 14857-14863. https://doi.org/10.1073/pnas.2009637117
6. Government of Canada. (2021, June 29). COVID-19: Main modes of transmission. https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirusinfection/health-professionals/main-modes-transmission.html
7. Government of Ontario. (2021, April 12). Archived – COVID-19: Government services changes and public closures. https://www.ontario.ca/page/covid-19-government-service-changes-andpublic-closures
8. Medhi, T., & Morissette, R. (2021, May 26). Working from home after the COVID-19 pandemic: An estimate of worker preferences. Statistics Canada.

https://www150.statcan.gc.ca/n1/en/pub/36-28-0001/2021005/article/00001-eng.pdf?st=N74vRdkM

9. Government of Canada. (2020, March 18). Orders in Council: PC Number 202-0157. https://orders-in-council.canada.ca/attachment.php?attach=38952&lang=en
10. Government of Canada. (2022, May 3). COVID-19: How to quarantine or isolate at home. https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirusinfection/prevention-risks/quarantine-isolate-home.html
11. Canadian Institute of Health Information. (2021, July 8). COVID-19's impact on emergency departments. https://www.cihi.ca/en/covid-19-resources/impact-of-covid-19-on-canadas-health-care-systems/emergency-departments
12. Rennert-May, E., Leal, J., Xuan Thanh, N., Lang, E., Dowling, S., Manns, B., Wasylak, T., & Ronksley, P. (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
13. Kwok, E., S., Clapham, G., & Calder-Sprackman, S. (2021). The impact of COVID-19 pandemic on emergency department visits at a Canadian academic tertiary care center. Western Journal of Emergency Medicine, 22(4), 851-859. https://doi.org/10.5811/westjem.2021.2.49626
14. Hartnett, K. P., Kite-Powell, A., DeVies, J., et al. (2020, June 28). Impact of the COVID-19 pandemic on emergency department visits – United States, January 1, 2019 – May 30, 2020. US Department of Health and Human Services & Centers for Disease Control and Prevention. https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6923e1-H.pdf
15. Peck, M. D. (2011). Epidemiology of burns throughout the world. Part I: Distribution and risk factors. *Burns, 37*(7), 1087-1100. https://doi.org/10.1016/j.burns.2011.06.005 19

16. Pike, I., Richmond, S., Rothman, L., & Macpherson, A. (Eds.). (2015). Canadian Injury Prevention Resource: An evidence-informed guide to injury prevention in Canada. Parachute: Toronto.
17. Forjuoh, S., & Gielen, A. (2008). Burns. In M. Peden, K. Oyegbite, J. Ozanne-Smith, A. A. Hyder, C. Branche, A. F. Rahman, F. Rivara, & K. Bartolomeos. (Eds.), World report on child injury prevention (pp. 78-99). WHO Press.
18. Jeschke, M. G., van Baar, M. E., Choudhry, M. A., Chung, K. K., Gibran, N. S., & Logsetty, S. (2020). Burn injury. Nature Reviews. Disease Primers, 6(1):11. https://doi.org/10.1038/s41572- 020-0145-5.
19. Smolle, C., Cambiaso-Daniel, J., Forbes, A. A., et al. (2017). Recent trends in burn epidemiology worldwide: A systematic review. Burns, 43(2), 249-257. https://doi.org/10.1016/j.burns.2016.08.013
20. Edelman, L. (2007). Social and economic factors associated with the risk of burn injury. Burns, 33(8), 958-965. https://doi.org/10.1016/j.burns.2007.05.002
21. Crain, J., McFaull, S., Rao, D. P., Do, M. T., & Thompson, W. (2017). Emergency department surveillance of thermal burns and scalds, electronic Canadian Hospitals Injury Reporting and Prevention Program, 2013. Health Promotion and Chronic Disease Prevention in Canada – Research Policy and Practice, 37(1). https://doi.org/10.24095/hpcdp.37.1.03.
22. Mason, S. A., Nathens, A. B., Byrne, J., et al. (2017). Trends in the epidemiology of major burn injury among hospitalized patients: A population-based analysis. Burns, 83(5), 867-874. https://doi.org/10.1097/TA.0000000000001586
23. James, S. L., Lucchesi, L. R., Bisignano, C., Castle, C. D., Dingels, Z. V., et al. (2020). Epidemiology of injuries from fire, heat and hot substances: Global, regional and national morbidity and mortality estimates from the Global Burden of Disease 2017 study. Injury Prevention, 26(1), i36-i45. https://doi.org/10.1136/injuryprev-2019-043299

24. Spinks, A., Wasiak, J., Cleland, H., Beben, N., & Macpherson, A. (2008). Ten-year epidemiological study of pediatric burns in Canada. Journal of Burn Care & Research, 29(3), 482-488. https://doi.org/10.1097/BCR.0b013e3181776ed9
25. Pelizzo, G., Vestri, E., del Re, G., Filisetti, C., Osti, O., et al. (2021). Supporting the regional network for children with burn injuries in a pediatric referral hospital for COVID-19. Healthcare, 9(5), 551. https://doi.org/10.3390/healthcare9050551
26. Williams, F. N., Nazimani, R., Chrisco, L. & King, B. T. (2020). Increased burn center admissions during COVID 19 pandemic. Journal of Burn Care Research, 41(5), 1128. https://doi.org/10.1093/jbcr/iraa112.
27. Monte-Soldado, A., Lopez-Masramon, B., Rivas-Nicolls, D., Andres-Collado, A., Aguilera-Saez, J., Serracanta, J. & Barret, J. P. Changes in the epidemiologic profile of burn patients during the lockdown in Catalonia (Spain): A warning call to strengthen prevention strategies in our community. Burns, 48(1), 228-233. https://doi.org/10.1016/j.burns.2021.03.006
28. Yamamoto, R., Sato, Y., Matsumura, K., & Sasaki, J. (2021). Characteristics of burn injury during COVID-19 pandemic in Tokyo: A descriptive study. Burns, 5(4), 40-45. https://doi.org/10.1016/j.burnso.2021.06.007
29. Akkoc, M. F., Bulbuloglu, S., & Ozfemir, M. (2021). The effects of lockdown measures due to COVID-19 pandemic on burn cases. International Wound Journal, 18(3), 367-374. https://doi.org/10.1111/iwj.13539
30. Canadian Institute for Health Information. (2023). National Ambulatory Care Reporting System (NACRS) metadata. https://www.cihi.ca/en/national-ambulatory-care-reporting-system-nacrs-metadata
31. Canadian Institute for Health Information. (2023). Discharge Abstract Database (DAD) metadata. https://www.cihi.ca/en/discharge-abstract-database-dad-metadata

32. Canadian Institute for Health Information. (2017). *CIHI's Information Quality Framework.* https://www.cihi.ca/sites/default/files/document/iqf-summary-july-26-2017-en-web_0.pdf
33. Statistics Canada. (February 1, 2023). *Census Profile, 2021 Census of Population: Profile Table.* https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/details/page.cfm?Lang=E&SearchText=Ontario&DGUIDlist=2021A000235&GENDERlist=1,2,3&STATISTIClist=1&HEADERlist=0
34. Statistics Canada. (December 16, 2022). *Focus on Geography Series, 2021 Census of Population.* https://www12.statcan.gc.ca/census-recensement/2021/as-sa/fogs-spg/Page.cfm?Lang=E&Dguid=2021A000235&topic=1
35. Drobot, A., & Bielska, I. (2015). An overview of the public health system in the province of Ontario, Canada. *Zdrowie Publiczne i Zarządzanie, 13*(2), 185-193. https://doi.org/10.4467/20842627OZ.15.019.4322
36. Ontario Health. (March 28, 2023). *About Us.* https://www.ontariohealth.ca/about-us
37. Ministry of Health and Ministry of Long Term Care. (January 30, 2023). *Understanding Health Care in Ontario.* https://www.health.gov.on.ca/en/ministry/hc_system/
38. Chen, Z., Zhang, M., Xie, S., Zhang, X., Tang, S., Zhang, C., & Li, H. (2021). Global burden of thermal burns, 1990-2017: Unbalanced distributions and temporal trends assessed from the Global Burden of Disease Study 2017. Burns, In Press. https://doi.org/10.1016/j.burns.2021.08.002
39. Farroha, A. (2020). Effects of COVID-19 pandemic on burns epidemiology. Burns, 46(6), 1466. https://doi.org/10.1016/j.burns.2020.05.022
40. D'Astra, F., Adamson, J., Wilson, Y., Wilson, D., Moiemen, N., & Farroha, A. (2020). Paediatric burns epidemiology during COVID-19 pandemic and 'stay home' era. Burns, 46(6), 1471-1472. https://doi.org/10.1016/j.burns.2020.06.028

41. Mann, J. A., Patel, N., Bragg, J., & Roland, D. (2021). Did children 'stay safe'? Evaluation of burns presentation to a children's emergency department during the period of COVID-19 school closures. Archives of Disease in Childhood, 106(3), e18. https://doi.org/10.1136/archdischild2020-320015

42. Rozenfeld, M., Peleg, K., Givon, A., Bala, M., Shaked, G., Bahouth, H. & Bodas, M. (2021). OVID19 changed the injury patterns of hospitalized patients. Prehospital and Disaster Medicine, 36(3), 251-259. https://doi.org/10.1017/S1049023X21000285

43. Pines, N., Bala, M., Gross, I., Ohana-Sarna-Cahan, L., Shpigel, R., Nama, A., Asaf, K., Rosenberg, M. P. & Hashavya, S. (2021). Changes in pediatric major trauma epidemiology, injury patterns, and outcome during COVID-19-associated lockdown. Trauma, 0(0), 1-5. https://doi.org/10.1177/14604086211045359

44. Tracy, L.,Hean Lo, C., Cleland, H., Teague, W. & Gabbe, B. (2022). Early impact of COVID-19 pandemic on burn injuries, admissions and care in a statewide burn service. *European Burn Journal, 3*, 447-456. https://doi.org/10.3390/ebj3030039

45. Demircan, M. (2021). Increased admissions and hospitalizations to pediatric burn center during COVID 10 pandemic. Burns, 47(2), 487-488. https://doi.org/10.1016/j.burns.2020.07.013

46. Rogers, A. D. & Cartotto, R. (2021). The impact of COVID-19 on burn care at a major regional burn center. Journal of Burn Care and Research, 42(1), 110-111. https://doi.org/10.1093/jbcr/iraa181

47. Charvillat, O., Plancq, M. C., Haraux, E., Gouron, R. & Klein, C. Epidemiological analysis of burn injuries in children during the first COVID-19 lockdown and a comparison with the previous 5 years. Annales de chirugie plastique esthetique, 66(4), 285-290. https://doi.org/10.1016/j.anplas.2021.06.001.

48. Sethuraman, U., Stankovic, C., Singer, A., Vitale, L., Krouse, C., Cloutier, D., Donoghue, L., Klein, J., & Kannikeswaran, N. (2021). Burn visits to a pediatric burn center during the COVID-10 pandemic and "Stay at home" period. *Burns, 47*(2). https://doi.org/10.1016/j.burns.2020.08.004
49. Codner, J. A., De Ayala, R., Gayed, R. M., Lamphier, C. K. & Mittal, R. (2021). The impact of the COVID-19 pandemic on burn admissions at a major metropolitan burn center. Journal of Burn Care Research, 42(6), 1103-1109. https://doi.org/10.1093/jbcr/irab106
50. Melquiades da Rocha, B., Bochnia, M., Ioris, R., Damin, R., Araujo Santos Nigro, M., & Nishihara, R. (2022). The impact of social isolation by COVID-19 on the epidemiological and clinical profiles of the burn patients. A retrospective study. *Burns, 48*(4), 976-983. https://doi.org/10.1016/j.burns.2022.02.016
51. Smith, A., Miranda, B., Strong, B., Jica, R., Pinto-Lopes, R., Khan, W., Martin, N., El-Muttard, N., Barnes, D., & Shelley, O. (2021). St Andrew's COVID-19 surgery safety (StACS) study: The Burns Center Experience. *Burns, 47,* 1547-1555. https://doi.org/10.1016/j.burns.2021.01.006
52. Runyan, C., Bangdiwala, S., Linzer, M., Sacks, J., & Butts, J. (1992). Risk factors for fatal residential fires. *The New England Journal of Medicine, 327*, 859-863. https://doi.org/10.1056/NEJM199209173271207
53. Lancien, U., Voisin, A., Faraj, S., Duteille, F., Perrot, P. (2022). Impact of the 2020 French lockdown due to the SARS-CoV-2 pandemic on emergency consultations for pediatric burns in a regional referral hospital. *Annales de Chirurgie Plastique Esthetique, 67*(2), 81-85. https://doi.org/10.1016/j.anplas.2022.02.001
54. Kruchevsky, D., Arraf, M., Levanon, S., Capucha, T., Ramon, Y., & Ullmann, Y. Trends in burn injuries in Northern Israel during the COVID-19 lockdown. Journal of Burn Care Research. https://doi.org/10.1093/jbcr/iraa154

55. Hemans, M. (2019). An introduction to burn care. *Advances in Skin & Wound Care, 32*(1), 9-18. https://doi.org/10.1097/01.ASW.0000549612.44844.75

56. Statistics Canada. (November 23, 2021). *Survey on Access to Health Care and Pharmaceuticals During the Pandemic, March 2020 to May 2021.* https://www150.statcan.gc.ca/n1/daily-quotidien/211123/dq211123b-eng.htm

57. Taylor, S., Landry, C., Rachor, G., Paluszek, M., & Asmundson, G. (2020). Fear and avoidance of healthcare workers: An important, under-recognized form of stigmatization during the COVID-19 pandemic. *Journal of Anxiety Discourse, 75,* 102289. https://doi.org/10.1016/j.janxdis.2020.102289

58. Keays, G., Friedman, D. & Gagnon, I. (2020). Pediatric Injuries in the time of COVID-19. Health Promotion and Chronic Disease Prevention in Canada, 40(11/12), 336-341. https://doi.org/10.24095/hpcdp.40.11/12.02

59. Parachute Canada. (July 26, 2023). *Burns and Scalds*. https://parachute.ca/en/injury-topic/burns-and-scalds/#:~:text=Children%20are%20at%20high%20risk,water%20is%2049%C2%B0%20C.

60. Mistry, R., Pasisi, L., Chong, S., Stewart, J., & Wong She, R. (2010). Socioeconomic deprivation and burns. *Burns, 36*, 403-408. https://doi.org/10.1016/j.burns.2009.05.021

61. Khan, Y., Glazier, R., Moineddin, R., & Schull, M. (2011). A population-based study of the association between socioeconomic status and emergency department utilization in Ontario, Canada. *Academic Emergency Medicine, 18*(8), 836-843. https://doi.org/10.1111/j.1553-2712.2011.01127.x

Appendix A Summary statistics of burn patient demographics from previous pre-pandemic years

Table A10

Full year descriptive summaries of all demographic variables for burn injury patients in 2017 and 2018.

		Year	
Variables		**2017**	**2018**
Demographic Variables		n=21460	n=21984
Age	< 1 year	540 (2.5%)	456 (2.1%)
	1 year	1108 (5.2%)	1093 (5.0%)
	2-4 years	1052 (4.9%)	1100 (5.0%)
	5-9 years	764 (3.6%)	775 (3.5%)
	10-14 years	727 (3.4%)	757 (3.4%)
	15-19 years	1842 (8.6%)	1810 (8.2%)
	20-29 years	4353 (20.3%)	4366 (19.9%)
	30-39 years	3017 (14.1%)	3142 (14.3%)
	40-49 years	2608 (12.2%)	2876 (13.1%)
	50-64 years	3590 (16.7%)	3624 (16.5%)
	65+ years	1859 (8.7%)	1985 (9.0%)
Sex	Female	9976 (46.5%)	10322 (47.0%)
	Male	11484 (53.5%)	11662 (53.0%)
Region	Rural/Remote	4063 (18.9%)	3908 (17.8%)
	Urban	17397 (81.1%)	18076 (82.2%)
Income Quintile	1 – low income	5443 (25.4%)	5701 (25.9%)
	2	4483 (20.9%)	4521 (20.6%)
	3	4191 (19.5%)	4346 (19.8%)
	4	3950 (18.4%)	3993 (18.2%)
	5 – high income	3393 (15.8%)	3423 (15.6%)
Month of Injury	January	1448 (6.7%)	1501 (6.8%)
	February	1339 (6.2%)	1186 (5.4%)
	March	1452 (6.8%)	1571 (7.1%)
	April	1641 (7.6%)	1640 (7.5%)
	May	1824 (8.5%)	2196 (10%)
	June	2179 (10.2%)	2255 (10.3%)
	July	2693 (12.5%)	2651 (12.1%)
	August	2239 (10.4%)	2225 (10.1%)
	September	1908 (8.9%)	1848 (8.4%)
	October	1685 (7.9%)	1763 (8%)
	November	1445 (6.7%)	1583 (7.2%)
	December	1607 (7.5%)	1565 (7.1%)
Time of Day	Early Morning	1837 (8.6%)	1982 (9%)
	Morning	4710 (21.9%)	4798 (21.8%)
	Afternoon	7406 (34.5%)	7488 (34.1%)

	Night/Evening	7507 (35.0%)	7716 (35.1%)
Ambulance Use	Any Type	2200 (10.3%)	2350 (10.7%)
	None/Walk-In	19260 (89.7%)	19634 (89.3%)
Disposition	Death	40 (0.2%)	51 (0.2%)
	Discharge Home	18561 (86.5%)	19818 (90.1%)
	Leave	680 (3.2%)	787 (3.6%)
	Transfer	2179 (10.2%)	1328 (6.0%)

Appendix B Additional multivariable regression models evaluating odds of severe burn ED visits

Table B11

Multivariable logistic regression, modelling the odds ratios of experiencing a severe burn injury in March to August 2019.

			Odds Ratio (95% Confidence Interval)	
Variables		**Estimate**	**Lower**	**Upper**
Age	20-29 years	REF		
	<1 year	0.76	0.40	1.45
	1 year	1.23	0.88	1.72
	2-4 years	1.26	0.88	1.80
	5-9 years	1.37	0.92	2.05
	10-14 years	1.11	0.68	1.80
	15-19 years	0.98	0.67	1.42
	30-39 years	1.18	0.91	1.53
	40-49 years	1.25	0.99	1.58
	50-64 years	**1.44**	**1.20**	**1.74**
	65+ years	**1.93**	**1.56**	**2.39**
Gender	Female	REF		
	Male	**1.76**	**1.51**	**2.60**
Income	5 – highest income	REF		
	1 – lowest income	1.51	0.98	1.36
	2	1.17	0.97	1.42
	3	1.05	0.80	1.37
	4	1.11	0.89	1.39
Region	Urban	REF		
	Rural	0.97	0.80	1.18
Month	March	REF		
	April	1.24	0.96	1.60
	May	1.05	0.81	1.37
	June	**0.63**	**0.47**	**0.85**
	July	**0.63**	**0.49**	**0.81**
	August	1.06	0.83	1.35
Daytime	Afternoon	REF		
	Early Morning	**1.54**	**1.23**	**1.94**
	Morning	1.04	0.87	1.25
	Evening/Night	1.06	0.88	1.28

Note: REF denotes the reference category. Statistically significant associations are highlighted in bold-face.

Table B12

Multivariable logistic regression, modelling the odds ratios of experiencing a severe burn injury, with data pooled from March to August in 2019 and 2020.

			Odds Ratio (95% Confidence Interval)	
Variables		**Estimate**	**Lower**	**Upper**
Age	20-29 years	REF		
	<1 year	1.19	0.67	2.10
	1 year	1.14	0.78	1.67
	2-4 years	1.03	0.67	1.58
	5-9 years	**1.87**	**1.35**	**2.61**
	10-14 years	0.94	0.58	1.53
	15-19 years	0.94	0.66	1.33
	30-39 years	1.14	0.90	1.45
	40-49 years	**1.36**	**1.08**	**1.72**
	50-64 years	**1.52**	**1.25**	**1.85**
	65+ years	**2.59**	**2.10**	**3.19**
Gender	Male	REF		
	Female	**0.62**	**0.53**	**0.72**
Income	5 – highest income	REF		
	1 – lowest income	**1.33**	**1.14**	**1.56**
	2	0.93	0.73	1.19
	3	0.90	0.73	1.10
	4	0.93	0.75	1.16
Region	Urban	REF		
	Rural	0.94	0.78	1.14
Month	July	REF		
	March	1.14	0.90	1.45
	April	**1.35**	**1.10**	**1.66**
	May	1.18	0.92	1.50
	June	**0.73**	**0.59**	**0.91**
	August	1.15	0.95	1.38
Daytime	Afternoon	REF		
	Early Morning	**1.54**	**1.24**	**1.93**
	Morning	1.12	0.92	1.34
	Evening/Night	1.07	0.91	1.26

Note: REF denotes the reference category. Statistically significant associations are highlighted in bold-face.

Appendix C Visualizations of burn patient age distributions

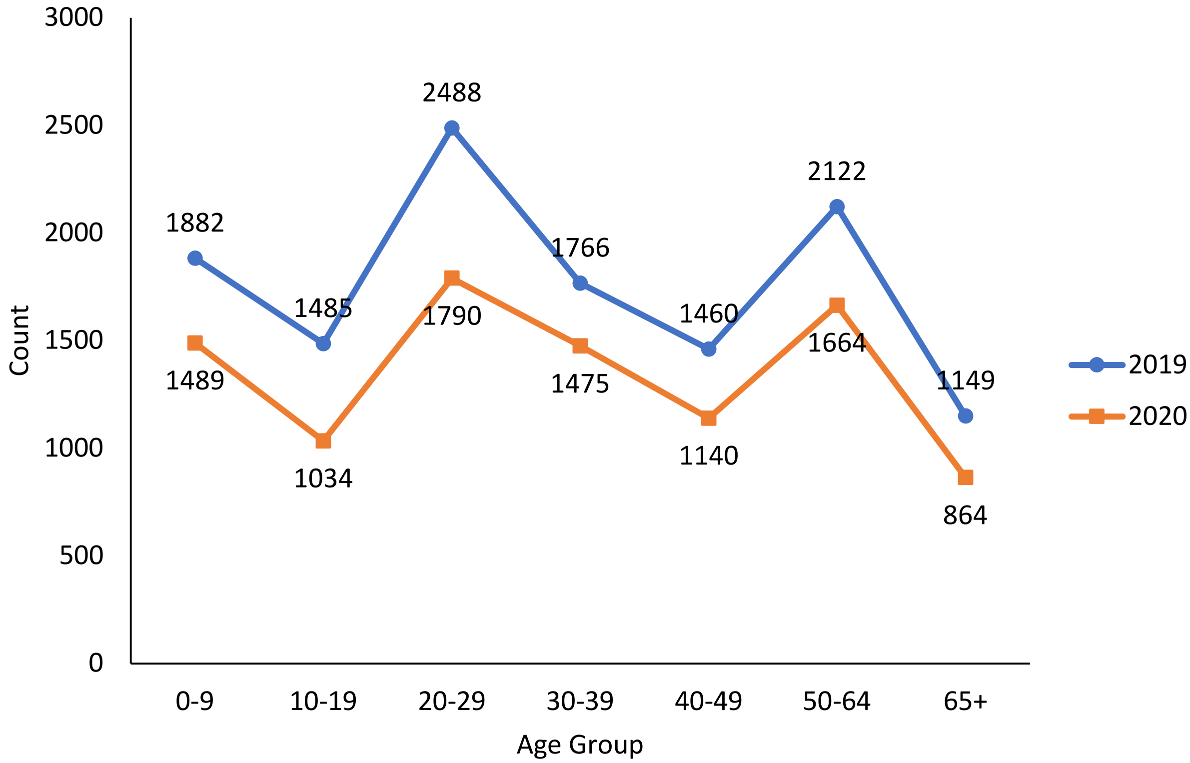

Figure C1. Age distributions for burn patients with combined youth age cohorts in 2019 and 2020.

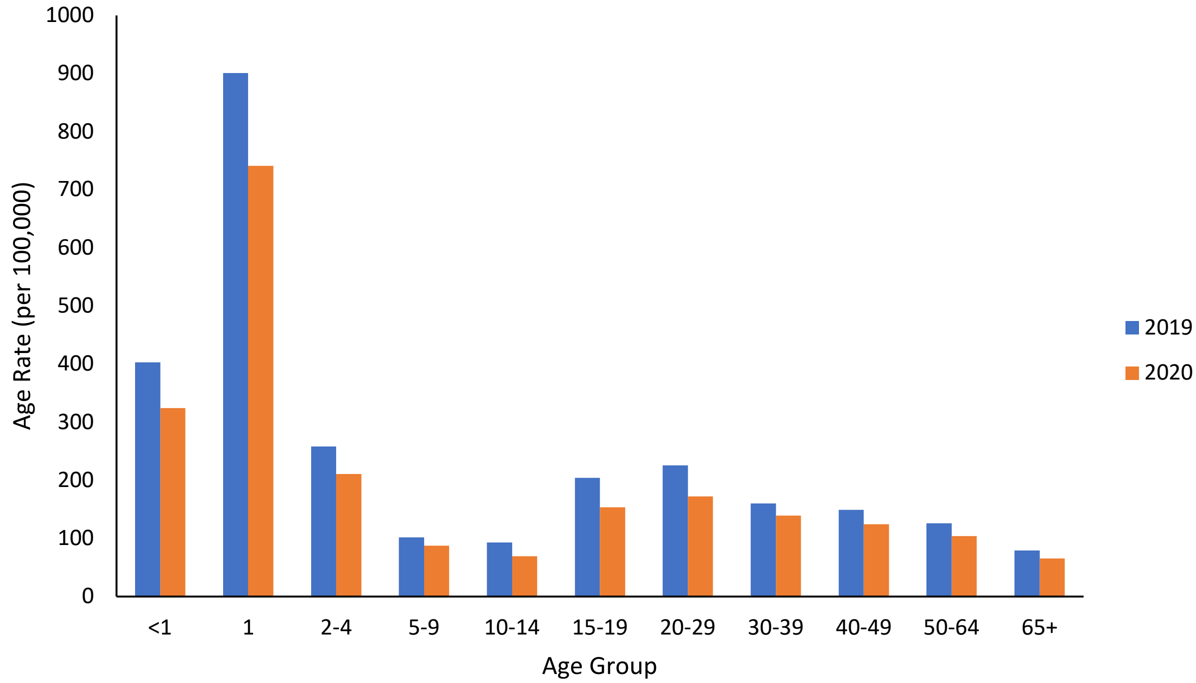

Figure C2. Age-standardized rate distributions for burn patients in January to December 2019 and 2020.

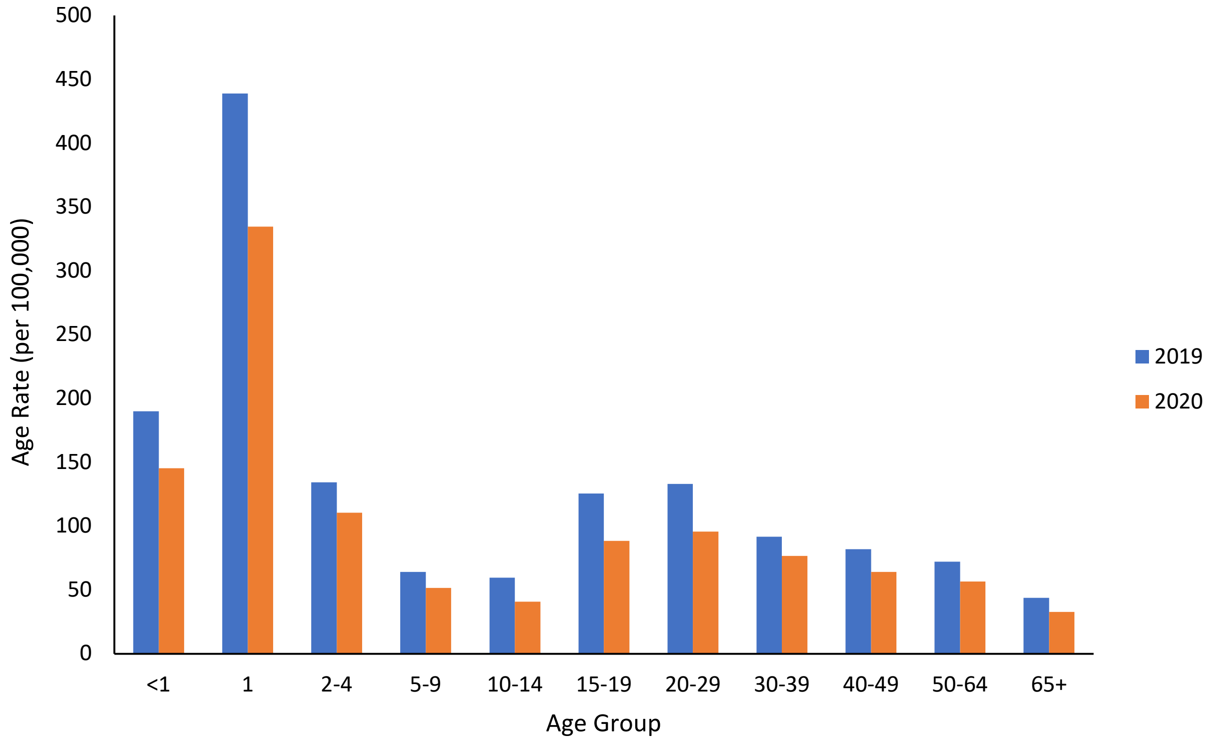

Figure C3. Age-standardized rate distributions for burn patients in March to August 2019 and 2020.

Appendix D Interpretation of additional severe burn visit regression models

Additional ORs were modelled for 2019 (Table Appendix B11) and for pooled data of parallel timelines in 2019 and 2020 (Appendix B12). Results were consistent across age groups with the pandemic period model, and male sex and early morning remained at higher odds of experiencing a severe burn. In the pre-pandemic model, only 50-64 years (OR=1.44, 1.20-1.74), and 65+ (OR=1.93, 1.56-2.39) had significant ORs for the age variable (Table B11). Male sex and early morning remained heightened ORs for severe burn ED visits. None of the income quintiles or the regional indicator came back significant for the 2019 model. For the month of ED visit, June (OR=0.63, 0.47-0.85) and July (OR=0.63, 0.49-0.81) had significant ORs (Table B11). For the pooled data (Table B12), age repeated the same significant cohort as 2020, 5-9 years, 40-49 years, 50-64 years, and 65+ years. Male patients and early morning visits both had ORs. For income, contrary to the 2019 model, but aligned with the 2020 model, Q1 was significantly associated with severe burn visits (OR=1.33, 1.14-1.56). Month was different from the other tables, as only April (OR=1.35, 1.10-1.66) and June (OR=0.73, 0.59-0.91) were significantly associated with severe burn visits. In comparison from the 2019 model to the 2020 model, more age cohorts were at risk during the COVID-19 pandemic. Males remained significant across both models, but Q1 was not significant only in 2019. Every other multivariable model found a significant association of income status to severe burn ED visits.