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ABSTRACT

Background

Traumatic brain injuries (TBIs) are a major public health concern impacting the lives of many Canadians. Among all TBIs, concussions are the most common. However, to date, the incidence of concussions among the Canadian population, has remained unknown. To address this data surveillance gap, this study presents national estimates on the percentage of Canadians aged 12 years or older (excluding those living in the territories) who sustained one or more concussions in 2019.

Data and methods

This study used data collected from the Traumatic Brain Injury Rapid Response (TBIRR) module of the 2020 Canadian Community Health Survey, a cross-sectional health survey. Descriptive statistics and logistic regressions were conducted to summarize the information in the TBIRR module.

Results

This study found that approximately 1.6% of Canadians aged 12 years or older reported sustaining one or more concussions in 2019. Age was significantly associated with concussion incidence after controlling for sex and annual household income, and the locations and activities surrounding respondents' most serious concussions varied by age group. Over one-third of respondents sustained multiple concussions.

Interpretation

The results suggest that certain populations, particularly younger individuals, may be more affected by concussions. While circumstances surrounding concussions vary by age group, the most important contributing factors were sports or physical activities among youth and falls among the adult population. Monitoring concussions among the national population is an important activity in injury surveillance, as it can help evaluate the efficacy of injury prevention intervention and better understand knowledge gaps and the burden of this injury.

Keywords

concussion, mild traumatic brain injury, Canadian Community Health Survey, epidemiology, incidence

AUTHORS

André S. Champagne, Xiaoquan Yao, Steven R. McFaull, Shikha Saxena and Wendy Thompson are with the Public Health Agency of Canada. Kevin R. Gordon is with Dalhousie University and Shelina Babul is with the University of British Columbia and the British Columbia Children's Hospital.

What is already known on this subject?

- Traumatic brain injuries (TBIs) are a major public health concern, impacting the lives of many Canadians. Among all types of TBIs, concussions are the most common.
- Each year, TBIs account for approximately 20,000 hospitalizations in Canada (excluding Quebec).
- Motor vehicle collisions, sports and falls continue to be important factors contributing to a significantly large proportion of concussion incidents.

What does this study add?

- In Canada, the incidence of concussions at the national level remains unknown.
- To address this data surveillance gap, this study presents national estimates on the percentage of Canadians aged 12 years or older who sustained one or more concussions in 2019, using the 2020 Canadian Community Health Survey.

Traumatic brain injuries (TBIs) are a major public health concern impacting the lives of many Canadians. Between 2002 and 2016, over one-fifth of all injury deaths in Canada were associated with a TBI diagnosis.[1] These injuries also result in approximately 20,000 hospitalizations in Canada each year (this estimate excludes Quebec).[1] Among all types of TBIs, concussions are the most common, accounting for approximately 80% to 95% of such injuries.[2-5] Often termed as a "mild TBI," a concussion typically results in a rapid onset of short-lived impairment of neurologic function that resolves spontaneously.[6] Common symptoms include headache, dizziness, nausea, fatigue, and sensitivity to light and sound. Though loss of consciousness may also occur, this outcome is observed in less than 10% of cases.[7,8]

Symptoms can, however, persist among individuals, and factors including age, sex, history of concussion, comorbidities and the time to initiate care can affect the duration of symptoms.[9-13] Adhering to guidelines centred on a progressive return to activity has also been shown to reduce the duration of symptoms among those injured.[14] Longer-term symptoms exceeding average recovery times have also been documented; this is a condition known as persistent post-concussion symptoms (PPCS).[15] Generally defined as symptoms lasting over three months,[16] PPCS can affect 11% to 25% of those injured[17-19] and has been associated with a reduction in health-related quality of life.[20,21]

Besides examining aspects of concussions at the individual level, studies have also documented broader-level risk factors. For instance, motor vehicle collisions,[22,23] sports[24,25] and falls[26,27] continue to be important factors contributing to large proportions of concussion incidents, with the latter factor being more pronounced across younger (younger than 5 years) and older (older than 65 years) populations.[1,28] Males may also be more at risk of sustaining a TBI than females,[29-31] though in certain sports settings, including soccer, basketball, and softball or baseball, concussion rates have been found to be higher among females.[32] Concussion research and surveillance activities that examine the associated factors and the affected populations continue to be integral in the realm of public health, as they can help inform injury prevention efforts, with the goal of ultimately reducing the overall burden of this injury.

Indeed, in Canada, important epidemiological work on concussions has been conducted in recent years, highlighting the magnitude of this injury in specific regions. For instance, in Canada's most populous province of Ontario, Langer et al.[33] found a 1.2% mean annual incidence of concussions among the general population using emergency department visits and primary care physician data from 2008 to 2016. Using similar data sources, Macpherson et al.[34] and Zemek et al.[35] found significant increases in concussion-related visits in Ontario among children and adolescents throughout the first decade of the 2000s; a particularly sharp increase between fiscal years 2010 and 2013 was noted in the latter study. Likewise, an increase in pediatric concussions was also observed in Alberta using similar data sources from 2004 to 2018.[36]

Not captured in the above studies' estimates, however, are incidents where no medical care is sought following a concussion, likely underestimating the incidence of this injury. To put this potential constraint in relation to concussion epidemiology, Gordon,[37] found that 21.9% of the Canadians surveyed in the 2014 Canadian Community Health Survey (CCHS) who reported sustaining a concussion or other brain injury also stated that they did not seek medical care within 48 hours. Similarly, using data from the National Health Interview Survey in the United States, Sosin et al.,[38] found that 25.0% of surveyed respondents who sustained head injuries resulting in a loss of consciousness in the past 12 months did not seek medical treatment. These findings highlight the potential limitations of concussion surveillance that relies on clinical and administrative data and the opportunity for alternative data sources, such as population health surveys, to help complement the knowledge on the incidence of concussions.

For instance, at the national level, the CCHS has served as an important resource in understanding the incidence of TBIs among the Canadian population. Specifically, a published estimate from the 2014 CCHS cycle revealed a 0.5% incidence of self-reported concussions or other brain injuries among the Canadian population aged 12 years or older during a 12-month period.[30] Findings from the 2017/2018 CCHS also showed a 2.2% overall incidence of sports-related concussions or other brain injuries among the Canadian population aged 12 years or older.[39] A closer examination of these findings, however, reveals that a current data surveillance gap still remains at the national level regarding the specific incidence of concussions. First, concussions are grouped with other forms of TBIs. Second, only injuries that are serious enough to limit normal activities are captured in the module. Third, among respondents sustaining multiple injuries, only the most serious injury is examined, likely resulting in the underestimation of concussions or other types of TBIs.

To address this gap, the 2020 CCHS cycle included the Traumatic Brain Injury Rapid Response (TBIRR) module, which allowed for the examination of the incidence of concussions in 2019 among Canadians aged 12 years or older residing in the 10 Canadian provinces. To the knowledge of the authors, this is the first national population-based health survey in Canada to collect specific information on concussions and, their occurrence and management, and on the recovery from these injuries. Specifically, this study aimed to (1) provide national estimates regarding the percentage of Canadians aged 12 years or older who sustained one or more concussions in 2019, (2) identify populations at risk, (3) present the circumstances surrounding this injury and (4) assess the recovery time (in days) of respondents who sustained a concussion in 2019. This new information will help provide a baseline estimate of concussions at the national level, allowing for a better understanding of the extent of this traumatic injury in Canada, and help in evaluating the effectiveness of injury prevention interventions.

Data and methods

Data source

This study used data from the TBIRR module of the 2020 CCHS, a cross-sectional survey that collected health information from a nationally representative sample of the Canadian population aged 12 years and older residing in the 10 Canadian provinces. Because of restraints from the COVID-19 pandemic, data collection was completed exclusively by telephone between September and December 2020. Individuals living in the three Canadian territories, people living on reserves and other Indigenous settlements in the provinces, full-time members of the Canadian Forces, the institutionalized population (i.e., those living in health institutions, prisons, religious institutions and convents), foster children, and people living in the Quebec health regions of Nunavik and Terres-Cries-de-la-Baie-James were excluded from this survey.

Sample size and response rate

Overall, 83,297 households were in scope for the CCHS TBIRR. Valid responses were obtained from 18,858 individuals, resulting in a response rate of 22.6%. Respondents who reported sustaining one or more concussions in 2019 were asked supplemental questions on the frequency of their concussions, the type of diagnosis, the health information they received, the circumstances surrounding their concussion and their recovery.

Variables

Self-reported concussions

Respondents were asked, "The next set of questions are about concussions. A concussion is a type of traumatic brain injury that is caused by a fall, a blow to the head or body, or another injury that jars or shakes the brain inside the skull. In 2019, did you have a concussion?" If respondents replied yes, they were asked how many concussions were (1) diagnosed by a medical doctor or nurse practitioner; (2) identified by a professional such as a physiotherapist, chiropractor, or sports coach; or (3) suspected or self-diagnosed. In this section, respondents were permitted to select multiple diagnosis types (if applicable), resulting in a non-mutually exclusive category.

Location, activity and contact type

Participants were asked questions regarding where they were (location) and what they were doing (activity) when their concussion occurred in 2019. If respondents indicated that they had multiple concussions in 2019, information on the location and activity pertained to their most serious concussion (hereafter "only or most serious concussion"). Lists of predetermined locations and activities were provided to respondents at the time of the survey, with an optional "other" category, if applicable. To reduce statistical variability, reported locations and activities or circumstances were further grouped across age groups. As a result, the category labelled as "other" in the corresponding table consists of responses that include multiple reported locations and activities or circumstances, as well as the initial "other" category that was provided to respondents at the time of the survey. All answers were mutually exclusive.

Recovery, receipt of health information and medical clearance

Respondents were asked, "Are you currently experiencing any signs or symptoms of your concussion that you had in 2019?" If respondents replied yes, they were asked to state how long their symptoms have been occurring in the form of days, weeks or months. Symptom duration was also obtained from respondents who reported not having symptoms at the time of the survey. Lastly, respondents were asked whether they received health information when seeking medical care and

whether they had been medically cleared to return to their regular activities.

Sociodemographic characteristics

Respondents were stratified by age, sex, gender, school attendance (school, CEGEP or university) and total self-reported household income ($0 to $59,999, $60,000 to $149,999, and $150,000 or more), where the sample size permitted. Age groups (in years) were categorized as 12 to 19, 20 to 39, 40 to 64, and 65 and older and adjusted accordingly to accommodate the sample size and reduce statistical variability.

Statistical analysis

Analyses were based on a sample of 18,858 respondents aged 12 years or older residing in the 10 provinces and used SAS Enterprise Guide 7.1 (SAS Institute, Cary, North Carolina). Descriptive statistics were derived using the SAS SURVEYFREQ and SURVEYMEANS procedures. Unless otherwise specified, estimates were based on all respondents who reported having one or more concussions in 2019, regardless of diagnosis types. The Rao-Scott chi-square test was used to test proportional differences between given groups. Adjusted odds ratios (ORs) were obtained by performing a multivariable logistic regression model using the SURVEYLOGISTIC procedure. To do so, univariate analyses were first performed, and variables showing a relaxed p value of less than 0.25 were included in the full model. Unadjusted ORs are also presented. The LIFETEST procedure was used to perform a time-to-event analysis where the resolution of symptoms (in days) was the main outcome of interest. This analysis allowed for the examination of the median time of symptom resolution among respondents (i.e., the time point where 50% of respondents' symptoms were resolved). The log-rank test was also used to test whether the differences between groups' symptom resolution times were statistically different. Statistical significance was set at a p value of 0.05. The 95% confidence intervals (CIs) and coefficients of variation were derived using the bootstrap repeated replication sampling method (n = 1,000) to account for the complex sampling design of the CCHS.

Results

Percentage of Canadians reporting a concussion and the frequency of concussions

Overall, 1.6% (95% CI: 1.3, 1.9) of respondents aged 12 years or older reported sustaining one or more concussions in 2019. This estimate was 1.4% (95% CI: 1.1, 1.7) when excluding respondents who solely reported sustaining suspected or self-diagnosed concussions. Demographic characteristics of all surveyed respondents and those reporting one or more concussions are presented in Table 1.

The national estimates on the percentage of Canadians aged 12 years or older who sustained one or more concussions in 2019, along with unadjusted and adjusted ORs by characteristics, are presented in Table 2. Unadjusted ORs revealed that age, household income and school attendance were associated with self-reported concussions; however, only age remained statistically significant when controlling for sex and household income. Compared with adults aged 40 to 64 years, youths and young adults aged 12 to 19 years had 5.2 times (95% CI: 3.3, 8.4) the odds of reporting a concussion. Individuals attending school, among whom 84.5% (95% CI: 74.8, 94.1) were aged 12 to 19 years, had 3.6 times (95% CI: 2.5-5.2—crude OR) the odds of reporting a concussion than those not attending school. No significant difference was observed when comparing the

Table 1
Sample distribution by selected demographic characteristics among all respondents and those self-reporting one or more concussions in 2019, household population aged 12 years and older, Canada (excluding the territories)

	All respondents			Respondents who reported one or more concussions in 2019		
	Weighted	95% confidence interval		Weighted	95% confidence interval	
Characteristics	percentage	from	to	percentage	from	to
Sex						
Male	49.3	49.2	49.4	44.2	35.6	52.7
Female	50.7	50.6	50.8	55.8	47.3	64.4
Age group (years)						
12 to 19	10.3	9.7	10.9	35.5	27.3	43.6
20 to 39	30.6	29.7	31.4	28.0 [E]	18.7	37.2
40 to 64	38.5	37.9	39.1	26.1 [E]	18.3	34.0
65 and older	20.6	20.6	20.7	10.4 [E]	6.2	14.6
School attendance						
Yes	15.9	15.0	16.7	39.6	31.2	48.0
No	84.1	83.3	85.0	60.4	52.0	68.8
Annual household income (CAN$)[1]						
0 or less to 59,999	26.3	25.2	27.4	25.9	18.6	33.2
60,000 to 149,999	46.8	45.5	48.1	37.8	29.9	45.6
150,000 or more	26.9	25.7	28.2	36.3	27.8	44.8

[E] use with caution

[1] Missing data are not included in weighted estimates.

Source: Statistics Canada, Canadian Community Health Survey – Rapid Response – Traumatic Brain Injury, 2020.

Table 2
Weighted percentage and crude and adjusted odds ratios of respondents self-reporting one or more concussions in 2019, by selected demographic characteristics, household population aged 12 years and older, Canada (excluding the territories)

Characteristics	Weighted percentage	95% confidence interval from	95% confidence interval to	Unadjusted odds ratio	95% confidence interval from	95% confidence interval to	Adjusted odds ratio	95% confidence interval from	95% confidence interval to
Overall	1.6	1.3	1.9	…	…	…	…	…	…
Excluding respondents who solely reported sustaining suspected or self-diagnosed concussions	1.4	1.1	1.7	…	…	…	…	…	…
Sex									
Male	1.4	1.0	1.8	0.8	0.6	1.2	0.8	0.5	1.1
Female[1]	1.8	1.4	2.1	1.0	…	…	1.0	…	…
Age group (years)									
12 to 19	5.6	4.1	7.0	5.3 *	3.4	8.4	5.2 *	3.3	8.4
20 to 39	1.5 E	0.9	2.1	1.4	0.8	2.4	1.4	0.8	2.4
40 to 64[1]	1.1 E	0.7	1.5	1.0	…	…	1.0	…	…
65 and older	0.8 E	0.5	1.1	0.7	0.4	1.2	0.8	0.5	1.2
School attendance (student)									
Yes	4.0	3.0	5.0	3.6 *	2.5	5.2	…	…	…
No[1]	1.2	0.9	1.4	1.0	…	…	…	…	…
Annual household income (CAN$)									
0 or less to 59,999	1.6 E	1.1	2.1	1.2	0.8	1.9	1.3	0.9	2.0
60,000 to 149,999[1]	1.3	1.0	1.6	1.0	…	…	1.0	…	…
150,000 or more	2.2 E	1.5	2.8	1.7 *	1.1	2.5	1.5	1.0	2.3

… not applicable

* significantly different from reference category ($p < 0.05$)

E use with caution

[1] Reference category.

Note: The multivariable logistic regression model included age group, sex and household income.

Source: Statistics Canada, Canadian Community Health Survey – Rapid Response – Traumatic Brain Injury, 2020.

incidence of self-reported concussions among sexes after controlling for age and household income (0.8 [95% CI: 0.5, 1.1]). A comparison among genders yielded a similar finding to that of the sex at birth analysis—a crude OR of 0.8 (95% CI: 0.6, 1.2).

Given the small sample size of respondents who did not identify as male or female (resulting in high statistical variability), only comparisons across the two most populous gender categories—male and female—were performed.

Location and activity

The reported locations in which the respondents' only or most serious concussion occurred varied across age groups (Table 3-1). While sporting areas (43.7% [95% CI: 30.5, 56.9]) and schools (25.5% [95% CI: 13.9, 37.2]) were the locations reported by the majority of respondents aged 12 to 19 years, homes (26.7% [95% CI: 16.5, 37.0]), highways or streets (26.3% [95% CI: 15.3, 37.3]), and workplaces (18.3% [95% CI: 8.1, 28.5]) accounted for the majority of locations where adults aged 20 to 64 years sustained their most serious concussion. Determining the location in which the majority of respondents aged 65 years or older sustained their most serious concussion was impossible, as 57.4% (95% CI: 38.2, 76.5) of locations were categorized as "other." However, 42.6% (95% CI: 23.5, 61.8) of this population reported homes as the location where their only or most serious concussion occurred.

Overall, sports or physical activities and slips or falls represented the topmost circumstances surrounding the respondents' only or most serious concussion (Table 3-2). The distribution of reported circumstances, however, varied across groups. While sports or physical activities (58.2% [95% CI: 45.1, 71.4]) were reported by the majority of respondents aged 12 to 19 years, slips or falls (29.5% [95% CI: 18.1, 40.9]), sports or physical activities (20.6% [95% CI: 8.3, 32.9]) and work-related activities (15.0% [95% CI: 6.0, 24.0]) were reported by the majority of respondents aged 20 to 64 years. Slips or falls were reported by the majority of respondents aged 65 years and older, at 61.3% (95% CI: 43.0, 79.6).

Among respondents reporting that sports or physical activities were taking place when their only or most serious concussion occurred, traditionally summer-based sports (football, rugby and soccer) and winter-based sports (hockey, skating, and skiing or snowboarding) accounted for the majority of total identified activities, at 36.0% (95% CI: 21.8, 50.2) and 34.4% (95% CI: 16.4, 52.4), respectively.

Multiple concussions, type of diagnosis, recovery and health information received

Overall, approximately one-third of respondents (34.6% [95% CI: 26.6, 42.5]) reported two or more concussions in 2019, with no proportional differences noted among sexes ($p = 0.48$) and age groups ($p = 0.16$) (Table 4-1). Among those reporting

Table 3-1
Weighted distribution of the reported location of the respondent's only or most serious concussion occurring in 2019, by age group, household population aged 12 years and older, Canada (excluding the territories)

Age group (years) and location	Weighted percentage	95% confidence interval from	to
12 to 19			
Sporting area	43.7 [E]	30.5	56.9
School	25.5 [E]	13.9	37.2
Home	18.0 [E]	6.9	29.1
Other	12.8 [E]	4.0	21.6
20 to 64			
Home	26.7 [E]	16.5	37.0
Street, highway	26.3 [E]	15.3	37.3
Workplace	18.3 [E]	8.1	28.5
Other	28.7 [E]	16.3	41.0
65 and older			
Home	42.6 [E]	23.5	61.8
Other	57.4 [E]	38.2	76.5

[E] use with caution

Note: To reduce statistical variability, the category labelled as "other" in the corresponding table consists of multiple reported locations, including the initial category "other" provided to respondents at the time of the survey.

Source: Statistics Canada, Canadian Community Health Survey 2020 – Rapid Response – Traumatic Brain Injury, 2020.

Table 3-2
Weighted distribution of the reported activity or circumstance of the respondent's only or most serious concussion, by age group, household population aged 12 years and older, Canada (excluding the territories)

Age group (years) - activity or circumstance	Weighted percentage	95% confidence interval from	to
12 to 19			
Sports or physical activity	58.2	45.1	71.4
Other	41.8 [E]	28.6	54.9
20 to 64			
Slip or fall without being pushed	29.5 [E]	18.1	40.9
Sports or physical activity	20.6 [E]	8.3	32.9
Working at a paid job	15.0 [E]	6.0	24.0
Riding or driving a motor vehicle	10.6 [E]	4.8	16.4
Other	24.3 [E]	13.4	35.2
65 and older			
Slip or fall without being pushed	61.3 [E]	43.0	79.6
Other	38.7 [E]	20.4	57.0

[E] use with caution

Note: To reduce statistical variability, the category labelled as "other" in the corresponding table consists of multiple reported activities or circumstances, including the initial category "other" provided to respondents at the time of the survey.

Source: Statistics Canada, Canadian Community Health Survey – Rapid Response – Traumatic Brain Injury, 2020.

multiple concussions, 56.9% (95% CI: 42.5, 71.3) reported sports or physical activities and slips or falls as the activities or circumstances when their most serious concussion occurred (data not shown).

Regarding the type of diagnosis, the majority of respondents (73.8% [95% CI: 66.3, 81.2]) indicated that their concussions were either diagnosed by a medical doctor or nurse practitioner or identified by a professional, whereas 11.7% (95% CI: 6.4, 16.9) indicated that they had a suspected or self-diagnosed concussion in 2019 (Table 4-2). Lastly, 13.3% (95% CI: 7.5, 19.0) indicated both types of diagnosis, highlighting that nearly one-quarter of respondents reported having one or more suspected or self-diagnosed concussions in 2019.

Table 4-1
Weighted percentage of multiple concussions, by sex and age group, household population aged 12 years and older, Canada (excluding the territories)

	Weighted percentage	95% confidence interval from	to
Overall	34.6	26.6	42.5
Sex (p = 0.48)			
Male	55.1 [E]	40.9	69.4
Female	44.9	30.6	59.1
Age group (years) (p = 0.16)			
12 to 19	40.2 [E]	26.5	53.8
20 and older	59.8	46.2	73.5

[E] use with caution
Source: Statistics Canada, Canadian Community Health Survey – Rapid Response – Traumatic Brain Injury, 2020.

Table 4-2
Weighted percentage of type of diagnosis reported by respondents, household population aged 12 years and older, Canada (excluding the territories)

	Weighted percentage	95% Confidence interval from	to
Diagnosed by a medical doctor or nurse practitioner or identified by a professional	73.8	66.6	81.2
Self diagnosed or suspected	11.7	6.4	16.9
Diagnosed by a medical doctor or nurse practitioner or identified by a professional and self diagnosed or suspected	13.3	7.5	19.0

Source: Statistics Canada, Canadian Community Health Survey – Rapid Response – Traumatic Brain Injury, 2020.

Table 4-3
Median time of resolution of symptoms (days) by sex, household population aged 12 years and older, Canada (excluding the territories)

	Days	95% Confidence interval from	to
Overall	30.0	14.0	60.0
Sex (p = 0.2)			
Male	14.0	10.0	60.0
Female	60.0	14.0	120.0

Source: Statistics Canada, Canadian Community Health Survey – Rapid Response – Traumatic Brain Injury, 2020.

Table 4-4
Information on absence of symptoms, receipt of health information, medical clearance and return to regular activities, household population aged 12 years and older, Canada (excluding the territories)

	Weighted percentage	95% Confidence interval from	to
Currently not experiencing signs or symptoms from their only or most serious concussion	77.8	69.8	85.8
Information received upon care (among those whose concussion was diagnosed by a doctor or nurse practitioner or identified by a professional)	93.6	89.9	97.4
Cleared by a doctor or nurse practitioner to return to all regular activities (among those who had a concussion diagnosed by a doctor or nurse practitioner)	90.4	85.4	95.4
Reported returning to regular activities	90.7	85.7	95.7

Source: Statistics Canada, Canadian Community Health Survey 2020 – Rapid Response – Traumatic Brain Injury, 2020.

Symptom resolution was studied through a time-to-event analysis that, considered information on symptom duration among those experiencing symptoms and those whose symptoms had resolved. Overall, half of the respondents' symptoms were resolved within 30 days (95% CI: 14, 60). No significant difference in the resolution of symptoms was noted among sexes (p = 0.2) (Table 4-3).

Most respondents who reported sustaining one or more concussion in 2019 (77.8% [95% CI: 69.8, 85.8]) indicated that they were not experiencing any concussion symptoms at the time of the survey (Table 4-4). Among respondents whose concussions were diagnosed by a medical doctor or nurse practitioner or identified by a professional, the majority (93.6% [95% CI: 89.9, 97.4]) reported that they were provided with some form of health information during their assessment, such as advice to assist recovery and, common signs and symptoms, including those requiring urgent follow-up.

Approximately 90.4% (95% CI: 85.4, 95.4) of respondents whose concussions were diagnosed by a medical doctor or nurse practitioner reported that they had been medically cleared to return to some or all regular activities. Overall, 90.7% (95% CI: 85.7, 95.7) of respondents reported returning to their regular activities (Table 4-4).

Discussion

In this study, a representative sample was used to estimate the percentage of Canadians aged 12 years or older who sustained one or more concussions in 2019. The context of, management of and recovery from these injuries were also examined. This study found that approximately 1.6% of Canadians aged 12 years or older reported sustaining one or more concussions in 2019 (1.4% when respondents who solely reported sustaining one or more suspected or self-diagnosed concussions were excluded). While age, school attendance and annual household income levels were associated with concussion incidence, only age remained statistically significant in the multivariable model. The locations and activities surrounding respondents' only or most serious concussion varied by age group, and the majority of the respondents' self-reported concussions were either diagnosed by a medical doctor or nurse practitioner or identified by a professional. Over one-third of respondents reported sustaining multiple concussions. Regarding recovery, half of the respondents' symptoms resolved within 30 days, and the majority of respondents reported fully returning to their regular activities.

Concussion incidence

This study expands on prior national-level work conducted by Gordon et al.,[30] whose study found a 0.5% incidence of self-reported concussions or other brain injuries among the Canadian population aged 12 years or older during a 12-month period using data from the 2014 CCHS. However, the TBIRR module made, it possible to further narrow the focus on concussions and broaden the injury inclusion criteria, that is, regardless of whether the respondents sustained other serious injuries or whether their concussions were not serious enough to limit normal activities, disclosed self-reported concussions were captured in this study. This departure in criteria may in part reflect the higher estimate of 1.6% among a demographically similar population. The use of the TBIRR module also provided further insight on information that is not captured in the CCHS, including symptom duration, multiple concussions, recovery and diagnosis of self-reported concussions. These additional components can help support epidemiological knowledge of concussions in Canada.

Context of concussions

This study found a high incidence of concussions among those aged 12 to 19 years, and the majority of this population acknowledged sports and physical activities as a factor when their only or most serious concussion occurred. This finding is consistent with other studies,[1,40] pointing to the inherent risks of injuries in sports. Regarding concussions, however, some sports may carry higher risks among athletes.[41] Hockey, rugby, and football, sports in which many Canadians participate, rank among the top three sports showing high overall incidences of concussions.[41] In this respect, injury prevention research and interventions continue to be an integral component in the evolution of sports. For instance, over the years, important measures and tools have been introduced to reduce the incidence of injuries (including concussions), such as the implementation of rule changes (e.g., no contact to the head or from behind); the delay of permissible body contact in hockey; and the dissemination of educational and awareness tools targeted at sporting and coaching staff, parents, and players—all of which underscore the importance of player safety in sports. Moving forward, the evaluation of these interventions through study designs, including time series analyses (i.e., before and after intervention),[42,43] will continue to be important in ensuring the effectiveness and understanding of their impact on concussion education in the field.

Among the adult population, the varied circumstances and locations of respondents' only or most serious concussion point to the challenges around injury prevention, as multiple targeted prevention efforts may be required among certain populations. For instance, these findings suggest that pedestrian, motor vehicle and workplace safety, and fall prevention could be targeted areas of interest among this population. Moreover, the latter area would also be particularly relevant to the senior population, nearly two-thirds of whom reported falls or slips as contributing factors in their only or most serious concussion. In this respect, interventions aimed at improving gait instability have been shown to have positive impacts among older adults participating in physical activities, including resistance aerobic exercise and stability ball training.[44] Gait stabilizing devices, such as traction cleats, may also help reduce the risks of outdoor winter falls.[45]

School attendance

Unsurprisingly, the student population had a higher annual incidence of concussions when compared with those not attending school, reflecting the young age distribution of this population. Nonetheless, this finding provides insight on some of the challenges faced by this population as school activities may be disrupted after sustaining a concussion. In recognition of the acute cognitive effects that may incur following concussions, important tools and resources have been developed, including the Concussion Awareness Training

Tool;[46] Université Laval's *Concussion: prevention, detection and management*;[47] Parachute's *Canadian Guideline on Concussion in Sport*;[48] and the Centers for Disease Control and Prevention's HEADS UP.[49] All of these provide evidence-based resources to educational staff to accommodate the needs of students following their recent trauma.

Multiple concussions

This study found that over one-third of respondents reported sustaining more than one concussion in 2019, and, among this group, sports or physical activities and slips or falls were reported by the majority of respondents when their most serious injury occurred. While this finding offers some potential insight on this subpopulation, whether such factors were involved when these respondents sustained their other concussions is not captured in the TBIRR.

Nonetheless, the overall finding that over one-third of respondents reported multiple concussions contrasts heavily with that of Lasry et al.'s systematic review,[31] which highlighted that approximately 5.5% of patients in the general population may experience a recurrent concussion after a one-year follow-up. This finding signals the ongoing need to disseminate educational tools and raise awareness to protect the health of those at risk, as patients with recurrent concussions may demonstrate poorer outcomes relating to cognitive function and functional impairment.[40,50] Moreover, in Ontario, the tragic death of Rowan Stringer, a 17-year-old rugby player who sustained multiple concussions the week before her death, raised significant awareness on this topic and led to important legislation changes: in 2018, *Rowan's Law* was enacted in the province, which, among other things, mandated all coaches and team trainers to annually review up-to-date concussion safety resources to protect the health of athletes.[51,52] Furthermore, van Ierssel et al.[53] highlighted that athletes aged 5 to 18 years who sustained a concussion were 3.6 times more likely to sustain another concussion than those without a history of concussion. Considering the potential health impacts, monitoring the recurrence of concussions among the Canadian population will likely be an important aspect in complementing concussion surveillance. In Canada, this may be achieved through health data sources, including surveys and clinical and administrative data.

Recovery

Recovery was assessed in this study using the reported duration of symptoms as stated by respondents. The median time of resolution of symptoms among respondents was 30 days. While these findings suggested a potential difference in symptom resolution among sexes (60 days among females; 14 days among males), a statistical comparison revealed a non-significant finding. Therefore, larger sample sizes in health surveys may be required for future studies aiming to compare symptom resolution among different populations. The median time of 30 days also reflects a duration below the generally defined period for PPCS (symptoms exceeding three months)—an area that has received increasing attention.[16,17,54] Moving forward, to better understand the magnitude of and to provide better insight on this condition among the Canadian population, it may be of value to inquire whether respondents have received such a diagnosis in future health surveys.

Strengths and limitations

The strength of this study centres on the established sampling methodology used in the CCHS, which allowed for estimates to be representative of the Canadian population aged 12 years or older (excluding the territories). The TBIRR module was also built on previously validated questions regarding TBIs that have been incorporated in previous injury modules of the CCHS. Limiting the questions specifically to concussions provided an opportunity to obtain more insight on this injury. There are, however, several limitations associated with this study. As with self-reported surveys, the inability to validate responses from the surveyed population is an inherent limitation that may affect the overall accuracy of the presented estimates. Recall bias may also have been introduced in the survey, as respondents were asked in the later months of 2020 whether they sustained concussions in 2019; moreover, long recall periods exceeding 12 months may translate in the underestimation of the rate of injuries among surveyed participants, especially for injuries of a less severe nature.[55] Suspected or self-diagnosed concussions for which no medical confirmation was obtained were also included in the estimates, and though respondents were provided with a brief definition of a concussion by survey staff, it is impossible to confirm whether these reported events were concussions. Regarding Canada's senior population aged 65 years and older, the CCHS did not capture responses from individuals residing in institutions, such as long-term care facilities. As a result, this study likely underestimates the concussion incidence of this population, who are at a high risk of concussions. The sampled population also excluded those living in Canada's three territories, limiting the overall national coverage. Because the circumstances noted in the results section reflect the surveyed respondents' only or most serious concussion, the circumstances of those who reported two or more concussions in 2019 were not fully captured in the questionnaire. Lastly, the overall response rate of the CCHS was low (22.6%); as such, despite rigorous adjustments and validations, the high non-response rate increases the risk of a remaining bias.

Conclusion

This research provides a national examination on the incidence of self-reported concussions occurring in 2019. The results of this study suggest that certain populations, particularly younger individuals, may be more affected by concussions. While circumstances surrounding concussions vary by age groups, the most important contributing factors were sports or, physical activities among youth and falls among the adult population. The ongoing monitoring of concussions among the national population is an important activity in injury surveillance, as it

can help evaluate the efficacy of injury prevention intervention, better understand knowledge gaps and the burden of this injury, inform public health policy, and complement future research examining potential long-term outcomes related to concussions.

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