

ENHANCED EPIDEMIOLOGICAL SUMMARY

Concussion Incidence in Ontario

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Highlights

- This Enhanced Epidemiological Summary presents the number and rate of all concussion and sport-related concussion in Ontario children and youth ages 0 – 25 years from 2015 to 2022/23.
- Although hospitalizations due to all concussions decreased over time, emergency department (ED) visits due to concussion have increased. This may indicate that the severity of concussion injury is decreasing, but the number of injuries is increasing.
- The peak year for total number of healthcare encounters [hospitalizations, emergency department and Ontario Health Insurance Plan (OHIP) visits] and ED visits due to concussion was 2019, with an average of 81,046 health care encounters per year.
- Generally, 10 – 14 year olds had the highest combined concussion rates, followed by 15 – 19 year olds.
- Males generally had higher rates of hospitalizations due to all concussion and sport-related concussion compared to females. Females had higher rates of OHIP visits owing to concussion.
- There were a higher number of non-sport related concussions compared to sport-related in Ontario.

Introduction

Concussions are defined as a traumatically induced transient disturbance of brain function,¹ typically from direct impact or forceful motion of the head or other body part causing rapid movement of the brain within the cranial cavity. Although symptoms typically resolve over time, concussions can cause long-term consequences² or even result in death.² Importantly, in Ontario, the incidence of concussions in children and youth has increased significantly over time, from 366.5 emergency department (ED) visits per 100,000 in 2013, to 504.4 per 100,000 in 2019 in children ages 0 – 19 years.³ These data include all mechanisms of concussions, including those sport-related, associated with falls, or involved in a motor vehicle collision (MVC). Regardless of the mechanism, this increase identifies an opportunity for prevention, particularly in sport-related concussion, the leading mechanism for this injury in children and youth.

In 2018, the provincial government in Ontario passed *Rowan's Law (Concussion Safety)*, legislation to govern organized amateur sport by improving concussion safety on the field and at school. The Ministry of Health (MOH) also included concussions as a topic of consideration in their injury prevention guidelines for public health practice. *Rowan's Law* and related amendments to the *Education Act*, aim to protect amateur athletes and students by establishing mandatory requirements for sport organizations and school boards about concussion education, prevention, detection and management.⁴ Following

Rowan’s Law, the MOH is required to report on sport-related concussion incidence in children and youth ages 0 – 25 years in Ontario.

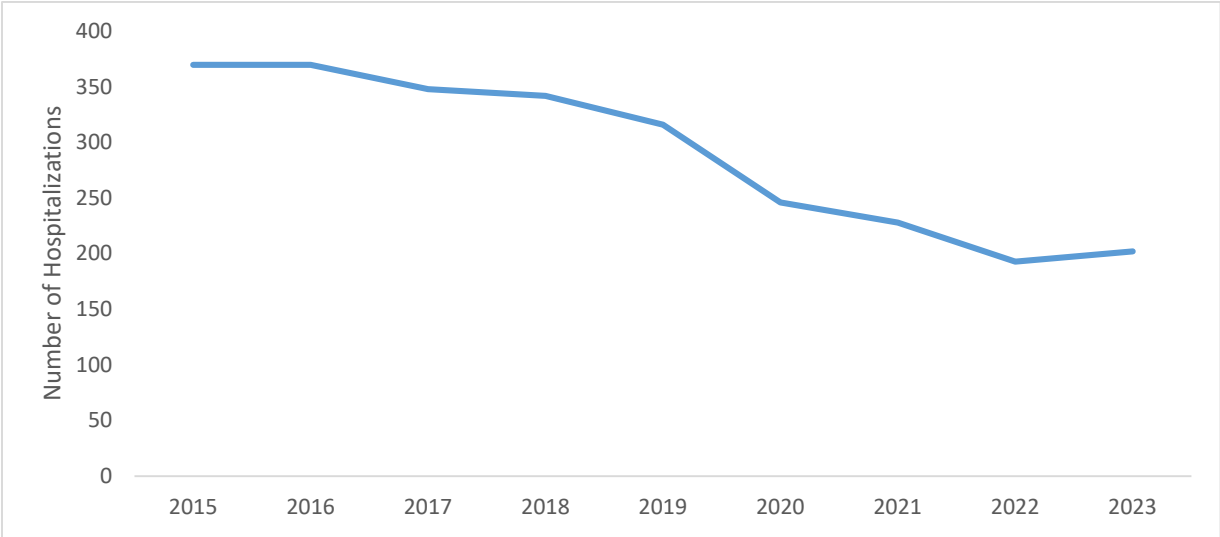
The methods used to calculate the estimated presented in this summary can be found in the Technical Notes section of this document. Data examined include the number of concussion injuries that present to the ED, are hospitalized, die as a result of concussion, and that are captured via physician visits. Data courses outside the MOH that could more accurately picture concussion incidence in Ontario are not included in this summary.

Results

All Concussion Hospitalizations

- There were a total of 2,615 unique concussion-related hospitalizations in Ontario among children and youth ages 0 – 25 years from January 2015 to December 2023.
- The number of concussions have decreased over time, with notable decreases in 2020 to 2022, likely due to the COVID-19 pandemic.
- In 2023, the number of concussions increased toward pre-pandemic numbers (Figure 1).

Figure 1. Number of hospitalizations due to all concussions in Ontario, January 2015-December 2023



- Overall, the number of hospitalizations due to all concussions from 2015 to 2023 have been decreasing across all age groups (Figure 2).
- The 10 – 14 year olds and 5 – 9 year olds have the highest number of concussions, compared to other age groups. The 20 – 25 year olds have the lowest number of concussions (Table 1).
- Hospitalizations for concussions in Ontario peaked in 2016, and was lowest in 2022. Males consistently had higher hospitalization rates compared to females over the included time period (Table 1).

Figure 2. Number of hospitalizations due to all concussions in Ontario, January 2015-December 2023 by age group

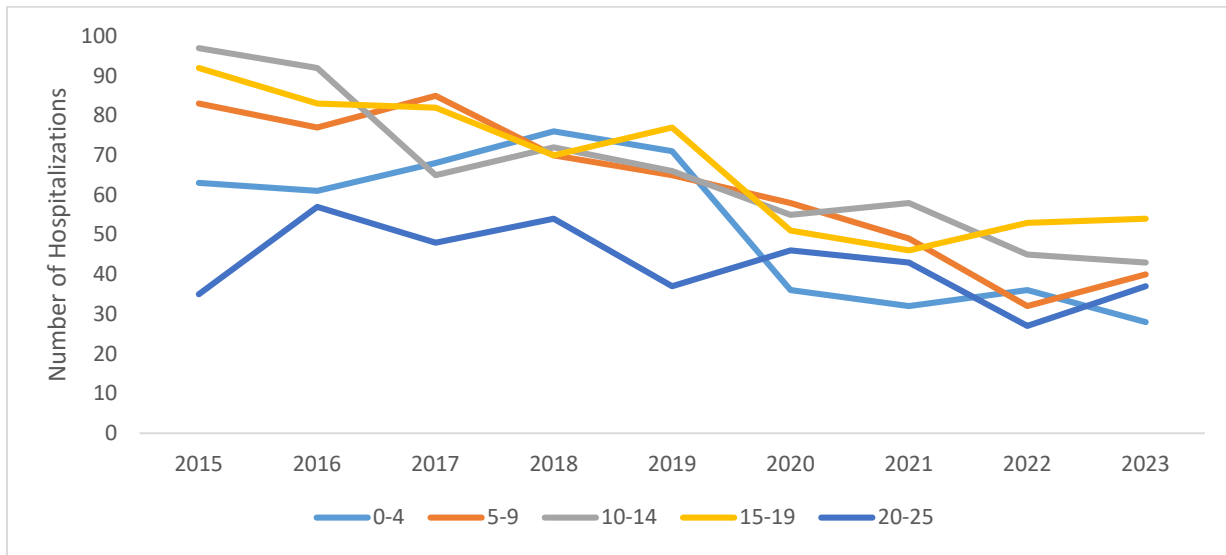
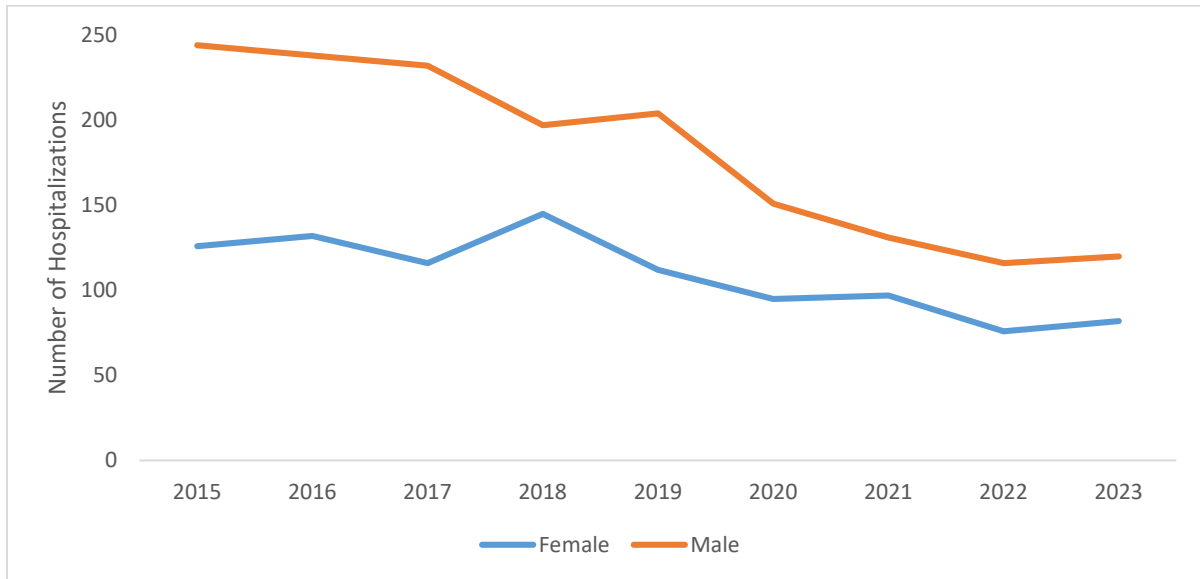


Table 1. Average rate of hospitalizations for all concussions by age group and sex per 100,000 population

Hospitalizations	2015	2016	2017	2018	2019	2020	2021	2022	2023
Overall	8.81	8.75	8.15	7.90	7.22	5.60	5.22	4.33	4.47
Male	11.30	10.95	10.57	8.84	9.06	6.69	5.83	5.06	5.16
Female	6.17	6.42	5.59	6.90	5.28	4.46	4.57	3.51	3.74
Age 0-4	8.83	8.49	9.48	10.57	9.85	4.98	4.40	4.90	3.76
Age 5-9	11.03	10.13	11.16	9.19	8.52	7.61	6.43	4.18	5.19
Age 10-14	12.86	12.08	8.46	9.23	8.39	6.94	7.29	5.61	5.35
Age 15-19	10.93	9.88	9.67	8.16	8.95	5.98	5.41	6.06	6.04
Age 20-25	3.07	4.96	4.09	4.46	2.98	3.65	3.48	2.11	2.83

- Males consistently had a higher number of hospitalizations due concussions compared to females, over the included time frame, although this trend is decreasing among both sexes (Figure 3).

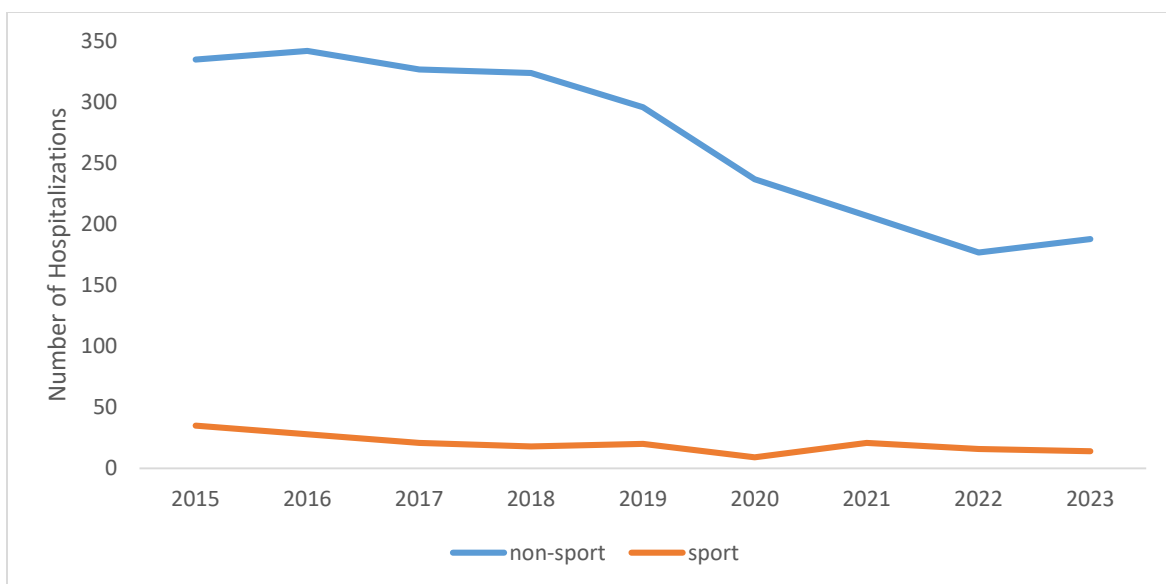
Figure 3. Number of hospitalizations due to concussions in Ontario, January 2015-December 2023 by sex



Sport-Related Concussion Hospitalizations

- There were a total of 182 hospitalizations for sport-related concussion in Ontario among children and youth ages 0 – 25 from January 2015 to December 2023, which represents 7% of all hospitalizations for concussion during this time period (Figure 4).
- The number of non-sport related concussion hospitalizations was higher than the number of sport-related concussions over the included time period (Figure 4).

Figure 4. Number of hospitalizations due to sport-related concussions in Ontario, January 2015-December 2023 by mechanism



- The highest rate for sport-related concussion hospitalizations was in 2015 (0.83 per 100,000 population) and the lowest was in 2020 (0.20 per 100,000 population) (Table 2).
- The 10 – 14 year olds had the highest rate of sport-related concussions compared to any other age group from 2015 to 2023 (Table 2).

Table 2. Average rate (per 100,000 population) of hospitalizations for sports-related concussions by age group and sex

Sport-related	2015	2016	2017	2018	2019	2020	2021	2022	2023
Overall	0.83	0.66	0.49	0.42	0.46	0.20	0.48	0.36	0.31
Male	1.07	1.01	0.77	0.54	0.49	0.31	0.45	0.52	0.30
Female	0.59	0.29	0.19	0.29	0.42	0.09	0.52	0.18	0.32
Age 0-4	0.28	0.14	0.42	0.00	0.14	0.14	0.14	0.00	0.13
Age 5-9	0.66	0.66	0.92	0.79	0.79	0.39	0.26	0.26	0.39
Age 10-14	2.12	1.84	1.17	0.77	1.27	0.50	1.51	1.00	1.00
Age 15-19	1.43	0.60	0.24	0.70	0.35	0.12	0.35	0.34	0.22
Age 20-25	0.00	0.26	0.00	0.00	0.00	0.00	0.24	0.23	0.00

- Both non-sport and sport-related concussion generally decreased over time, with rates ranging from 0.83 annual sport-related concussions per 100,000 population to the highest in 2015 to 0.20 sport-related concussion per 100,000 population in 2020 (Table 3).

Table 3. Number and rate of hospitalizations (per 100,000 population) for sports-related and non-sports related concussions by year

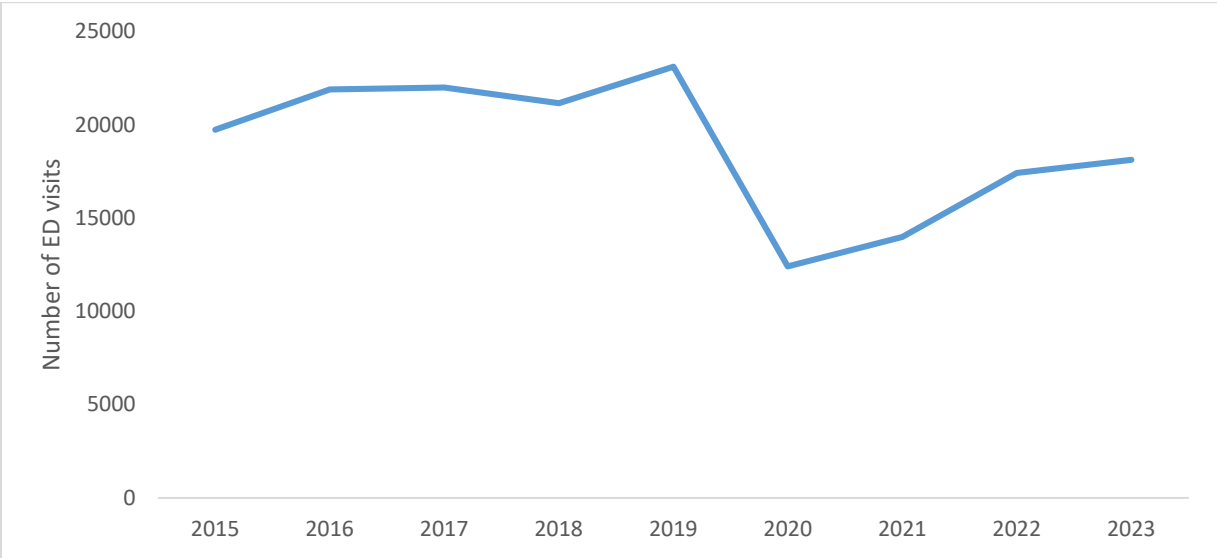
Year	Sport-Related Hospitalizations (Rate/100,000)	Non-Sport Related Hospitalizations (Rate/100,000)
2015	35 (0.83)	335 (7.97)
2016	28 (0.66)	342 (8.09)
2017	21 (0.49)	327 (7.66)
2018	18 (0.42)	324 (7.48)
2019	20 (0.46)	296 (6.77)
2020	9 (0.20)	237 (5.40)
2021	21 (0.48)	207 (4.74)

Year	Sport-Related Hospitalizations (Rate/100,000)	Non-Sport Related Hospitalizations (Rate/100,000)
2022	16 (0.36)	177 (3.97)
2023	14 (0.31)	188 (4.16)

All Concussion Emergency Department Visits

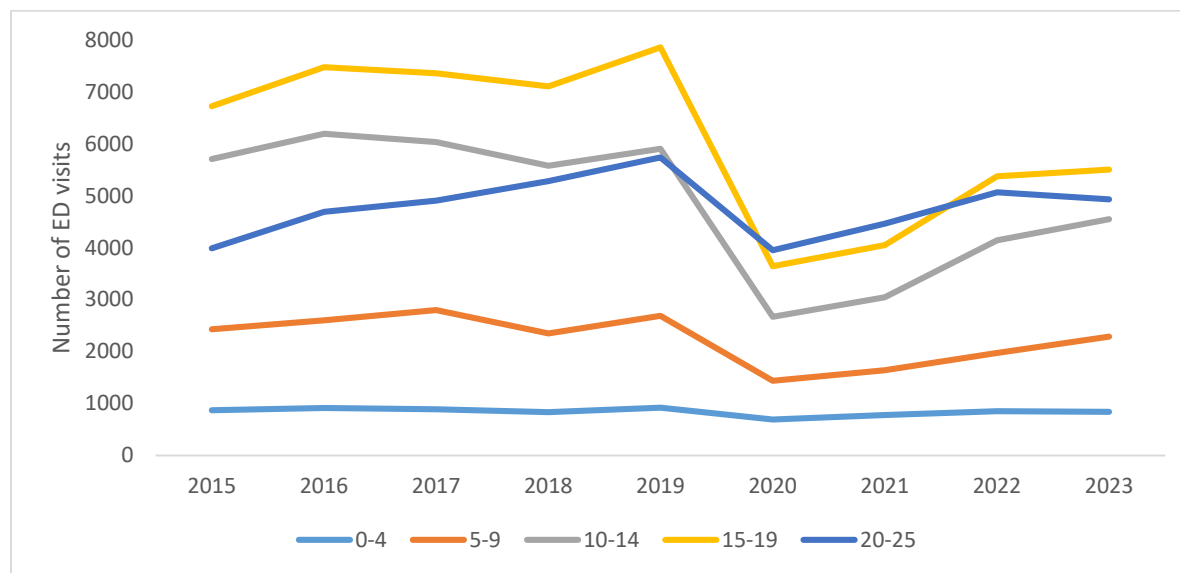
- There was a total of 169,864 unique concussion-related ED visits in Ontario among children and youth ages 0 – 25 from January 2015 to December 2023, with a decrease in 2020 and subsequent increases afterwards (Figure 5).

Figure 5. Number of emergency department (ED) visits due to all concussions in Ontario, January 2015-December 2023



- The 15 – 19 year olds demonstrate the highest rates of ED visits due to all concussion compared to other age groups, with the 0 - 4 year olds having the lowest (Table 4).
- All age groups demonstrated a peak in rates in 2019 and a significant drop in rates in 2020.

Figure 6. Number of emergency department (ED) visits due to concussions in Ontario, January 2015-December 2023 by age group



- Average rates of ED visits for concussions overall peaked in 2019 and significantly dropped in 2020 (Table 4).
- Males demonstrated higher rates than females from 2015 – 2017, and again in 2023. The 15 – 19 year old age group had higher rates compared to any other age group.

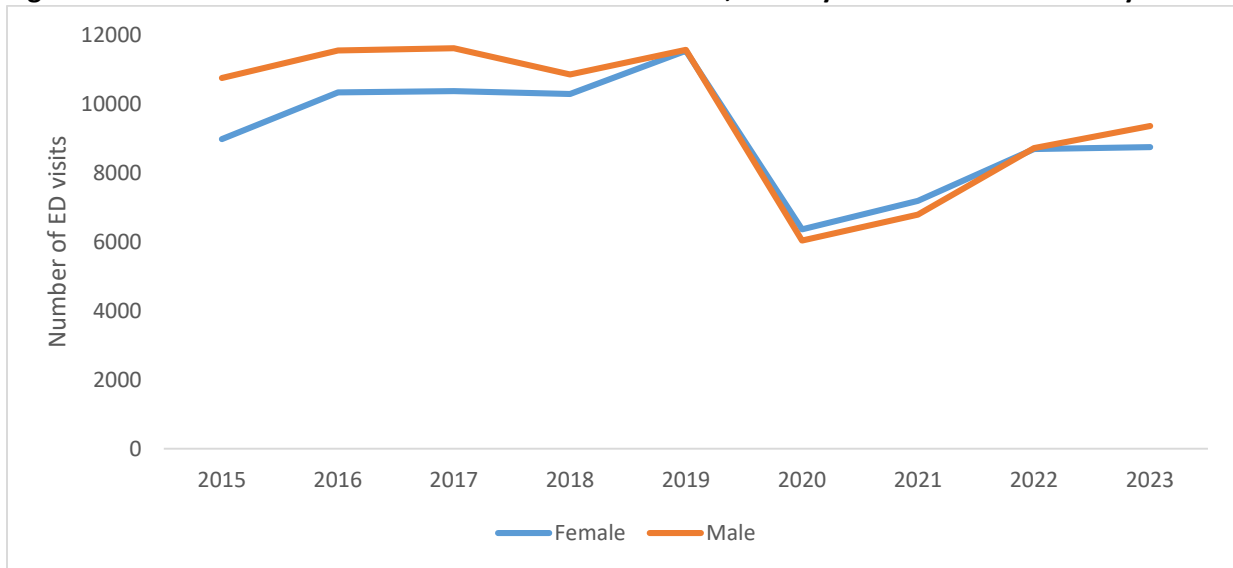
Table 4. Average rate (per 100,000 population) of emergency department (ED) visits for concussions by age group and sex

Concussions	2015	2016	2017	2018	2019	2020	2021	2022	2023
Overall	469.82	517.88	515.51	488.73	528.60	282.54	320.14	390.89	400.81
Male	498.05	531.97	529.61	487.31	513.92	267.46	302.42	380.54	402.64
Female	439.84	502.95	500.45	489.90	543.90	298.42	338.55	401.59	398.47
Age 0-4	122.61	127.54	124.54	116.09	127.80	95.85	107.61	116.61	112.81
Age 5-9	323.24	343.10	367.74	308.75	353.00	188.95	215.78	257.94	296.89
Age 10-14	757.49	814.22	785.72	715.64	750.35	336.97	383.18	517.57	566.24
Age 15-19	798.82	890.09	868.46	828.84	913.69	427.85	476.26	614.80	615.87
Age 20-25	350.50	408.94	418.32	436.27	461.91	313.77	361.49	395.52	377.33

- The number of ED visits due to all concussions in Ontario peaked in 2019 for both sexes, before their lowest incidence in 2020. However, both have steadily increased since 2020 (Figure 7).

- Males consistently had higher rates of concussion compared to females from 2015 to 2019; however, there appears to be no discernable differences in the rate of concussion between males and females from 2019 – 2023.

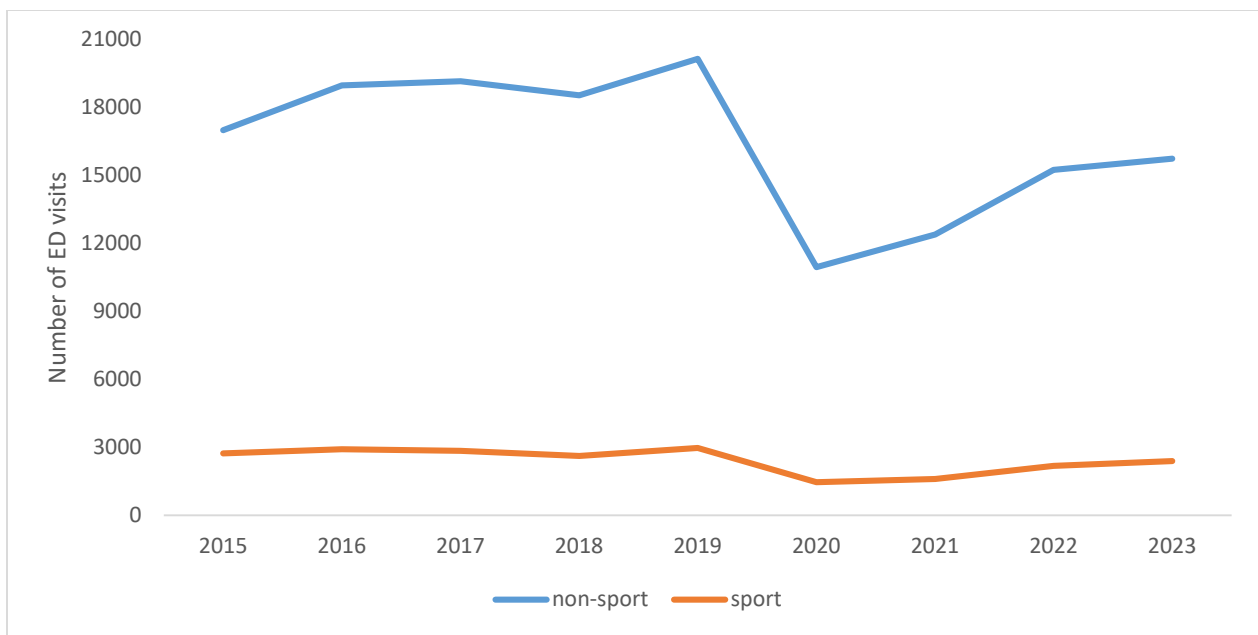
Figure 7. Number of ED visits due to concussions in Ontario, January 2015-December 2023 by sex



Sport-Related Concussion Emergency Department Visits

- There were a total of 21,718 ED visits for sport-related concussion in Ontario among children and youth ages 0 – 25 from January 2015 to December 2023, which represents 12.8% of all ED visits for concussions during this time period (Figure 8).

Figure 8. Number of emergency department (ED) visits due to sport-related concussions in Ontario, January 2015-December 2023 by mechanism



- The 10-14 year old age group consistently had the highest rate of ED visits sport-related concussion over any other age group, from 2015 to 2023 (Table 5).
- The rate of ED visits due to sport-related concussion varied between males and females. It declined in 2020 for both sexes, but has steadily been increasing.

Table 5. Average rate (per 100,000 population) of emergency department (ED) visits for sport-related concussions by age group and sex

Sport-related	2015	2016	2017	2018	2019	2020	2021	2022	2023
Overall	65.10	68.97	66.63	60.55	68.06	33.12	36.66	48.90	52.82
Male	66.98	67.80	68.26	57.97	67.29	33.87	36.91	45.70	51.46
Female	63.11	70.22	64.86	63.20	68.83	32.32	36.39	52.28	54.25
Age 0-4	2.10	1.95	2.79	1.25	2.64	1.80	3.44	3.00	1.75
Age 5-9	40.54	40.80	42.78	35.95	41.95	23.86	25.32	29.09	38.12
Age 10-14	154.33	172.04	165.00	145.15	157.06	71.38	83.50	109.43	126.22
Age 15-19	109.98	109.53	102.96	100.95	119.40	54.79	54.42	75.59	77.35
Age 20-25	28.54	31.52	30.43	28.16	30.16	17.94	20.81	30.97	28.68

- The number and rate of ED visits for non-sport related concussions were consistently higher than the number and rate of ED visits due to sport-related concussions in Ontario, from 2015 to 2023 (Table 6).
- The rate peaked in 2019, and was lowest in 2020, but has since been steadily increasing.

Table 6. Number and rate (per 100,000 population) of emergency department (ED) visits for sports-related and non-sports related concussions by year

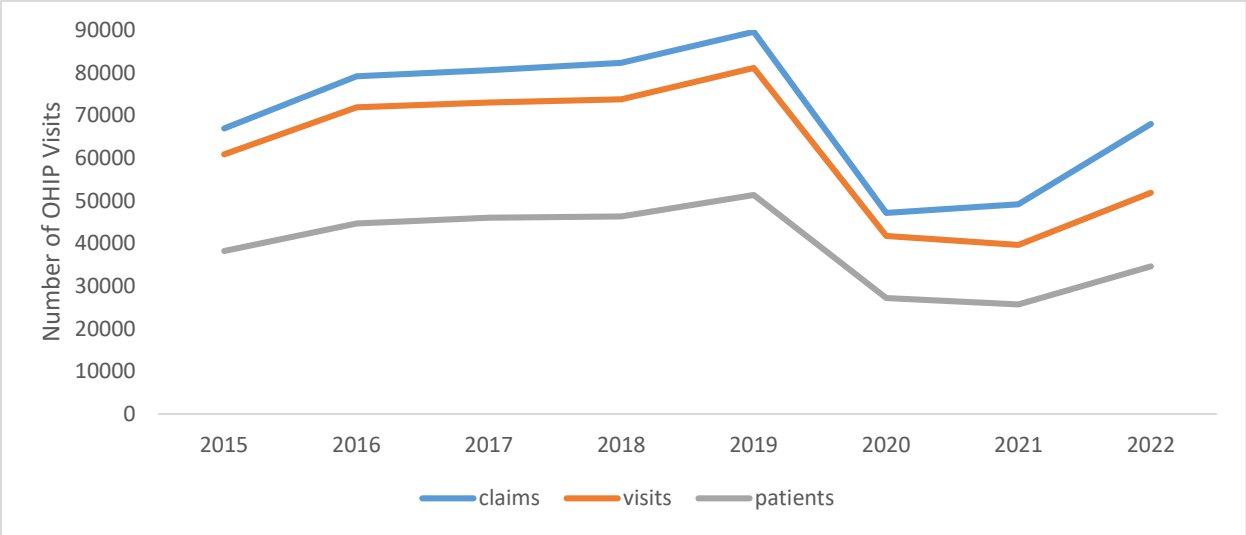
Year	Sport-Related Hospitalizations (Rate/100,000)	Non-Sport Related Hospitalizations (Rate/100,000)
2015	2735 (65.10)	17,003 (404.72)
2016	2916 (68.97)	18,979 (448.91)
2017	2844 (66.63)	19,160 (448.88)
2018	2622 (60.55)	18,540 (428.18)
2019	2977 (68.06)	20,144 (460.54)
2020	1454 (33.12)	10,951 (249.42)

Year	Sport-Related Hospitalizations (Rate/100,000)	Non-Sport Related Hospitalizations (Rate/100,000)
2021	1602 (36.66)	12,388 (283.48)
2022	2180 (48.90)	15,247 (342.00)
2023	2388 (52.82)	15,734 (348.00)

Ontario Health Insurance Plan (OHIP) Visits

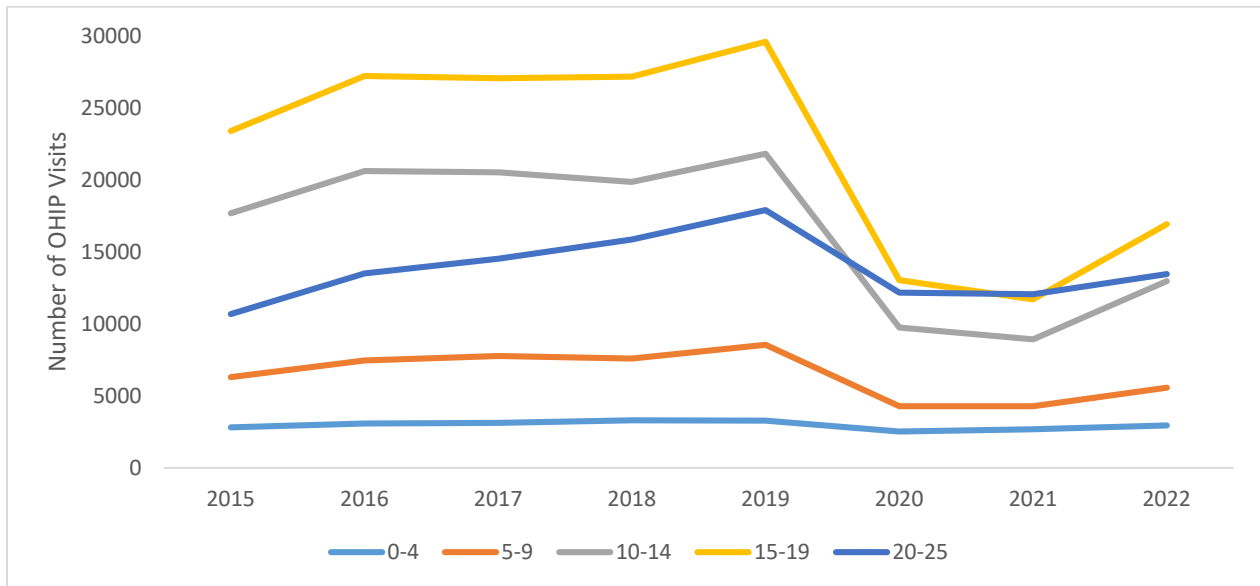
- There were a total of 494,210 visits by distinct health card number in Ontario among children and youth ages 0-25 from January 2015 to December 2022, with a decreases from 2020 to 2021 and subsequent increases in 2022 (Figure 9).

Figure 9. Number of Ontario Health Insurance Plan (OHIP) visits by distinct health card number due to concussions in Ontario, January 2015-December 2022



- Among children and youth presenting due to concussions, the 15 – 19 year old age group consistently had higher numbers of OHIP visits compared to any other age group from 2015 to 2022, the 0 – 4 year olds had the lowest number (Figure 10).

Figure 10. Number of Ontario Health Insurance Plan (OHIP) visits by distinct health card number due to concussions in Ontario, January 2015-December 2022 by age group



- The number of OHIP visits by distinct health card number due to concussions in Ontario from 2015 to 2022 initially steadily increased, but decreased in 2020. It has since been steadily increasing across both sexes (Figure 11).
- There was a peak in the number of concussions in 2019 for both sexes.
- Females consistently had higher numbers of concussion to Ontario physicians from 2017 to 2022.
- The 15 – 19-year-old age group consistently had higher rates of OHIP visits by distinct health card number compared to any other age group from 2015 to 2022 (Table 7).

Figure 11. Number of Ontario Health Insurance Plan (OHIP) visits by distinct health card number due to concussions in Ontario, January 2015-December 2022 by sex

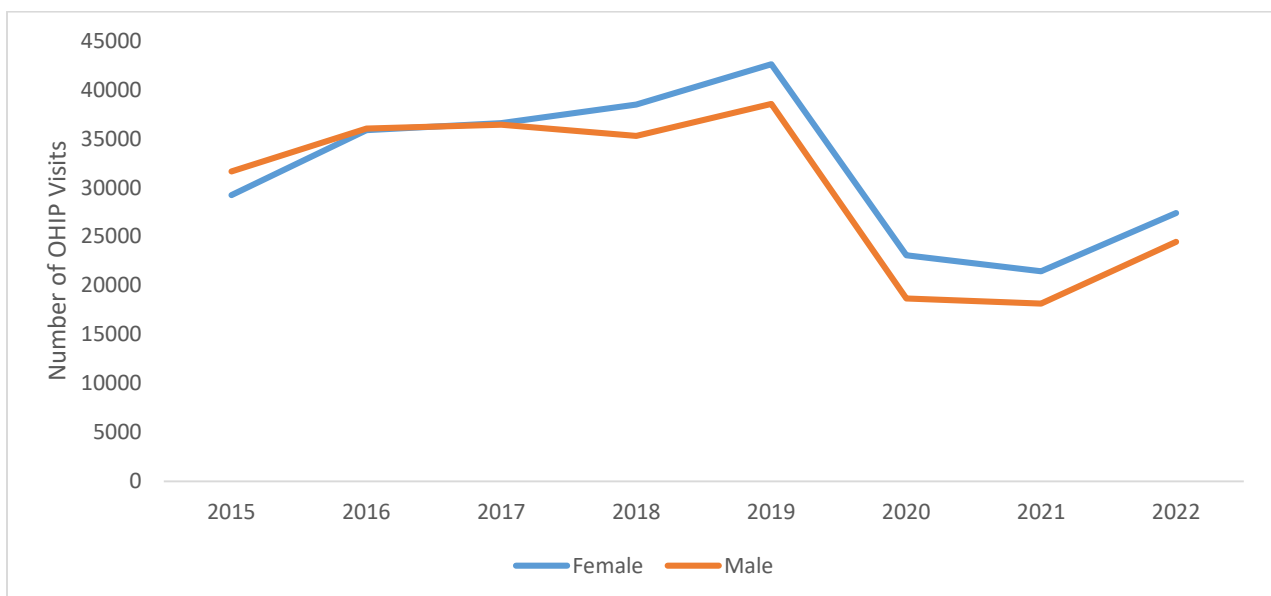


Table 7. Average rate (per 100,000 population) of Ontario Health Insurance Plan (OHIP) visits by distinct health card number for concussions by age group and sex

OHIP Visits	2015	2016	2017	2018	2019	2020	2021	2022
Overall	1449.80	1701.15	1711.55	1704.96	1856.07	951.52	907.20	1164.00
Male	1466.95	1658.95	1660.49	1584.35	1713.66	827.30	808.77	1066.86
Female	1431.68	1745.77	1765.60	1832.90	2007.11	1083.13	1011.27	1266.88
Age 0-4	394.86	428.29	436.53	458.66	456.24	348.68	367.54	401.74
Age 5-9	837.61	982.57	1018.56	997.50	1121.90	562.25	561.94	726.07
Age 10-14	2344.59	2709.78	2673.36	2548.67	2772.29	1228.83	1124.02	1619.21
Age 15-19	2781.02	3242.82	3193.74	3168.61	3442.94	1531.20	1374.95	1936.22
Age 20-25	938.59	1176.30	1239.53	1310.30	1440.19	966.40	976.04	1050.99

- Total number of concussion-related healthcare encounters was aggregated by including hospitalizations, ED visits and OHIP visits each year from 2015 to 2022.
- The peak year for total number of healthcare encounters was 2019, with an average of 81,046 encounters per year (Table 8).

Table 8. Total number of concussion-related health care encounters (hospitalizations, ED visits and OHIP visits), 2015 - 2022

Encounters	2015	2016	2017	2018	2019	2020	2021	2022
Overall	81,017	94,186	95,408	95,329	104,621	54,428	53,862	69,514
Male	42,665	47,840	48,297	46,369	50,354	24,878	25,087	33,306
Female	38,349	46,345	47,108	48,953	54,261	29,548	28,768	36,201
Age 0-4	3,756	4,053	4,091	4,210	4,280	3,250	3,485	3,841
Age 5-9	8,817	10,150	10,648	10,025	11,317	5,787	5,978	7,574
Age 10-14	23,493	26,926	26,647	25,529	27,788	12,471	12,043	17,170
Age 15-19	30,234	34,796	34,527	34,361	37,550	16,750	15,796	22,360
Age 20-25	14,717	18,261	19,495	21,204	23,686	16,170	16,560	18,569

Deaths

There were no deaths associated with concussion in Ontario from 2015 – 2023.

Discussion

The data presented in this summary provides some information specific to concussions in children and youth in Ontario. Overall, hospitalizations from all concussions, both sports-related and non-sports-related, declined between 2015 to 2023, from 8.81 per 100,000 to 4.47 per 100,000. This decline remained consistent across all age groups and sexes. Notably, this trend continued despite an increase in ED visits due to concussions from all mechanisms. Generally, admission to hospital following an ED visit for concussions is warranted when needing observation or further supportive measures unavailable in the outpatient setting. This may suggest concussions seen in the ED or managed by initial primary care providers may be less severe; however, significant enough to bring the patient to hospital.

Ontario was the first province to adopt a policy towards concussion. Policy/Program Memorandum 158 (PPM 158),^{5,6} was enacted in 2014 and further expanded in 2018 with the development of Rowan's Law.⁴ These pieces of legislation have included concussion education, prevention, and management guidance including return-to-play, and return-to-learn protocols, which will likely have a role in reducing the incidence and severity of concussions in children and youth.

Emergency department visits for concussions, as previously noted, peaked in 2019, with an overall rate of 528.60 per 100,000. It sharply declined to its lowest rate in 2020, 282.54 per 100,000. This is presumably due to the implementation of the COVID-19 lockdown restrictions, which have been associated with reduced reporting of injury rates globally.⁷ Emergency department visits for concussions have since steadily increased, with the rate rising to 400.81 per 100,000 overall in 2023. The 15-19 year olds demonstrated the highest rate of all concussions compared to other age groups, at 615.87/100,000, followed by 10-14 year olds. These two particular demographics may represent a particular focus for concussion prevention.

There are higher rates of non-sport-related concussions across all age groups and sexes compared to sport-related concussions. The two are important to differentiate as the mechanisms that contribute to non-sport-related concussions include MVCs, falls, and intentional or unintentional impacts to the head, among others. This is consequential as non-sport-related concussions may bear delayed symptom onset, more severe symptoms, and are less recognized than sport-related concussions.⁸ Given that non-sport-related concussions encompass a larger range of causes and outnumber sport-related concussions, this may require further stratification to allow for more effective recommendations toward interventions.

Males consistently had higher rates of both non-sport and sport-related concussions resulting in hospitalization. In contrast, females had a higher rate of OHIP visits for concussion, at a rate of 1266.8 per 100,000 over males at 1066.86 per 100,000 (in 2022), as well as a higher absolute number for all concussion-related healthcare encounters. This disparity may suggest males experience concussions of a greater severity at a higher frequency, though females appear to experience more health care encounters due to concussions (Table 8). There is evidence to suggest that females in sport, experience a higher frequency of concussion compared to males;^{9,10} given many concussions are not sport-related, this disparity may warrant further investigation.

Literature in youth sport suggests that previous concussion significantly increases the risk of subsequent concussion (i.e., greater than 3-fold risk compared to children and youth without previous concussion), placing children and youth at increased risk of long-term sequelae.¹¹ Further, recent literature suggests that greater exposure to head impacts (i.e., repeated sub-concussive head impacts) reduces concussion

tolerance in youth, resulting in increased report of concussion.¹² Importantly, this finding may be differential between males and females.¹²

There are limitations to this work. The existing data bases available to the MOH and PHO, do not fully capture the true burden of concussions in Ontario. As well, there are challenges in specifically reporting sport-related concussion over concussions suffered via other mechanisms (e.g., motor vehicle collision). Cases where a concussed youth presents to a community health centre, nurse practitioner, physiotherapist or other allied health professional would not be included in these data. Students reporting concussion as part of PPM-158 would also not be reported in these data, as PPM-158 requires schools and school boards to develop concussion codes of conduct. This is in addition to establishing a process to, and report of, the removal of students with a suspected concussion from physical activity.⁶ Finally, we do not have access to sport-related concussions that occurred at sporting events in Ontario (elite or recreational) that do not result in a health care encounter.

To support Rowan's Law (Recommendation 2), future work should include report of repeat concussions in children and youth as well as accessing other data sources toward understanding the true burden of this injury in a sporting context. Evidence suggests repeated concussion in youth (i.e., youth with 2 or more previous concussions) increases the risk of long-term neurophysiological impairment (e.g., cognitive, sleep, and neuropsychiatric symptom clusters), compared to athletes with one previous concussion.¹³ Thus, there is a need to address and prevent repeated injury, starting with an understanding of the number of children and youth with multiple concussions. To understand the true burden of sport-related concussion, access to other databases, outside the MOH and PHO, is necessary. Access to the Ministry of Education data bases on the number of concussions reported in schools in Ontario (i.e., to support Return to Learn programming following concussion) can best support these efforts. Other possible data sources include the Public Health Agency of Canada's (PHAC) Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP); the Canadian Health Survey of Children and Youth (CHSCY) (i.e., national survey of Canadians ages 1 to 17 years); and data from the Office of the Chief Coroner for fatalities from severe concussion/multiple concussions, including second impact syndrome.

Technical Notes

Data Sources

A population-based retrospective cohort study design was used for this project. The following data was extracted from the following sources:

- Emergency department (ED) visits due to concussions among individuals' ages 0-25 years in Ontario, Canada were extracted from the National Ambulatory Care Reporting System (NACRS).
- Concussion-related hospitalizations in the same population was obtained from the Discharge Abstracts Database (DAD).
- Concussions presenting to Ontario physicians in the form of clinical visits was obtained using OHIP (OHIP Claims History Database- CHDB).
- Deaths associated with concussion was derived from the Vital Statistics (VS) data base.
- All databases, including population estimates (provided by the Demography Division of Statistics Canada estimated using Census data) were obtained from IntelliHealth.

To ensure sufficient counts for analysis, in addition to presenting trends, data from January 2015 to December 2022 inclusive, was extracted.

Injury Codes

All concussion cases were selected from NACRS, DAD, and VS using the International Classification of Diseases (10th Revision) (ICD-10CA) code for concussion S06.0:

- For sport-related concussion, we extracted cases from a cross-tab of the S06.0 concussion code with injury external cause codes W21 (striking against or struck by sports equipment) and W02 (fall involving ice-skates, skis, roller-skates, or skateboards).
- Unique visits with S06.0 concussion code and injury external cause codes W21 or W21 were identified as sports-related concussions.
- All concussions presenting to a physician clinic in Ontario was extracted from OHIP using the three digit billing code, 850 (diagnostic code for concussion).

Data Analysis

The data for number of concussions for children and youth ages 0-25 was stratified into several categories for analysis, the following categories were included:

- Age group: 0-4, 5-9, 10-14, 15- 19, 20-25
- Sex: male, female
- Mechanism: sport, non-sport

The total population of children and youth in Ontario ages 0 – 25 years was used as the denominator in the calculation of rates. Population estimates based on the census received from Statistics Canada (up to 2020)¹⁴ and projections data received from the Ontario Ministry of Finance (starting from 2021)¹⁵ were used. To analyze the trends in concussion injury over time, a rate per 100,000 population was calculated for both all concussion and sport-related concussions across age groups and among males and females. Records with missing sex other than 'male' or 'female' were excluded from the stratified analyses (excludes 1 DAD record, 44 NACRS records).

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