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THE BURDEN OF CONCUSSION AMONG CHILDREN & YOUTH IN BRITISH COLUMBIA (UPDATE)

BC INJURY research and prevention unit

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KEY HIGHLIGHTS

The purpose of this report is to provide details on the burden of concussion hospitalizations among children and youth in British Columbia (BC). This report is targeted to health care providers and community stakeholders in BC to be used to facilitate discussion of the need for standardized concussion prevention, diagnosis and management specific to children and youth.

Evidence suggests that children and youth are at greater risk of concussion and more serious head injury than the general population, take longer than adults to recover following a concussion, and that concussions can permanently change the way a child or youth talks, walks, learns, works and interacts with others.

Concussion management and appropriate return to activity is crucial, particularly in the pediatric and adolescent populations. Active and timely rehabilitation is essential for concussion patients who remain symptomatic longer than a six week period. This may include physiotherapy, occupational therapy, educational support, neuropsychology and in some cases, neuropsychiatry.

It is important to note that an individual is 3-times more likely to sustain a subsequent concussion while recovering from the previous concussion. Furthermore, while a rare occurrence, a condition known as second-impact syndrome (SIS) may occur if a subsequent injury to the brain is sustained within a day or two after the previous concussive event. This leads to swelling of the brain that can result in brain damage, causing severe disability and in a few cases even death.

Concussions are the most common form of head injury, yet this significant health issue is under-reported due to a lack of education and awareness among the general public and inconsistent and limited availability of data related to the burden of this injury. The data presented in this report represent only a fraction of the children and youth that may have sustained a concussion in BC, as this report does not capture children and youth with concussions who were treated at physicians' offices, walk-in clinics, or those not recognized and treated at all.

Concussion highlights from 2001/02 to 2013/14 include but are not limited to the following:

- There were 2,539 concussion hospitalizations due to unintentional injuries among children and youth ages 0 to 19 years who reside within BC.
- Male children and youth in BC had more than twice the rate of concussion hospitalizations as females (27.1/100,000 vs. 12.6/100,000).
- The leading causes of child and youth concussion hospitalizations in BC were due to falls (43%, n=1,093) and transport-related events (39%, n=993).
- Among children and youth aged 0 to 19 years in BC, those aged 1 to 4 years had the highest rate of fall-related concussion hospitalizations (14.6/100,000) and older youth aged 15 to 19 years had the highest rate for transport-related concussions (12.9/100,000).
- Leading causes of child and youth fall-related concussion hospitalizations in BC were 'fall on the same level' (16.1%, n=176) and 'fall involving skates, skis and skateboards' (15.4%, n=168).
- Older children in BC experienced a larger proportion of sport and recreation-related concussion hospitalizations as compared to younger children, with a greater rate of occurrence among males rather than females.
- Cycling (37.6%, n=406), playground (8.2%, n=89) and hockey (7.7%, n=83) activities were the greatest contributors for sport and recreation-related concussion hospitalizations in BC among children and youth 0 to 19 years.
- Proportions of emergency department visits to BC Children's Hospital were highest for both males (31.4%, n=854) and females (36.2%, n=619) ages 1 to 4 years, followed by 5 to 9 year olds and 10 to 14 year olds.

Concussions remain a significant health issue for children and youth in BC, and require further attention given the potential for long-lasting negative effects. Efforts may include concussion prevention, education and awareness, standardizing care, ensuring correct treatment protocols are adhered to, and that appropriate concussion management is employed.

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INTRODUCTION

Concussions are the most common form of head injury. Also known as mild traumatic brain injury (mTBI), concussion occurs as a result of an impact to, or forceful motion of, the head or other part of the body resulting in rapid acceleration/deceleration of the brain.¹

Concussion has received enormous attention in recent years. The US Centers for Disease Control and Prevention estimates that 1.6 to 3.8 million sport-related concussions occur annually in the United States (US).² The rate of concussion hospitalization in the US adult at-risk population has been measured at 1 to 3 per 1,000, but it is estimated that the true rate could be as high as 6 per 1,000.³ Nonetheless, concussions reportedly account for 3 to 8 per cent of all sports-related injuries among youth presenting to urban emergency departments in Canada, and is expected to increase as public awareness rises^{4,5}. Studies using US national injury reporting databases indicate that sports-related injuries are responsible for 46 to 58 per cent of all concussions suffered by youth ages 8 to 19 years.^{4,6} Comparable Canadian data are not available.

Concussion can occur to anyone anywhere. Common causes of concussion include falls and transport-related events, as well as sports and recreational activities. Children and youth may be at greater risk of concussion from similar forces due to their physical differences with adults, such as greater head-to-body ratio, weaker neck muscles, and an immature nervous system with less myelination of the nerve fibres.⁷⁻¹⁰

Concussion causes changes in brain function including information processing, attention, and executive functioning.¹¹ Symptoms of this altered mental status can include confusion, loss of memory directly preceding the event, sensitivity to light, slurred speech, dizziness and emotional changes.^{1,4,12} It is a misconception that loss of consciousness must occur in order to sustain a concussion.^{1,13}

The symptoms of concussion can be subtle and may not appear for hours or several days. Individuals may experience many different signs and symptoms ranging from physical, cognitive, emotional and sleep-related disturbances. While 70 to 80 per cent of concussions resolve within seven to ten days, recovery time is usually longer for children and youth.^{1,4} This may be due to their brains not being fully matured, and concussion can permanently change the way a child or youth talks, walks, learns, works and interacts with others.^{4,11}

Concussion management and appropriate return to activity protocol are crucial, particularly for the pediatric and adolescent populations. The current recommended treatment is physical and cognitive rest for up to three days as needed, followed by gradually resuming activity as tolerated.^{1,14} Active and timely rehabilitation is essential for concussion patients who remain symptomatic longer than six weeks, and may include physiotherapy, occupational therapy, educational support, neuropsychology, and in some cases neuropsychiatry. It is important to note that an individual is 3-times more likely to sustain a subsequent concussion while in recovery from a previous concussion.¹⁵ Also, while rare, a condition known as second-impact syndrome (SIS) may occur if a subsequent injury to the brain is sustained within a day or two of the previous concussion event, resulting in a swelling of the brain that can result in brain damage, severe disability and even death.¹⁶

Purpose

The purpose of this report is to provide an update to our previous report, *Concussion among Children and Youth in British Columbia* (2013), with more recent data. In addition, this report is a supporting document for the health authority reports, *Concussion among Children and Youth* (2015).^a

^a <http://www.injuryresearch.bc.ca/reports/concussion-among-children-youth/>

Details on the burden of concussion hospitalizations due to unintentional injuries among children and youth living in British Columbia are provided, as well as concussion-related emergency department visits to BC Children's Hospital (BCCH). This report will be used to facilitate discussion of the need for standardized concussion prevention, diagnosis and management specific to children and youth.

METHODOLOGY

Data Sources

Hospitalization Data: Discharge Abstract Database (DAD) obtained from the BC Ministry of Health was used to provide information on concussion hospitalizations for the fiscal years 2001/02 to 2013/14. The data include external causes of injury classified according to *International Classification of Disease* (ICD)-10 CA. In 2001/02, injury hospitalization data coding switched from ICD-9 to ICD-10 CA. By 2002/03, all hospitals in BC reported using ICD-10 CA for their Discharge Abstract Data. Differences in numbers between 2001/02 and 2002/03 may be attributed to some hospitals that were converting to the new coding structure. Concussion hospitalizations due to unintentional injuries were extracted separately using ICD-10 CA external cause codes V01 to X59 and nature of injury code S06. The hospitalization data include all acute, rehabilitation and day care (including day surgery) cases. The data are based on hospital separation cases rather than individual patients, therefore multiple admissions of the same patient for the same injury would be counted as separate cases.

Emergency Department Visit Data: Emergency department visit data are reported only for those visits to BC Children's Hospital. Data were obtained from Decision Support Services, Provincial Health Services Authority (PHSA). Data for BC Children's Hospital were available for the period, April 1, 2012 to May 21, 2015.

Decision Support Services, PHSA, also provided the emergency department data that are part of

the National Ambulatory Care Reporting System (NACRS), which are included in the individual health authority concussion reports.^b NACRS data for BC are not included in this report due to data limitations for certain health authorities where data were only available for some hospitals, and due to low compliance ranging from 60 to 70 percent.

Analysis

Hospitalization rates were calculated per 100,000 population for age, sex, year and leading cause of injury. Age-specific and crude rates are used throughout this report to describe actual burden rather than comparative rates across time and regions (where age-standardized rates would normally be used). The age-specific rates were calculated by dividing the number of cases in each age-group by the population of that specific age-group within BC. Rates presented by region are based on the patients' residence and not the location of injury occurrence.

Population data were obtained from BC Vital Statistics Agency for the years 2001 to 2014 and were converted to fiscal year population.

Trend analyses were conducted using a linear regression model to test the statistical significance of the association between injuries over time. This test appraises the linear component of the relationship between injury rates and scores allocated to the categories of time (calendar years). In addition, Z-tests for proportions were conducted to test the association between age groups and sex.

^b <http://www.injuryresearch.bc.ca/reports/concussion-among-children-youth/>

Definitions for leading causes of concussion:

- *Transport-related events* include: crashes involving cars, trucks, motorcycles, bicycles, pedestrians, etc.
- *Falls* include: fall on the same level, fall from a height, falls on stairs or steps, fall from a building or other structure, etc.
- *Struck by/against an object* includes: forceful contact with a falling object, striking against or struck accidentally by objects or persons, and caught between objects, depending on the coding system, struck by/against an object involving sport may be captured by *sports and recreation activities*. This category does not include assault.
- *Sports and recreational activities* include: falls on same level from collision, pushing or shoving by or with other person in sports; striking against or struck accidentally by objects or persons in sports; and object in sports with subsequent fall.

Data Limitations

Concussion, as a health event, is recognized to be under-reported and inconsistently coded in health administrative data bases. Concussion is often not clearly defined and may also be labelled as a minor traumatic brain injury (mTBI), or sometimes as a 'head injury' that may include other injuries not involving the brain.

The data presented in this report represent only a fraction of the children and youth in BC that may have sustained a concussion. This report does not capture those children and youth with concussions who were treated at physician offices, medical clinics, or those not treated at all.

Hospitalization data can vary over time and between areas as a result of factors not related to health, such as accessibility of treatment, medical or administrative decisions, among others, that may affect the number of hospitalizations and lengths of hospital stay.^{17,18}

CONCUSSION HOSPITALIZATION

There were 2,539 hospitalizations among children and youth aged 0 to 19 years resulting from concussion due to unintentional injury within BC over the 13-year period from 2001/02 to 2013/14. Concussion hospitalization rates were lowest among infants less than one year of age (7.8/100,000), and highest among 10 to 14 year olds (24.4/100,000), and youth 15 to 19 years of age (22.4/100,000) (Figure 1). Significant differences were found between the younger age groups and the older age groups, for example, a significant difference was found between the 5 to 9 years and 10 to 14 years age groups ($p < 0.05$).

Concussion hospitalization rates among children and youth were seen to decline significantly between 2001/02 and 2013/14 ($p < 0.05$) (Figure 2). The trends for males and females were also seen to significantly decline between this period ($p < 0.05$). Concussion hospitalization rates were consistently higher among males than females from 2001/02 to 2013/14.

Males accounted for 70.0 percent ($n=1,772$) of all concussion hospitalizations among children and youth and a rate of concussion hospitalizations that was twice as high as for females (27.1/100,000 vs. 12.6/100,000).

Rates for males were higher than for females for all age groups, except among infants less than one year of age (Figure 3). As age increased, males accounted for higher rates of concussion hospitalizations than females.

Among males, significant differences were found between the younger age groups and the older age groups, for example, a significant difference was found between the 5 to 9 and 10 to 14 age groups ($p < 0.05$). However, among females, significant differences were only found between age groups less than one year and 1 to 4, and between age groups 1 to 4 and 5 to 9 years ($p < 0.05$).

Figure 1: Concussion hospitalization counts and rates by age group, ages 0-19 years, BC, 2001/02 - 2013/14.

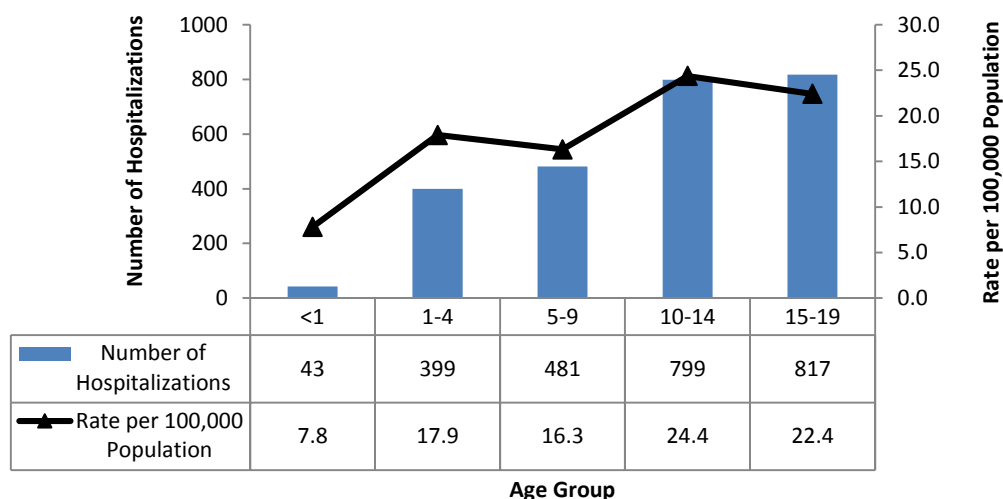


Figure 2: Concussion hospitalization rates by year and sex, ages 0-19 years, BC, 2001/02 - 2013/14.

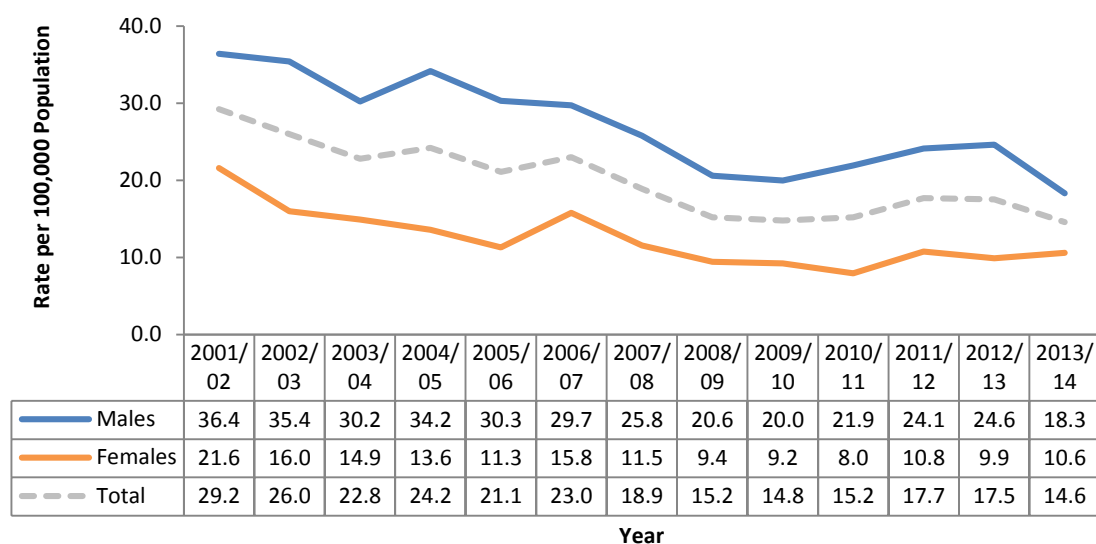
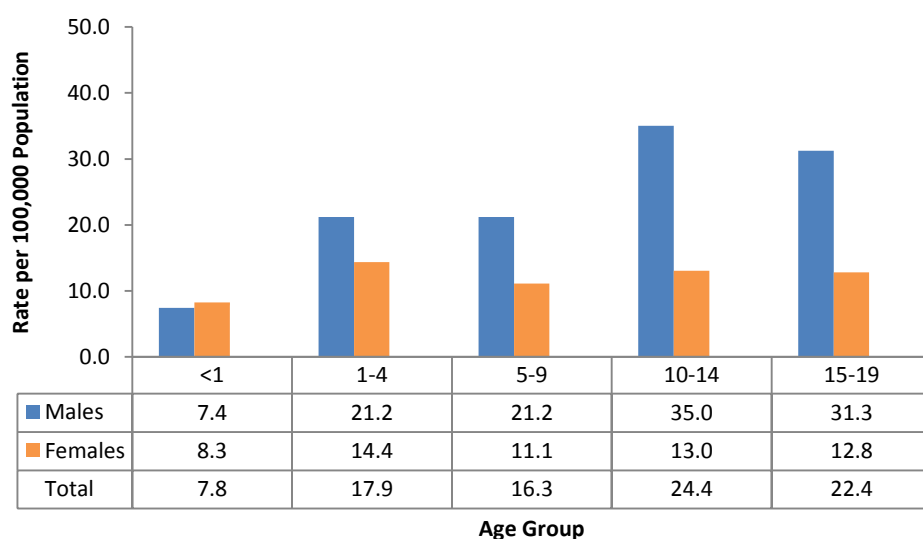


Figure 3: Concussion hospitalization rates by age group and sex, ages 0-19 years, BC, 2001/02 - 2013/14.



The leading causes of child and youth concussion hospitalizations in BC were due to falls (43%, n=1,093) and transport-related events (39%, n=993).

Fall-related concussion hospitalization was the leading cause for both males and females at 11.3 per 100,000 and 5.8 per 100,000, respectively (Figure 4). Of those concussions caused by struck by/against an object, 67.0 percent (n=288) occurred during sport and recreation activities.

Leading causes varied by age group, with falls being the leading cause for 0 to 9 year olds, while transport-related events were the leading cause of concussion hospitalizations for 10 to 19 year olds (Figure 5). Concussion hospitalization rates for falls were highest among 1 to 4 year olds (14.6/100,000), while transport-related concussion rates were highest among 15 to 19 year olds (12.9/100,000).

The rate for transport-related concussion among 15 to 19 year olds was significantly higher than the rates among children of all other ages ($p < 0.05$). Moreover, the rate for fall-related concussion among 1 to 4 year olds was significantly higher than the rates among children of all other ages ($p < 0.05$).

Figure 4: Concussion hospitalization rates by cause and sex, ages 0-19 years, BC, 2001/02 - 2013/14.

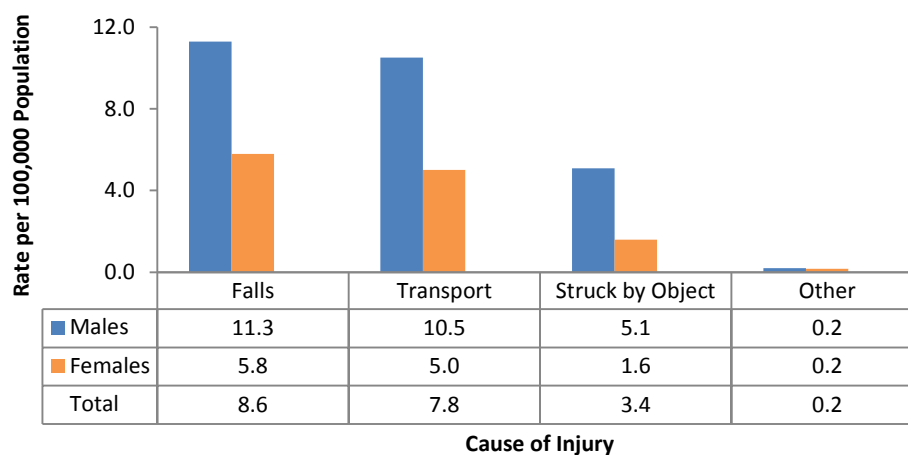
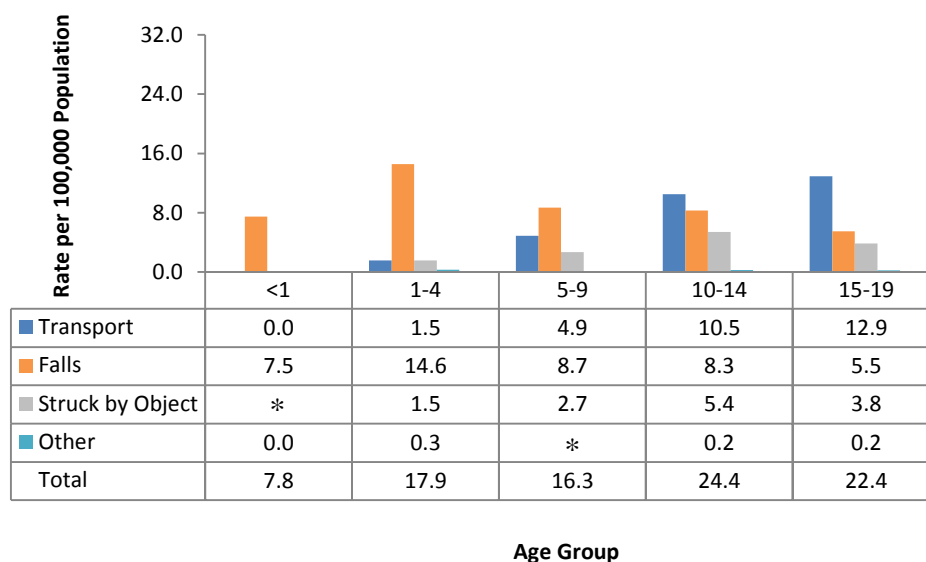


Figure 5: Concussion hospitalization rates by cause and age group, ages 0-19 years, BC, 2001/02 - 2013/14.



Note: *Represents fewer than 5 cases.

Fall-related Concussion Hospitalization

Concussion hospitalizations among children and youth resulting from a fall were primarily the result of a fall on the same level (16.1%, n=176), falls involving skates, skis and skateboards (15.4%, n=168), and falls from furniture (11.9%, n=130) (Figure 6). Nearly one-third of cases were classified as “other and unspecified” falls (25.7%, n=281).

Concussion-related falls from furniture was most common among children aged 0 to 4 years (3.27/100,000 for infants less than one years of age and 3.32/100,000 for children aged 1 to 4 years) (Figure 7).

Concussion rates among children aged 5 to 9 years were highest for falls involving playground equipment (1.43/100,000). Falls involving skates, skis and skateboards resulting in a concussion were more common among older youth aged 10 to 14 years (2.20/100,000) and 15 to 19 years (2.08/100,000) (Figure 7).

Figure 6: Proportion of fall-related concussion hospitalizations by type of fall, ages 0-19 years, BC, 2001/02 - 2013/14.

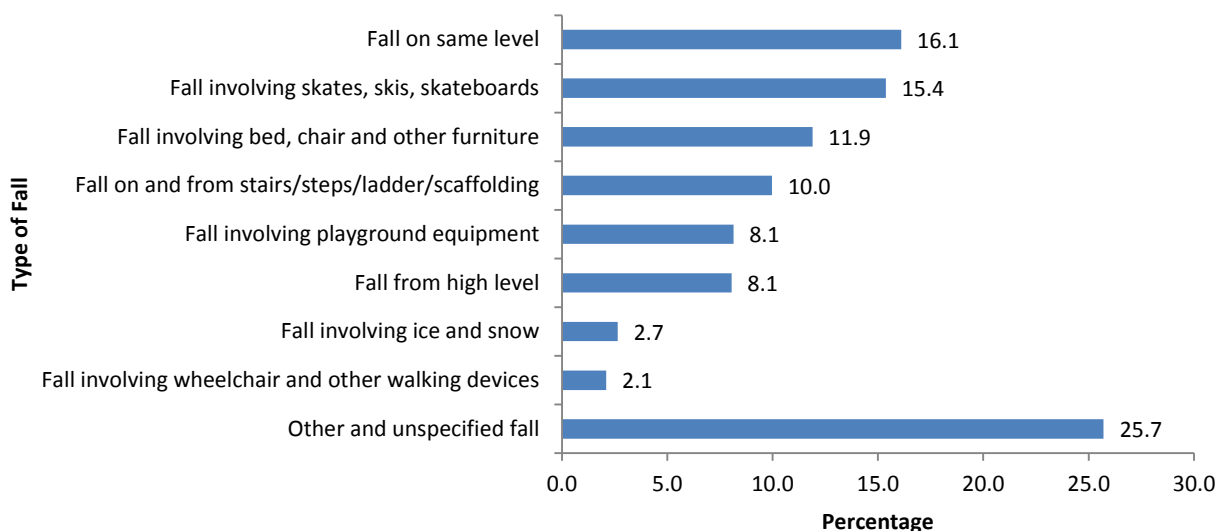
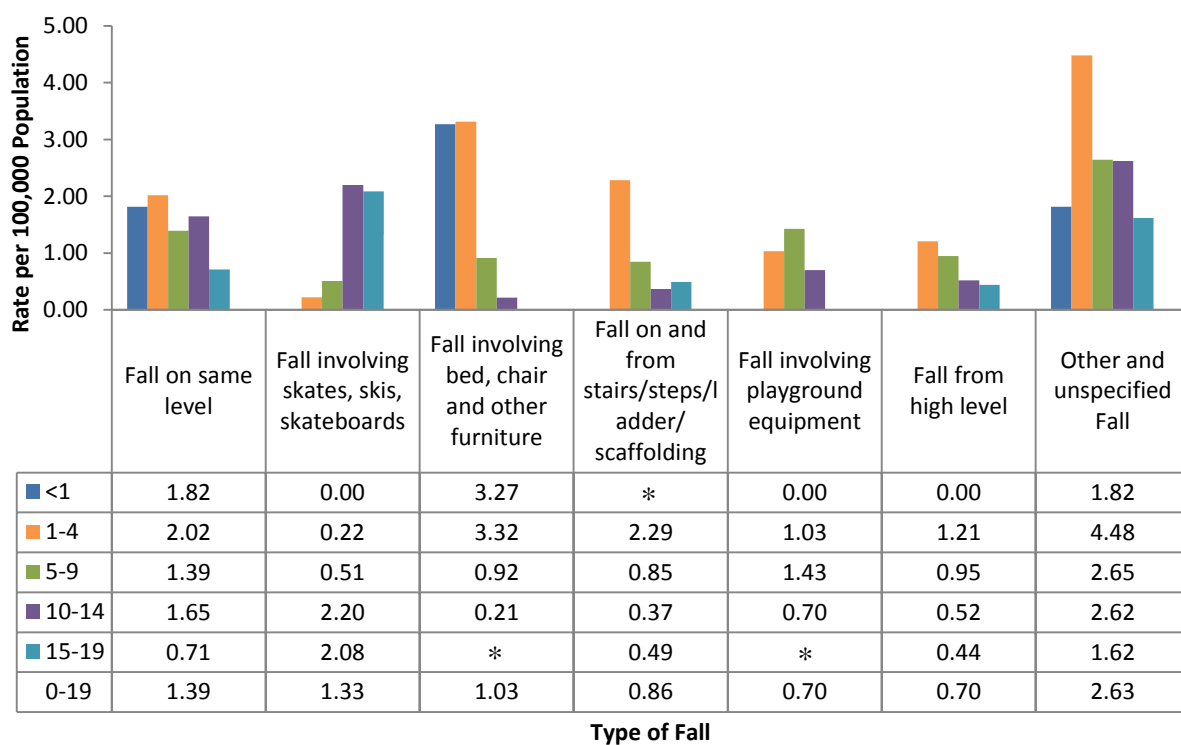


Figure 7: Fall-related concussion hospitalization rates by type of fall and age group, ages 0-19 years, BC, 2001/02 - 2013/14.



Note: *Represents fewer than 5 cases; 'Other and unspecified falls' includes fall involving ice and snow and fall involving wheelchair.

Transport-related Concussion Hospitalization

Concussion hospitalization rates resulting from transport-related injuries among children and youth were generally higher among males than females (Figure 8). Significant differences were found between males and females for all types of transport, except for pedestrian and other/unspecified transport ($p < 0.05$).

Rates among males were highest for pedal cyclists (5.32/100,000) and motor vehicle occupants (2.54/100,000), while rates among females were highest for motor vehicle occupants (2.05/100,000) followed by pedal cyclists (0.95/100,000).

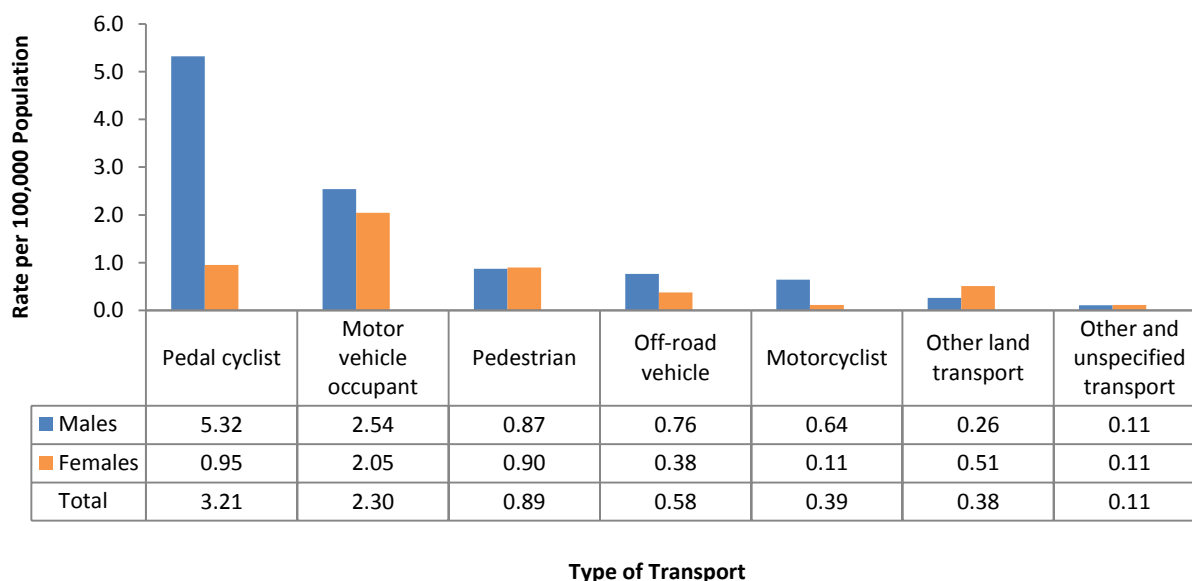
Rates of motor vehicle occupant-related concussion hospitalization were highest among youth 15 to 19 years (5.9/100,000) while pedal

cyclist rates were highest among 10 to 14 year olds (5.8/100,000) (Figure 9). The motor vehicle occupant-related rate among 15 to 19 year olds was significantly higher than the rates among children of all other ages. Similarly, the pedal cyclist rate among 10 to 14 year olds was significantly higher than the rates among children of all other ages ($p < 0.05$).

Highest rates of concussion hospitalizations among children aged 5 to 9 years were for pedal cyclist – related injuries (2.5/100,000).

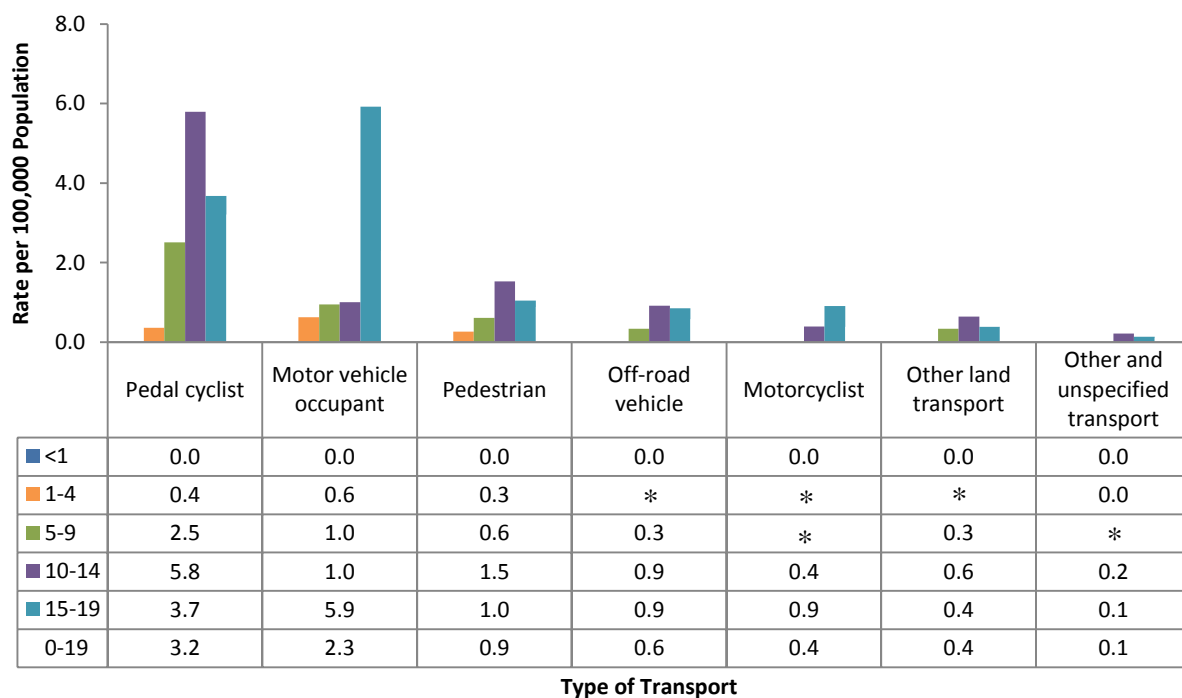
Among pedestrians, highest rates were among children 10 to 14 years (1.5/100,000). This rate was significantly higher than the rates among children of all other ages ($p < 0.05$).

Figure 8: Transport-related concussion hospitalization rates by type of transport and sex, ages 0-19 years, BC, 2001/02 - 2013/14.



Note: 'Other transport' includes concussion hospitalizations due to water, air and space transport.

Figure 9: Transport-related concussion hospitalization rates by type of transport and age group, ages 0-19 years, BC, 2001/02 - 2013/14.



Note: * Represents fewer than 5 cases; 'Other transport' includes concussion hospitalizations due to water, air and space transport.

Sport and Recreation-related Concussion Hospitalization

Sport and recreation-related concussion hospitalization rates for children and youth were significantly higher among males than females across all age groups ($p < 0.05$), with the highest rates being among males aged 10 to 14 years (22.1/100,000) and 15 to 19 years (15.8/100,000) (Figure 10). Rates for females were highest for children aged 10 to 14 years at 6.4 per 100,000.

Cycling was the sport and recreation activity with the highest proportion of concussion hospitalizations among children and youth, at 37.6 percent ($n=406$) (Figure 11). Other leading types included playground, hockey, skis/snowboards, all-terrain vehicles and skateboards.

The rate of cycling-related concussion hospitalizations for males was 5.32 per 100,000, followed

by hockey (1.15/100,000) and playground (0.89/100,000) (Figure 12). For females, highest rates were seen for cycling (0.95/100,000) followed by playground and animal rider (both at 0.51/100,000). Rates were significantly higher for males than females for the leading causes depicted in Figure 12 ($p < 0.05$).

Rates of cycling-related concussion hospitalizations were highest among youth 10 to 14 years (5.8/100,000) and 15 to 19 years (3.7/100,000) (Figure 13). The cycling-related concussion rate among youth 10 to 14 years was significantly higher than the rate among 15 to 19 year olds ($p < 0.05$). Playground concussion rates were higher among younger children, while generally sport concussion rates were highest among 10 to 14 year olds.

Figure 10: Sport and recreation-related concussion hospitalization rates by age group and sex, ages 0-19 years, BC, 2001/02 - 2013/14.

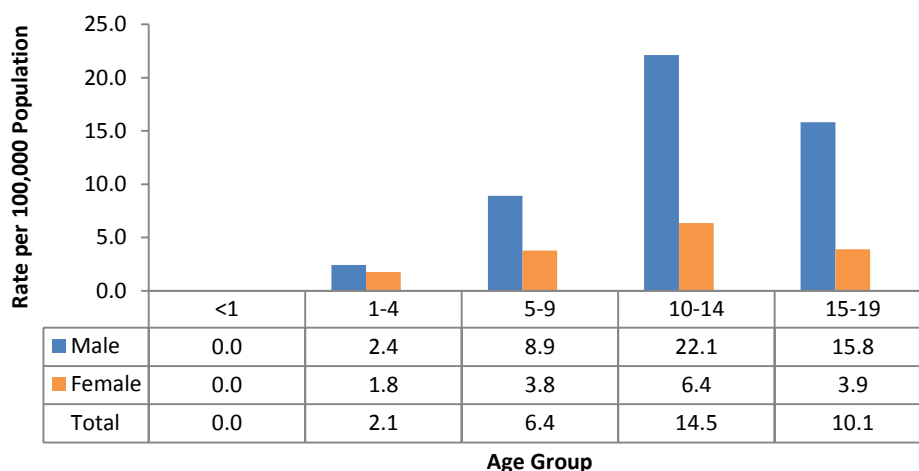
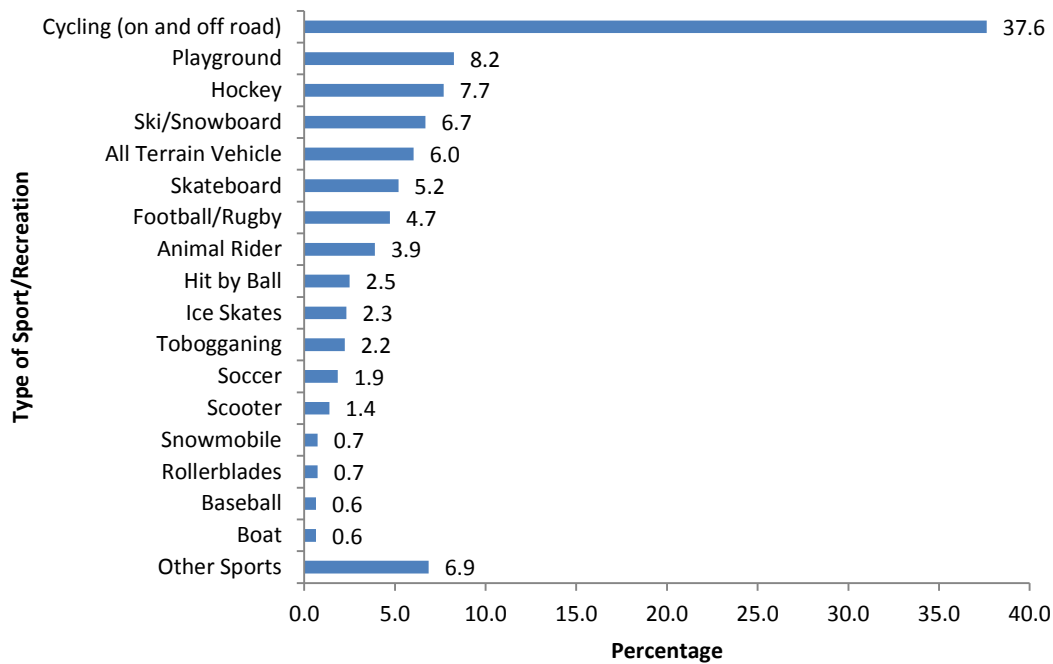
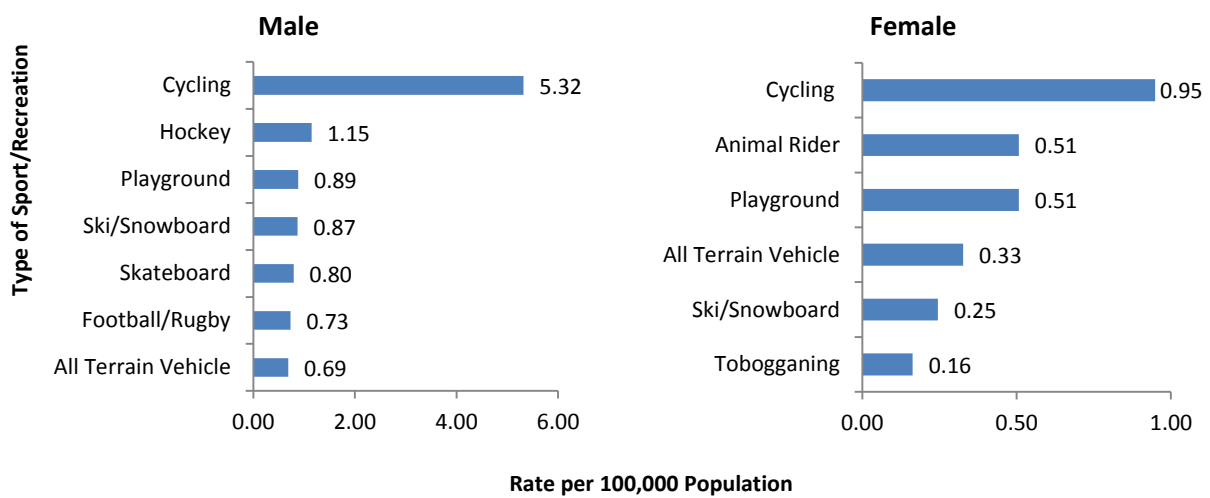


Figure 11: Proportion of sport and recreation-related concussion hospitalization by type of sport/recreation, ages 0-19 years, BC, 2001/02 - 2013/14.



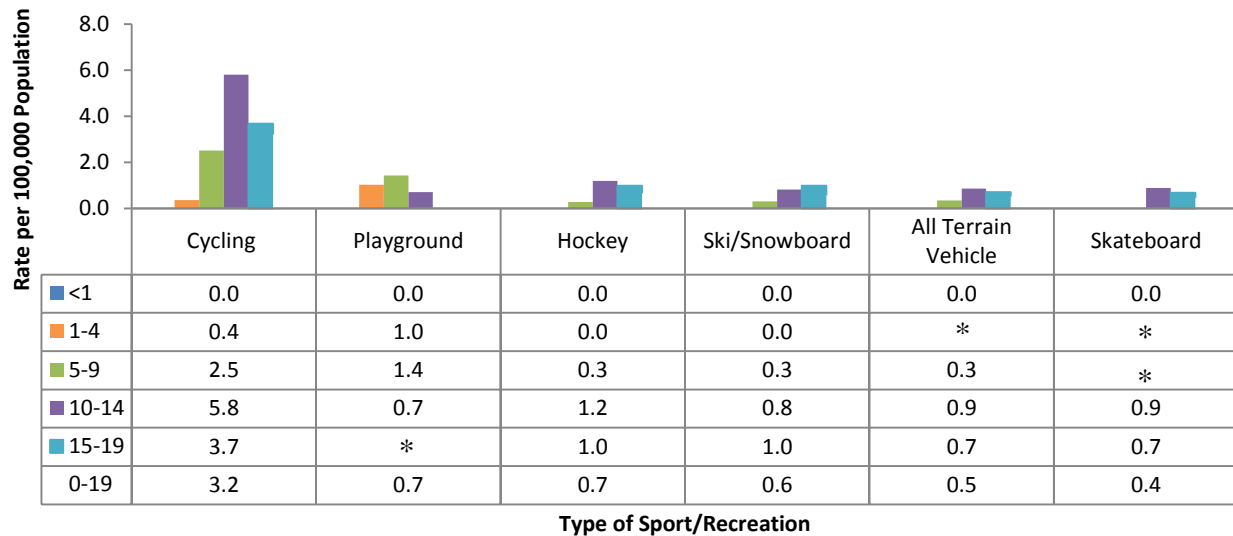
Note: Other sports include diving into water, hit by bat and drowning.

Figure 12: Sport and recreation-related concussion hospitalization rates by leading type of sport/recreation and sex, ages 0-19 years, BC, 2001/02 - 2013/14.



Note: Please note the scale difference between males and females.

Figure 13: Sport and recreation-related concussion hospitalization rates by leading type of sport/recreation and age group, ages 0-19 years, BC, 2001/02 - 2013/14.



Note: * Represents fewer than 5 cases.

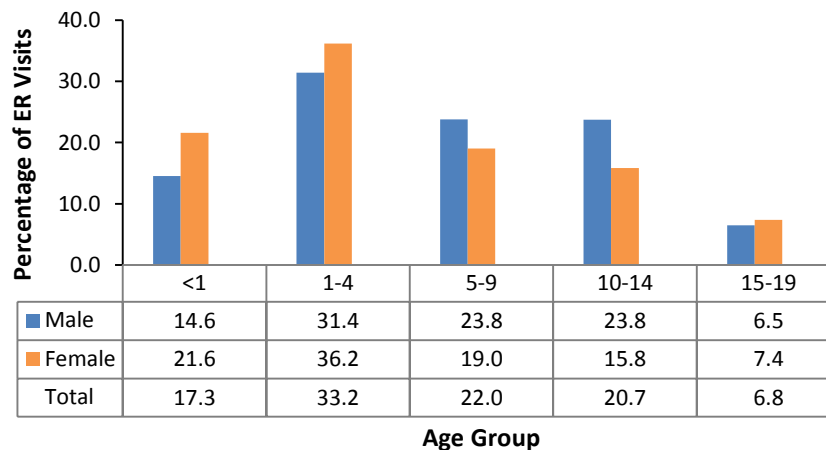
EMERGENCY DEPARTMENT VISITS AT BC CHILDREN'S HOSPITAL

The highest proportions of concussion-related emergency department visits to BC Children's Hospital were highest among ages 1 to 4 years for both males (31.4%, n=854) and females (36.2%, n=619), followed by 5 to 9 year olds and 10 to 14 year olds for males, and

infants less than one year and 5 to 9 year olds for females (Figure 14).

The proportions of concussion-related emergency department visits were significantly different among males and females ($p < 0.05$).

Figure 14: Proportion of concussion emergency department visits at BC Children's Hospital by age group and sex, ages 0-19 years, NACRS, April 1, 2012 - May 21, 2015



CONCLUSION

The highest rates of concussion hospitalizations were seen among those in the 10 to 14 year age group, largely due to transport-related causes and falls. The majority of transport concussion hospitalizations were due to being a pedal cyclists or motor vehicle occupant. Falls were the leading cause of concussion hospitalization among children under five years of age. The leading cause of falls within this age group was falls from furniture. Transport-related concussion hospitalizations rates increased as age increased.

Males within BC exhibited higher rates of concussion hospitalizations than females across all age groups between 0 to 19 years. Sport and recreation-related concussion hospitalizations were mostly observed among males between the ages of 10 and 19 years.

Emergency department visits to BC Children's Hospital were highest among 1 to 4 year olds for both males and females.

This report provides a comprehensive overview of the burden of concussion among children and youth within BC. With this information, injury prevention stakeholders can address, plan and prioritize effective intervention strategies through efforts such as raising the level of education and awareness, standardizing care, ensuring correct treatment protocols are adhered to, and that appropriate concussion management is employed.

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