



CONCUSSION AMONG CHILDREN AND YOUTH IN BRITISH COLUMBIA



BC INJURY research and prevention unit

This report was commissioned and funded by Child Health BC. Child Health BC is a network of British Columbia health authorities, BC government ministries, health professionals, and provincial partners dedicated to improve the health status and health outcomes of BC's children and youth by working collaboratively to build an integrated and accessible system of health services. One of the focus areas of Child Health BC is Injury Prevention.

The British Columbia Injury Research and Prevention Unit (BCIRPU) was established by the Ministry of Health and the Minister's Injury Prevention Advisory Committee in August 1997. BCIRPU is housed within Developmental Neurosciences and Child Health (N2N) cluster and supported by the Provincial Health Services Authority (PHSA), the Child and Family Research Institute (CFRI) and the University of British Columbia (UBC). BCIRPU's vision is "to be a leader in the production and transfer of injury prevention knowledge and the integration of evidence-based injury prevention practices into the daily lives of those at risk, those who care for them, and those with a mandate for public health and safety in British Columbia".

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EXECUTIVE SUMMARY

The purpose of this report is to provide details on the burden of concussion among children and youth in BC as a supplement to the report *The Burden of Concussion in British Columbia*. This supplement is targeted to Health Authorities, health care providers and community stakeholders to be used to facilitate discussion of the need for standardized concussion prevention, diagnosis and management in BC specific to children and youth.

Evidence suggests that children and youth are at greater risk of concussions 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 case neuropsychiatry.

If an individual returns to activity too soon and a second concussion is sustained before recovering from the first, a condition known as second-impact syndrome (SIS) may occur: a swelling of the brain that can result in brain damage causing severe disability or even death. Furthermore, an individual is 3-times more likely to sustain a second concussion while in recovery from a concussion.

Concussions are the most common form of head injury, yet it is believed that they are under-reported owing to both a lack of consensus on the minimum requirements of the definition of a concussion, and the presence of misconceptions among the general public regarding concussions. Therefore, the data presented in this report represent only a fraction of the children and youth that suffer a concussion.

Highlights include but are not limited to the following:

- * From 2001-2010, there were 268 head injury deaths among children and youth ages 0 to 19 years. The vast majority of them were transport-related¹ (91%).
- * Over the 10 year period from 2001/02-2010/11, there were 1,619 concussion-related hospitalizations of children 0-19 years in BC. The leading causes were falls², transport related, and struck by/against an object³.
- * In a one year period, there were 6, 675 concussion-related emergency department visits by children and youth in the Lower Mainland. The leading causes of these visits were falls, sports and recreational activities⁴, and struck by/against an object.
- * Males account for 60-70 percent of head injuries resulting in death and concussion-related hospitalizations and emergency department visits.

It is important to note that although head injury mortality rates were seen to decline significantly over the years, concussion-related hospitalization rates and emergency department visits do not follow the same pattern. Concussion hospitalization rates varied from year to year, whereas emergency department presentations rose steadily.

The findings of this report, which goes beyond the above mentioned highlights, identifies that concussions remain a significant health issue and require further attention given the long-lasting effects. This may include concussion prevention, education and awareness, standardizing care, ensuring correct treatment protocols are adhered to and appropriate concussion management is employed.

¹ Transport-related events include crashes involving cars, trucks, motorcycles, bicycles, pedestrians, etc.

² Falls include fall on the same level, from a height, on stairs or steps, from a building or other structure, etc.

³ Struck by/against an object includes forceful contact with a falling object, striking against or struck accidentally by objects or persons, and being caught between objects. Depending on the coding system, struck by/against involving sport may be captured by *sports and recreation activities*. This category does not include assault.

⁴ Sports and recreational activities include falls on same level from collision, pushing or shoving, by or with other person in sports, striking against or being struck accidentally by objects or persons in sports, and object in sports with subsequent fall.

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INTRODUCTION

Children and youth are at greater risk of concussions and more serious head injury than the general population. Concussions are the most common form of head injury, yet it is believed that they are under-reported owing to both a lack of consensus in the minimum requirements of the definition of a concussion and the presence of misconceptions among the general public regarding concussions [1]. Nonetheless, concussions reportedly account for 3 to 8 percent of all sports-related injuries among youth presenting to urban emergency departments in Canada, which is expected to increase as public awareness rises [1, 2]. Furthermore, studies using national injury reporting databases in the United States indicate that sports-related injuries are responsible for 46 to 58 percent of all concussions suffered by youth between the ages of 8 and 19 [1, 3]. Comparable Canadian data are not available.

Concussions, also known as mild traumatic brain injury (mTBI), occur as a result of an impact to or forceful motion of the head or other part of the body, resulting in a jarring of the brain. This may lead to a brief alteration of mental status, which may include: confusion, loss of memory directly preceding the event, sensitivity to light, slurred speech and/or dizziness or emotional changes, and may or may not be accompanied by loss of consciousness or seizures [1, 4, 5].

Evidence exists that children and youth take longer than adults to recover following a concussion [6], and can permanently change the way a child or youth talks, walks, learns, works and interacts with others. Therefore, concussion management and appropriate return to activity is crucial, particularly in the paediatric 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 case neuropsychiatry. If an individual returns to activity too soon and a second concussion is sustained before recovering from the first, a condition known as

second-impact syndrome (SIS) may occur: a swelling of the brain that can result in brain damage causing severe disability or even death [7]. Furthermore, an individual is 3-times more likely to sustain a second concussion while in recovery from a concussion [8].

Although no information is currently available concerning the economic burden of concussion for children and youth, a study is currently being conducted at the Children's Hospital of Eastern Ontario (CHEO). Assessing young athletes ages 12 to 17 while suffering from concussion for over three months regarding their quality of life, results using a standardized quality of life survey found similar findings as those for patients receiving chemotherapy treatments for cancer. [9].

Purpose

The purpose of this report is to provide details on the burden of concussion among children and youth in British Columbia (BC) as a supplement to the report *The Burden of Concussion in British Columbia*. This supplement will be used to facilitate discussion of the need for standardized concussion prevention, diagnosis and management in BC specific to children and youth.

Concussion as a health event is recognized to be under reported and inconsistently coded. Concussion may also be labelled as a minor traumatic brain injury (mTBI), or sometimes as a head injury (which may include other injuries not involving the brain).

For the purposes of this report, concussion is considered a subgroup of head injury. Mortality data are presented for head injury alone, as no data for concussion mortality are available. Hospitalization data are presented for both head injury and for concussion as a subgroup of head injury, and emergency department data are presented for concussion alone.

THE BURDEN OF CONCUSSION AMONG CHILDREN AND YOUTH IN BC: AN OVERVIEW

Mortality

- 268 head injury deaths among children and youth ages 0-19 years in BC from 2001 to 2010
- Males accounted for 67.9 percent of head injury deaths (n=182)
- Head injury mortality rates were lowest among 5-9 year olds (0.7/100,000) and highest among 15-19 year olds (6.5/100,000)
- Head injury mortality rates declined significantly ($p=0.014$) from 2001 (3.5/100,000) to 2010 (1.8/100,000)
- Head injury mortality rates for ages 0-19 years were highest in the Northern Health Authority and lowest in Vancouver Coastal and Fraser Health Authorities
- Almost 91 percent of head injury deaths were transport-related

Hospitalization

- 9,514 head injury hospitalizations among children and youth ages 0-19 years in BC from 2001/02 to 2010/11
- Concussion accounted for 17.0 percent of all head injury hospitalizations (n=1,619)
- Males accounted for 69.2 percent of concussion hospitalizations (n=1,121)
- Concussion hospitalization rates were lowest among infants less than one year of age (6.9/100,000) and highest among 10-14 year olds (19.8/100,000)
- Concussion hospitalization rates for ages 0-19 years were highest in the Northern Health Authority and lowest in Vancouver Coastal and Fraser Health Authorities
- Leading causes of concussion hospitalizations among children and youth ages 0-19 include falls, transport-related and struck by/against an object

Emergency Department

- 6,675 concussion-related emergency department visits among children and youth ages 0-19 years in the Lower Mainland (Vancouver Coastal HA – 2011; Fraser HA - 2011/12; BC Children's Hospital - 2009)
- Males accounted for 63.7 percent of concussion-related emergency department visits (n=4,250)
- Concussion-related emergency department visit rates were lowest among 5-9 year olds (819.3/100,000) and highest among infants less than one year of age (1,930.6/100,000)
- The leading cause of concussion-related emergency department visits among children and youth ages 0-19 include falls, sports and recreational activities and struck by/against an object

BC CHIRPP

- 9,027 concussion or minor head injury visits to BC Children's Hospital among children and youth ages 0-19 years from 2001 to 2009
- Males accounted for 61.7 percent of concussion or minor head injury visits to BC Children's Hospital (BCCH) (n=5,567)
- The leading cause of concussion or minor head injury visits to BC Children's Hospital among children and youth ages 0-19 include falls and struck by/against an object
- The highest proportion of concussion or minor head injuries due to falls was among 2-4 year olds (25.7%)
- The highest proportion of concussion or minor head injuries due to being struck by/against an object was among 10-14 year olds (35.2%)
- The proportion of concussions or minor head injuries occurring at home decreased with age, being highest among infants less than one year of age (84.3%) and lowest among teens 15-19 years old (7.5%)

METHODOLOGY

Data Sources

The five datasets used for this report were:

- BC Vital Statistics
- Discharge Abstract Database
- Vancouver Coastal Health (VCH), Public Health Surveillance Unit, Emergency Department Data
- Fraser Health (FH) Emergency Department Data
- BC Children's Hospital Emergency Department data from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)

Mortality: Mortality data were provided by the BC Vital Statistics Agency. This report is based on 268 head injury deaths from 2001 to 2010 among known residents of BC ages 0 to 19 years. The mortality dataset includes external causes of death classified as injury deaths according to the International Classification of Diseases Canada (ICD-10 CA) which was implemented at the beginning of the year 2000 [10]. Head injury cases were extracted using ICD-10 codes S00-S09.

Hospital Separations: Source data were obtained from the Discharge Abstract Database, BC Ministry of Health Services. This report is based on 9,514 head injury and 1,619 concussion- related hospitalizations during the fiscal years 2001/02 to 2010/11 among known residents of BC ages 0 to 19 years. Data for this study include external causes of injury classified according to ICD-10 CA. In 2001, injury hospitalization data coding switched from ICD-9 to ICD-10 CA. By 2002, all hospitals in BC reported using ICD-10 CA for their Discharge Abstract Data. Differences in numbers between 2001 and 2002 may attribute to some hospitals still converting to the new coding structure. Causes of injury categories were derived according to the same coding scheme as used for mortality data. In addition to head injury hospitalizations, concussion- related hospitalizations were also extracted separately using ICD-10 CA code S06. The

hospitalization data includes all acute, rehab and day surgery cases. The data is based on each hospital separation rather than by patient, therefore any multiple admissions for the same injury are counted as separate cases.

Vancouver Coastal Health: Emergency department visit data for the years 2008 to 2011 were obtained with 5,082 identified concussions from nine of thirteen acute care hospitals: CareCast System (Richmond Hospital, UBC Hospital, Vancouver General Hospital), Eclipsys System (Mount Saint Joseph Hospital, St. Paul's Hospital) and McKesson System (Lions Gate Hospital, Pemberton Health Centre, Squamish General Hospital, Whistler Health Care Centre). Concussion data were extracted through ICD9 code 800-804, 850-854, 907.0 and 959.01 and keywords "concussion" or "head injury" where indicated in presenting complaints or discharge diagnoses.

Fraser Health: Data for the fiscal year 2011/12 were obtained for head injuries from decision support services in Fraser Health, with 3,897 identified concussions. The twelve participating hospitals included: Abbotsford Regional, Burnaby, Chilliwack General, Delta, Eagle Ridge, Fraser Canyon, Langley Memorial, Mission Memorial, Peace Arch, Royal Columbian, Ridge Meadows, and Surrey Memorial. The raw data included information by facility. Head injury information was captured using the patient chief and stated complaints, as well as description. The patient chief and stated complaint fields did not capture concussions and therefore the data required some cleaning and coding so that concussion information could be captured using both the complaint fields as well as the description field.

BC CHIRPP: Data were extracted from the emergency department of BC Children's Hospital (BCCH) for the period 2001-2009. This report is based on 9,027 injuries captured by BC CHIRPP. This surveillance system collects in-depth information regarding the patient's age and sex; the activity when injured, cause of injury, and

factors contributing to the injury; the nature of injury, body area affected by the injury and the outcome of the emergency department visit. Additional cleaning and coding of the data was conducted using the injury event description to provide more detail to the missing information that was recorded in some of the variables.

Similar to the hospital separation data, the emergency department visit datasets are per visit and therefore any multiple visits for the same injury are counted as separate cases.

Only unintentional head injuries and concussions were included in the analysis.

Analysis

Mortality and hospitalization rates were calculated per 100,000 population for age, sex, year, leading cause of injury and Health Authority. Age-specific and crude rates are used in the 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. Rates by region are based on the patient residence and not the injury location.

As CHIRPP data are not population based, rates can not be calculated based on this database alone. In order to calculate rates, the CHIRPP data for 2009 was extracted by postal code and matched to its corresponding health authority. Cases for the Lower Mainland were then identified. Emergency department visit rates for Lower Mainland were calculated using the total number of cases from CHIRPP 2009 Lower Mainland data for ages 0-19, 2011 VCH data and 2011/12 FHA data. The 2009 CHIRPP data was used as an estimate for the most recent year. Lower Mainland population data for ages 0-19 years was calculated using the average FHA and VCHA population for 2009 and 2011. The remaining age-specific rates were calculated using 2011 population. Population data were obtained from BC Vital Statistics Agency.

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).

The in-depth analysis of BC CHIRPP data allowed for the examination of several variables describing the pre-injury, injury and post-injury phases [11]. Specifically, patterns of injury among males and females were described by time (year, month, day of the week, and time of day), location of injury (where the injury occurred), activity and nature of injury. This provides additional information that is not captured in the mortality, hospitalization or other emergency department datasets.

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 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. Concussion is often not clearly defined and may also be labelled as a minor traumatic brain injury (mTBI), or sometimes as a head injury (which may include other injuries not involving the brain).

Complete accuracy and consistency of mortality data cannot be assumed because physicians and other health professionals responsible for

diagnosing and coding the cause of death differ in their skills and practices. Some variation in death certification and coding practices may exist. None of the mortality head injury cases were coded as concussion; however 74.3 percent were “other/ unspecified head injury”.

Hospitalization data can vary over time and between areas for factors not related to health, such as accessibility of treatment, and medical and administrative decisions that may affect the number of hospitalizations and lengths of hospital stay [12, 13].

The CHIRPP emergency department data are not representative of all regions of BC. BC Children’s Hospital (BCCH) is the only BC hospital participating in CHIRPP, capturing children from across the Lower Mainland as well as higher severity cases from across BC. As such, this is not considered to be stand-alone population-based data; data are presented as frequencies and proportions only. It is also important to note that CHIRPP forms may not be completed for all injuries seen in the emergency department as it may not be the parent’s nor physician’s priority at the time of admittance. As a result, there may be missing data for certain variables and cases.

When combining emergency department data from VCH, FH and BCCH, the data are reported as 2011 in order to obtain rates for the lower mainland. For VCH, this represents the 2011 calendar year. For FH this represents the fiscal 2011/12 year. However, for BCCH, the most recent data available are for 2009. These data (i.e. BCCH) have been used as a proxy for the 2011 numbers when added to the VCH and FH emergency department data.

Although external causes of injury are uniformly classified and analyzed according to the ICD-10 for both mortality and hospitalization data, CHIRPP data are not coded using this system. Further, VCH data were coded using ICD-9, while FH data were pulled based on text. Therefore the emergency department data presented are the best representation of concussion available at this time.

MORTALITY FROM HEAD INJURIES IN BC, 2001-2010

There were 268 deaths among children and youth ages 0 to 19 years resulting from head injuries in BC over the 10-year time period from 2001 to 2010. Males accounted for 67.9 percent (n=182) of all cases.

Although none of these deaths were documented to be the result of a concussion, 74.3 percent (n=199) were coded as “other/unspecified head injury”, followed by 16.4 percent (n=44) as “intracranial injury excluding concussion” and the remainder (n=25) as a skull fractures.

Head injury mortality rates were lowest among 5 to 9 year olds (0.7/100,000) and highest among 15 to 19 year olds (6.5/100,000) (Figure 1). Numbers of head injuries by age group followed the same pattern.

Head injury mortality rates among children and youth ages 0 to 19 years were seen to decline significantly ($p=0.014$) from 2001 to 2010 (Figure 2). Rates within this age group peaked in 2002 at 4.5 per 100,000 and conversely were the lowest in 2009 at 1.6 per 100,000.

Figure 1: Head injury mortality rates and cases by age group, BC, 2001-2010

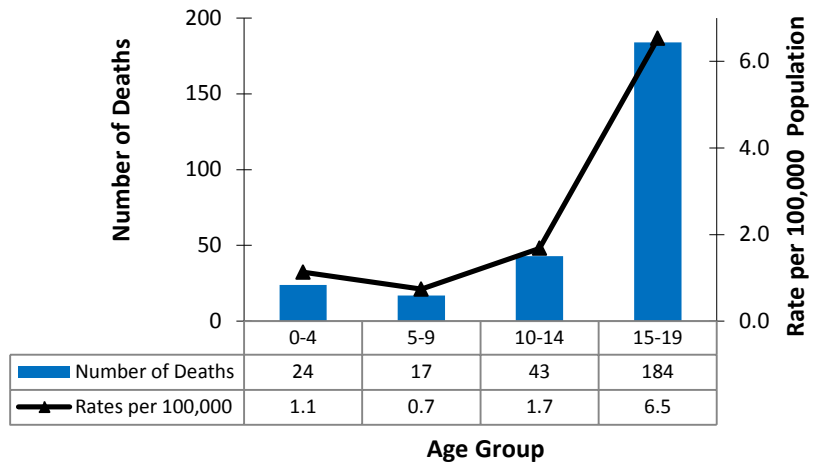
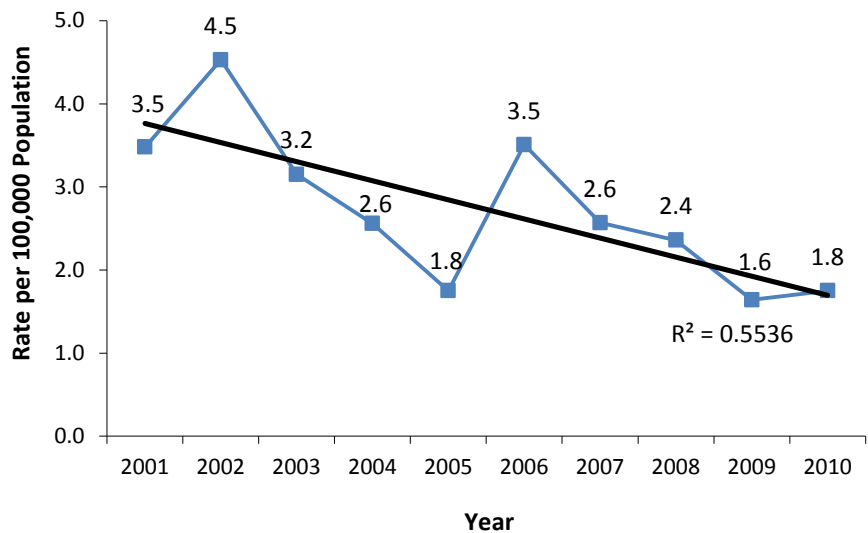


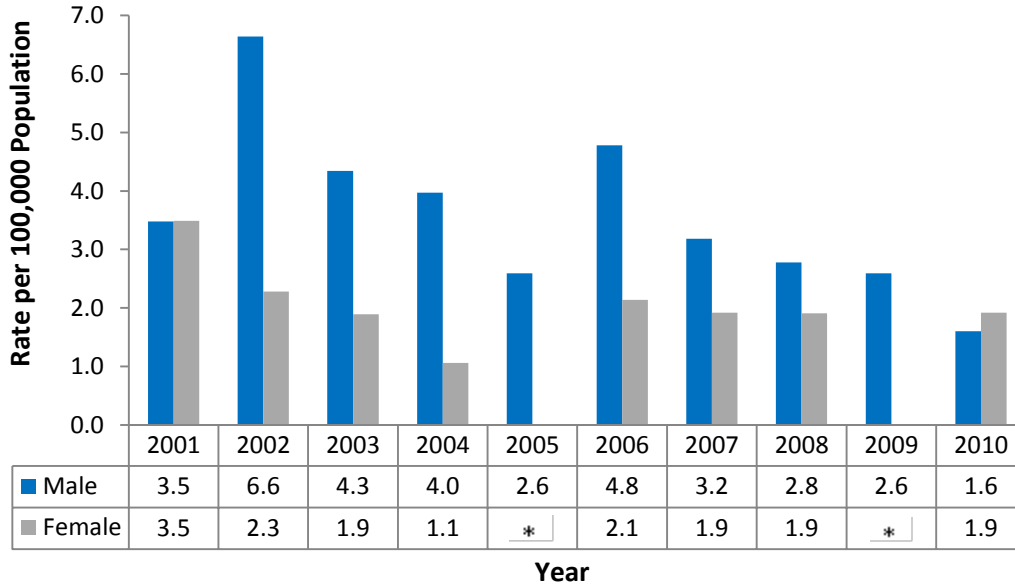
Figure 2: Head injury mortality rates, ages 0-19, by year, BC, 2001-2010



Head injury mortality rates for children and youth were consistently higher among males from 2002 to 2009. Rates were the same between the two sexes in 2001 and females demonstrated higher head injury mortality rates than males in 2010 (Figure 3).

Mortality rates peaked for males in 2002 at 6.6 per 100,000, and were lowest in 2010 at 1.6 per 100,000. Rates peaked for female children and youth in 2001 at 3.5 per 100,000 and were lowest in 2005 and 2009 where there were fewer than 5 cases of head injury mortality (Figure 3).

Figure 3: Head injury mortality rates, ages 0-19, by sex and year, BC, 2001-2010



Note: * Numbers less than 5 suppressed in the chart to maintain confidentiality

Head injury mortality rates for ages 0 to 19 years were highest in the Northern Health Authority and lowest in Vancouver Coastal and Fraser Health Authorities (Figure 4).

an object ⁷(1.9%, n=5) and machinery and firearms with less than 5 cases each.

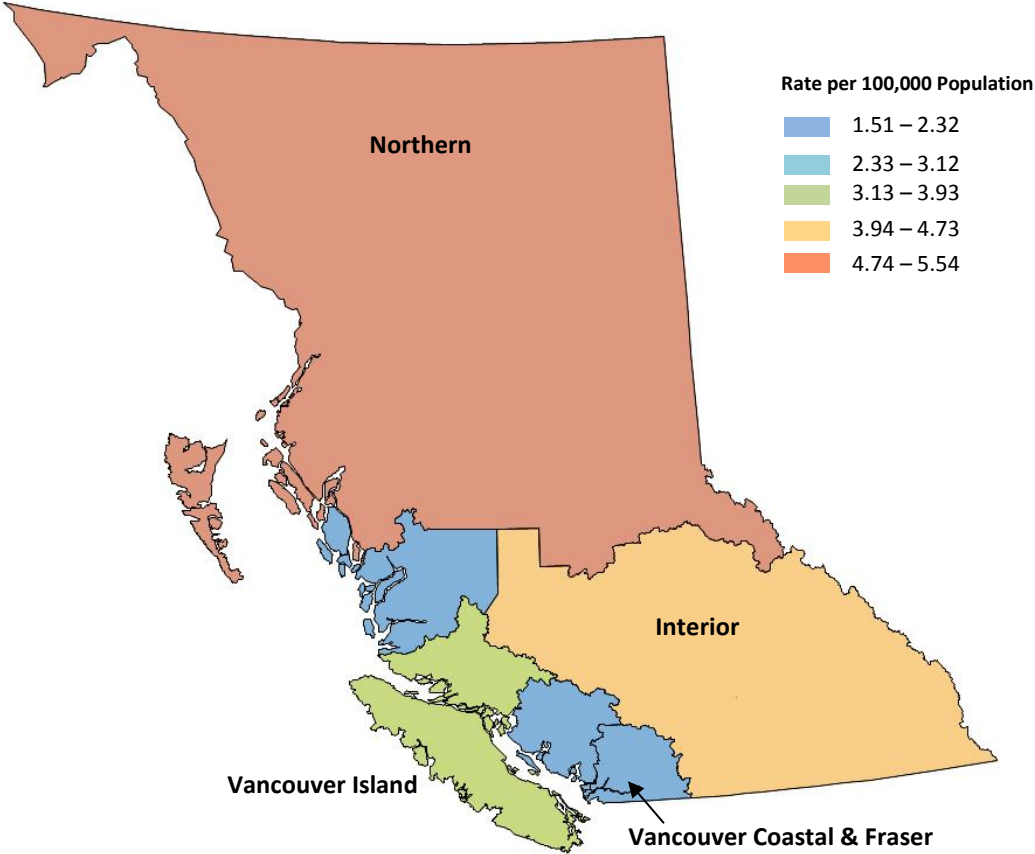
Almost 91 percent (n=241) of head injury deaths were motor vehicle transport-related⁵. Other causes included falls⁶ (7%, n=18), struck by/against

⁵ Transport-related events include crashes involving cars, trucks, motorcycles, bicycles, pedestrians, etc.

⁶ Falls include fall on the same level, fall from a height, falls on stairs or steps, fall from a building or other structure, etc.

⁷ 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 involving sport may be captured by *sports and recreation activities*. This category does not include assault.

Figure 4: Map of age-specific head injury mortality rates for 0-19 year olds, BC, 2001-2010



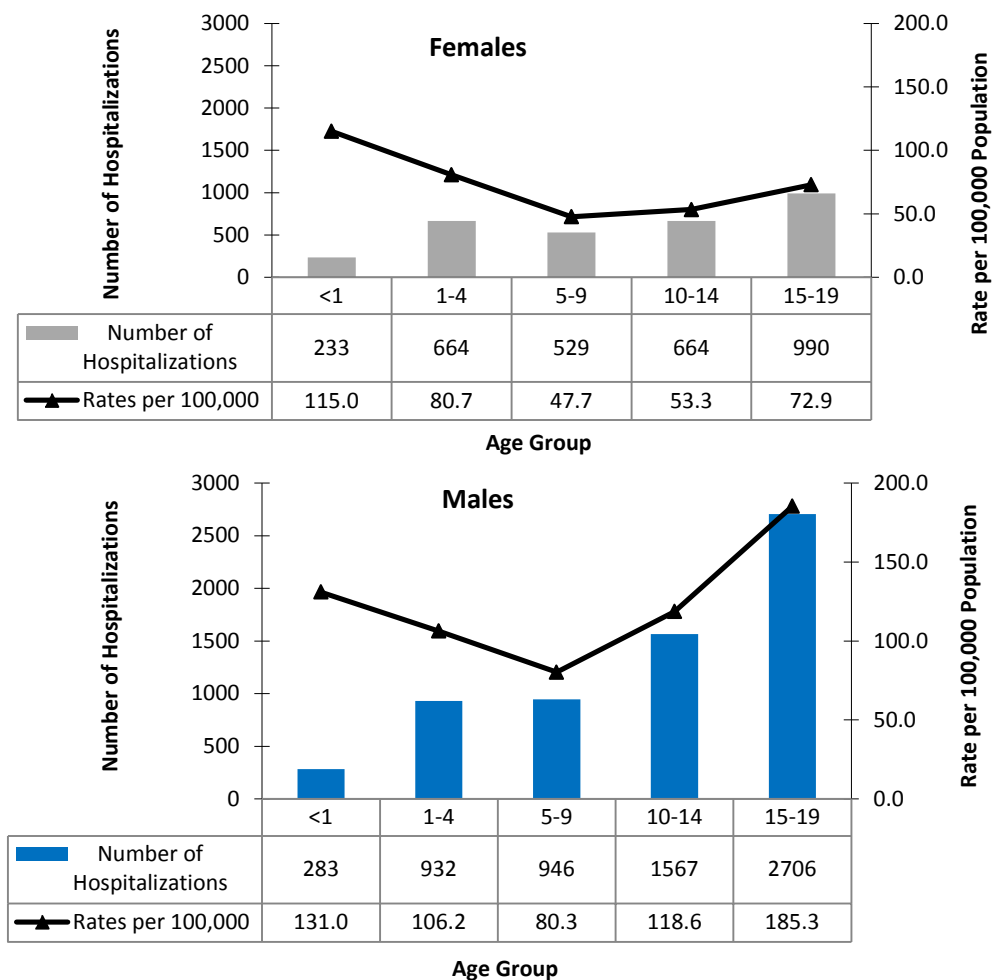
HOSPITALIZATION FOR CONCUSSIONS IN BC, 2001/02 - 2010/11

There were 9,514 hospitalizations among children and youth ages 0 to 19 years resulting from all types of head injuries in BC over a 10-year period, from 2001/02 to 2010/11. Males accounted for 67.6 percent (n=6,434) of these cases.

Head injury hospitalization rates were consistently higher among males than females between 0-19 years of age (Figure 5). Among males, rates were highest among 15 to 19 year olds (185.3/100,000) and lowest among 5 to 9 year olds (80.3/100,000). Among females, rates were highest among infants less than one year of age (115.0/100,000) and lowest among 5 to 9 year olds (47.7/100,000).

Head injury hospitalization rates among children and youth for both males and females were highest among 15 to 19 year olds at 131.2 per 100,000, followed by infants less than one year of age (123.3/ 100,000). It should be noted that the burden of head injury hospitalizations among infants less than one year of age was the lowest at 516 when compared to the other age groups; however the rates per 100,000 population was high.

Figure 5: All types head injury numbers and hospitalization rates by sex and age group, BC, 2001/02 - 2010/11



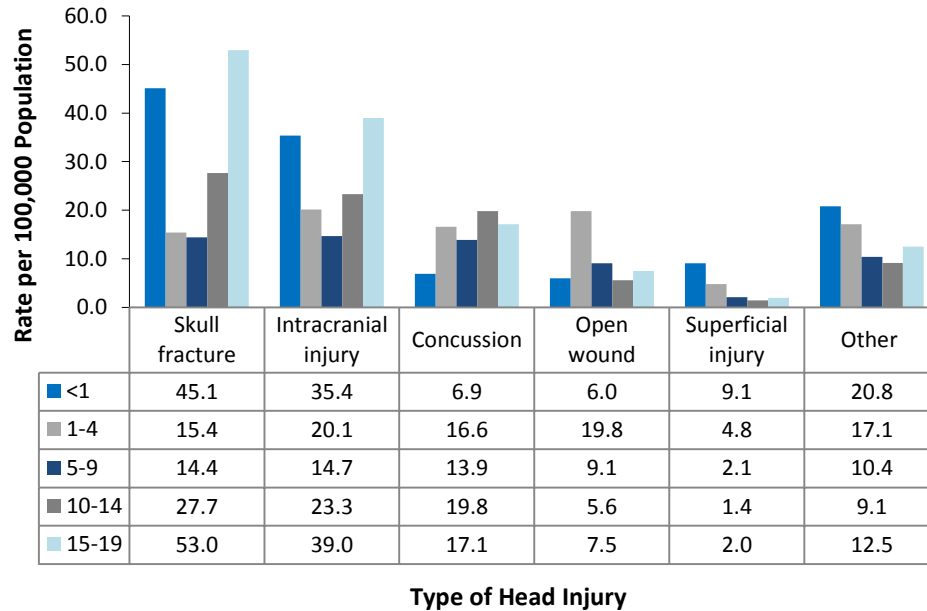
Concussions accounted for 17.0 percent of all head injury hospitalizations (n=1,619), with the leading

type of injury being skull fracture at 31.4 percent (n=2,984), followed by intracranial injury at 26.5

percent (n=2,524). The rest of the head injuries accounted for 25.1 percent of all cases, which included open wounds, superficial injuries and other specified and unspecified injuries. Rates for head injury hospitalization by type and age group are presented in the Figure 6.

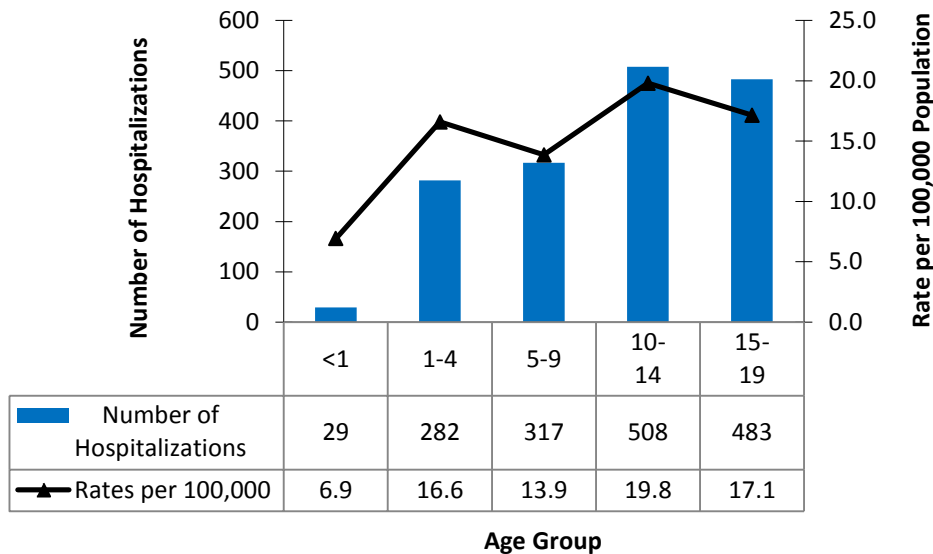
Concussion-related hospitalization rates were lowest among infants less than one year of age (6.9/100,000), and highest among 10 to 14 year olds (19.8/100,000), followed by teens 15 to 19 years of age (17.1/100,000) (Figure 7).

Figure 6: Head injury hospitalization rates, ages 0-19, by type and age group, BC, 2001/02 - 2010/11



Note: 'Skull fracture' includes facial bone fracture

Figure 7: Concussion-related hospitalization rates and cases by age group, BC, 2001/02 - 2010/11



Concussion-related hospitalization rates among children and youth ages 0 to 19 years were seen to vary from 2001/02 to 2010/11 (Figure 8). Rates peaked in 2006/07 at 23.0 per 100,000 and were lowest in 2003/04 at 12.4 per 100,000. Concussion-related hospitalization rates were consistently higher among males from 2001/02 to 2010/11.

Males accounted for 69.2 percent (n=1,121) of all concussion-related hospitalizations. Rates peaked

for males in 2005/06 at 30.3 per 100,000, and were lowest in 2003/04 at 15.6 per 100,000. Rates peaked for females 0 to 19 years of age in 2006/07 at 15.8 per 100,000 and were lowest in 2010/11 at 7.9 per 100,000 (Figure 9).

Concussion-related hospitalization rates among children and youth 0 to 19 years were highest in Northern Health and lowest in Vancouver Coastal and Fraser Health Authorities (Figure 10).

Figure 8: Concussion-related hospitalization rates, ages 0-19 years, by year, BC, 2001/02 - 2010/11

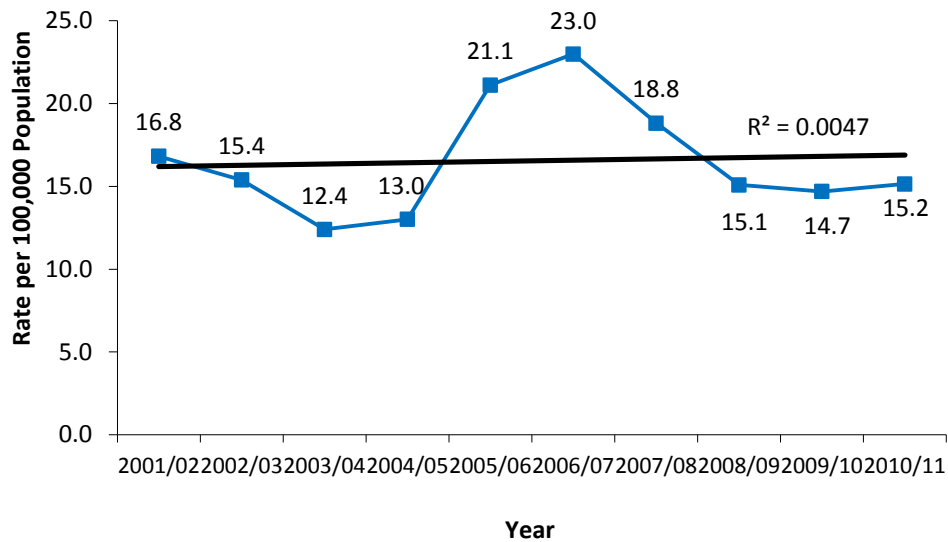


Figure 9: Concussion-related hospitalization rates, ages 0-19 years, by sex and year, BC, 2001/02 - 2010/11

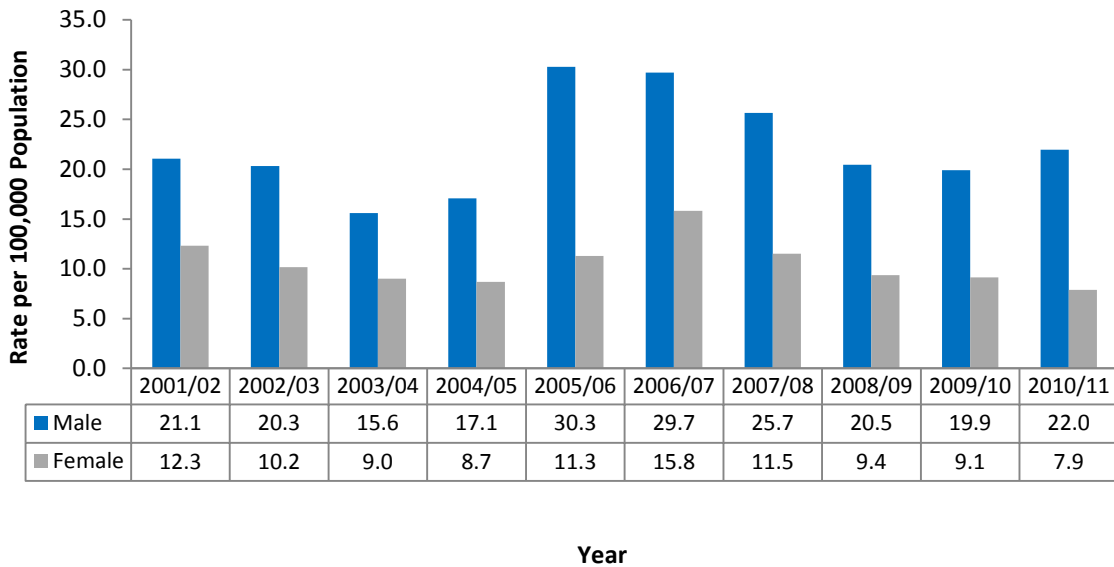
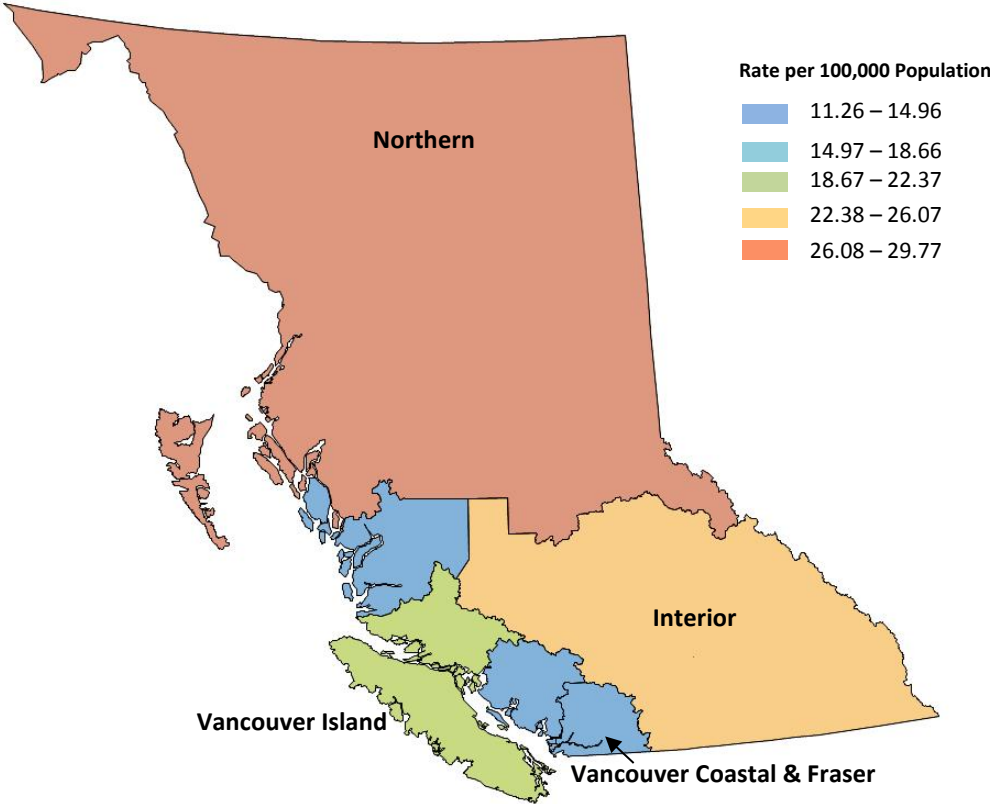


Figure 10: Map of age-specific concussion-related hospitalization rates for 0-19 year olds, BC, 2001/02 - 2010/11



Leading causes of concussion-related hospitalization among children and youth include falls, transport-related, struck by/against an object and other (Figure 11). Falls was the leading cause for both males and females, at 9.3 per 100,000 and 5.1 per 100,000 respectively. Of those concussions caused by struck by/against an object, 68.0 percent occurred during sport and recreation activities.

Leading causes are seen to vary 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-related hospitalizations for 10 to 19 year olds (Figure 12). Concussion-related hospitalization rates for falls were highest among 1 to 4 year olds (13.6/100,000), while transport-related concussion rates were highest among 15 to 19 year olds (9.8/100,000).

Figure 11: Concussion-related hospitalization rates, ages 0-19 years, by cause and sex, BC, 2001/02 - 2010/11

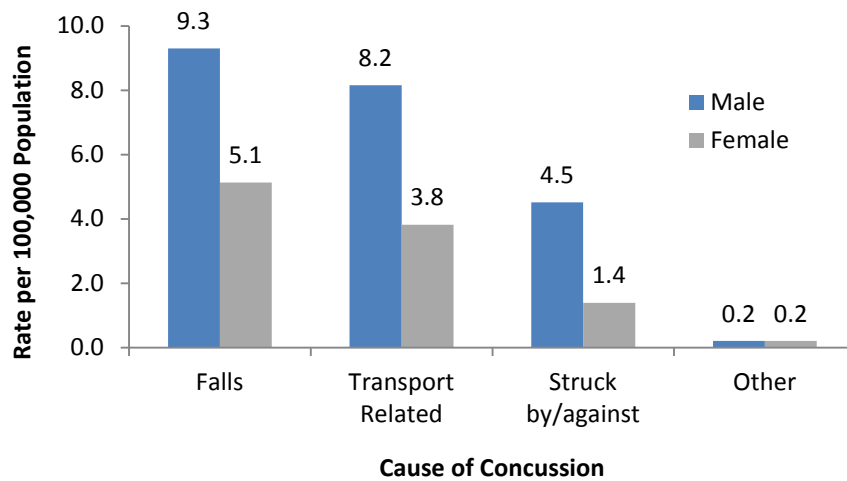
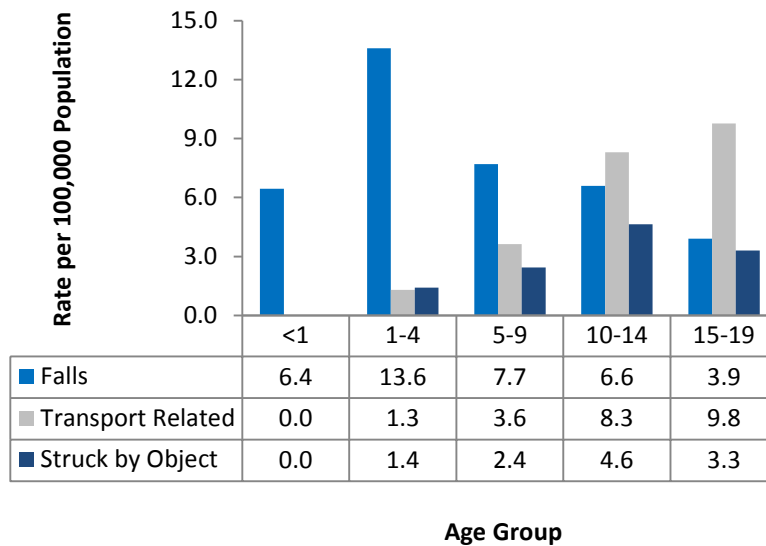


Figure 12: Concussion-related hospitalization rates, ages 0-19 years, by cause and age group, BC, 2001/02 - 2010/11



Fall-related Concussion Hospitalization

Concussion-related hospitalizations among children and youth resulting from a fall were primarily the result of a fall on the same level (17.0%, n=121), falls involving skates, skis and skateboards (13.7%, n=98), and falls from furniture (12.9%, n=92) (Figure 13). Over a quarter of cases were classified as “other and unspecified” falls (26.8%, n=191). Falls from furniture and falls on

the same level were most common among infants less than one year of age (2.9/100,000 and 1.7/100,000, respectively). A similar pattern was observed in young children 1-4 years (3.1/100,000 and 2.1/100,000, respectively) (Figure 14). Falls involving skates, skis and skateboards were more common among older youth ages 10-14 years (1.7/100,000) and 15-19 years (1.5/100,000).

Figure 13: Fall-related concussion hospitalization proportions, ages 0-19 years, by type of fall, BC, 2001/02 - 2010/11

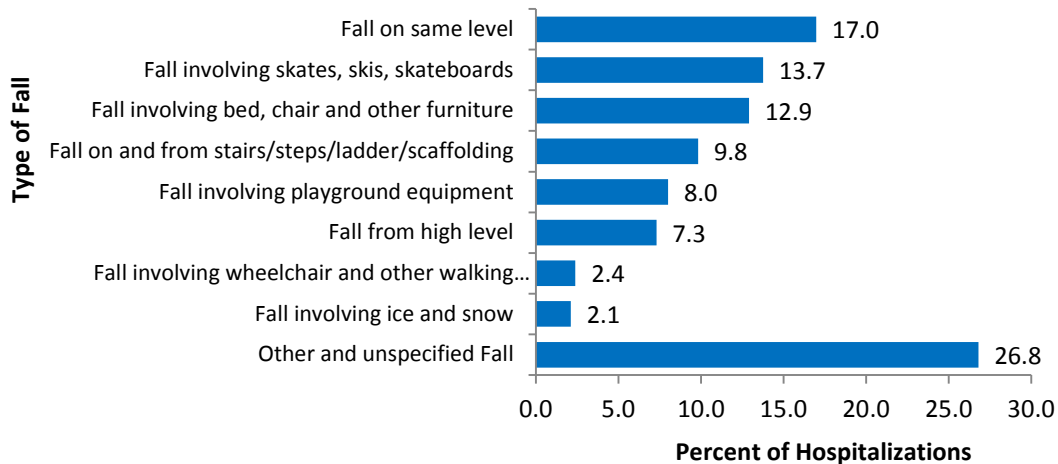
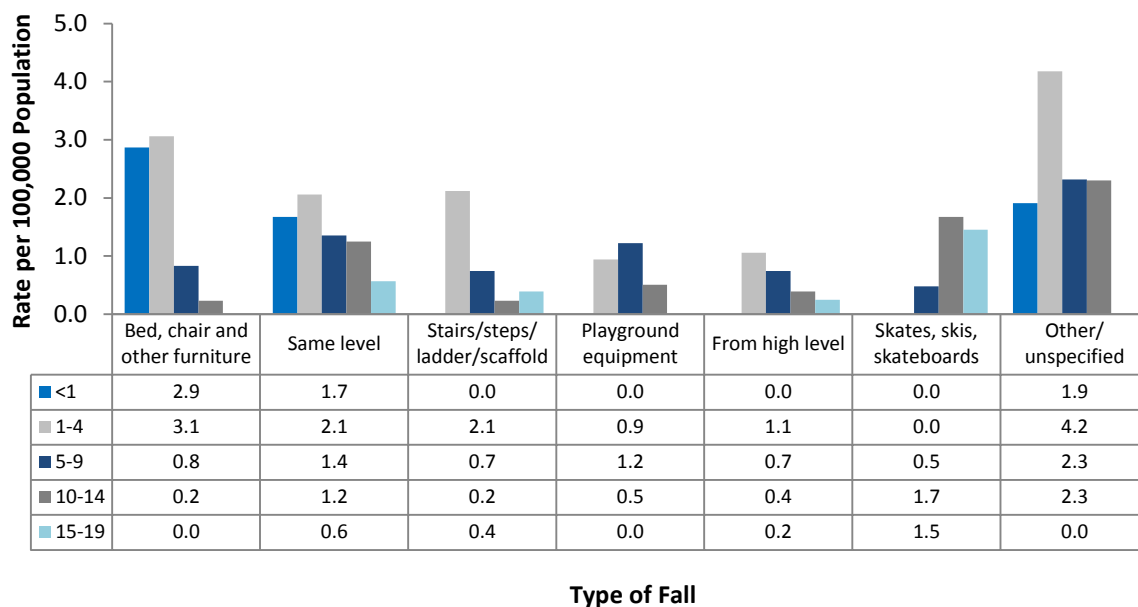


Figure 14: Fall-related concussion hospitalization rates, ages 0-19 years, by type of fall and age group, BC, 2001/02 - 2010/11

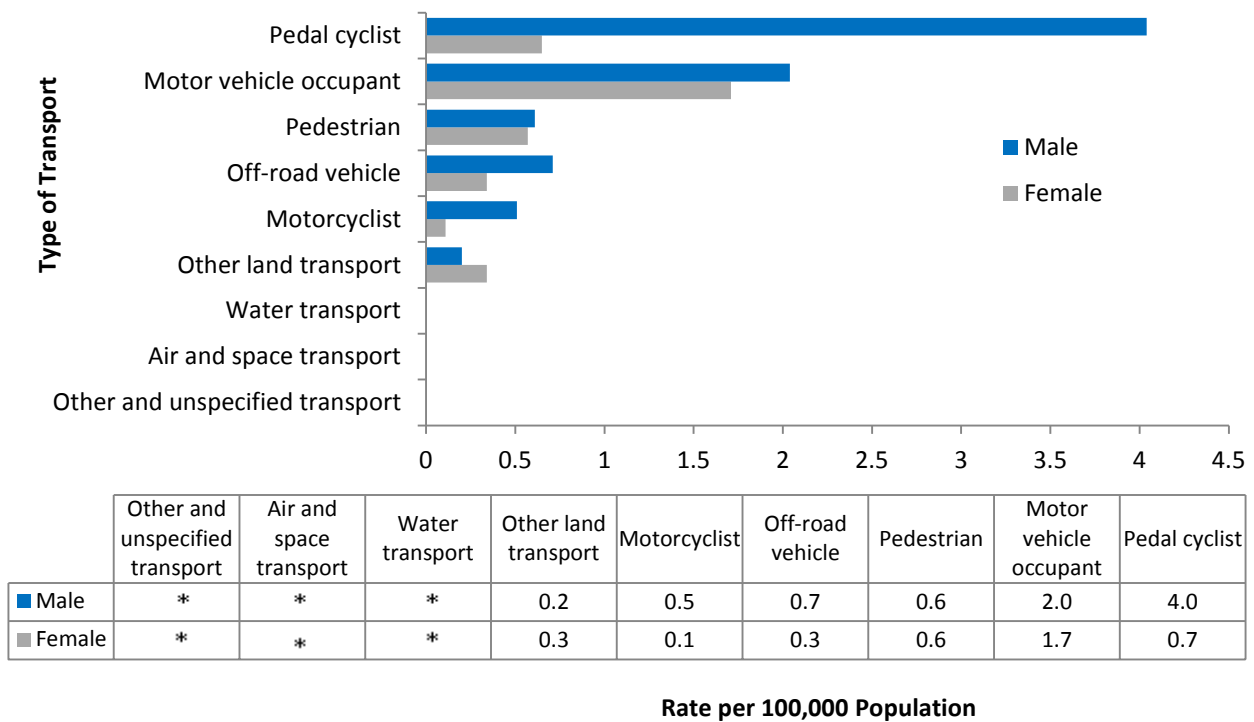


Transport-related Concussion Hospitalization

Concussion hospitalization rates from transport-related injuries among children and youth were generally higher among males than females (Figure 15). Rates among males were highest for pedal cyclists (4.0/100,000) and motor vehicle occupant (2.0/100,000), while highest rates among females were reversed with motor vehicle occupant first (1.7/100,000) and pedal cyclist second (0.7/100,000).

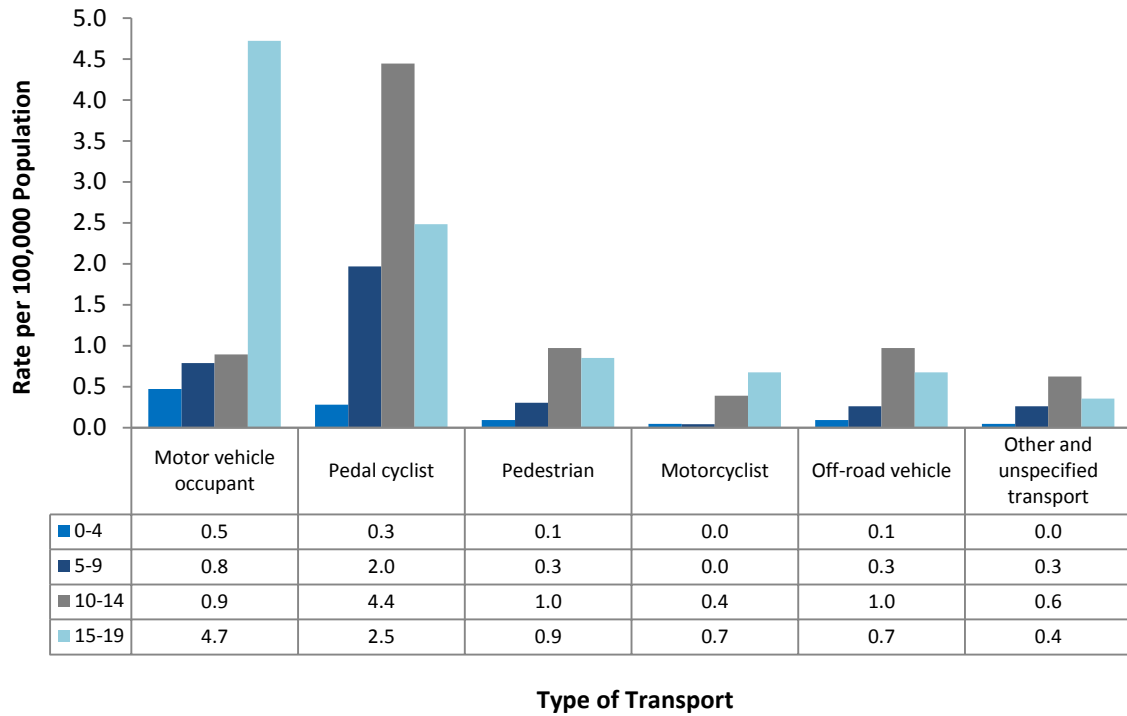
Rates of motor vehicle occupant-related concussion hospitalizations were highest among youth 15 to 19 years (4.7/100,000) and pedal cyclist rates were highest among 10 to 14 year olds (4.4/100,000) (Figure 16).

Figure 15: Transport-related concussion hospitalization rates, ages 0-19 years, by type of transport and sex, BC, 2001/02 - 2010/11



Note: * Numbers less than 5 suppressed in the chart to maintain confidentiality

Figure 16: Transport-related concussion hospitalization rates, ages 0-19 years, by type of transport and age group, BC, 2001/02 - 2010/11



Sport and Recreation-related Concussion Hospitalization

Sport and Recreation-related concussion hospitalization rates for children and youth were generally higher among males than females, with the highest rates being among males ages 10 to 14 years (17.5/100,000) and 15 to 19 years (11.3/100,000) (Figure 17). Rates for females were highest for ages 10 to 14 years at 3.9 per 100,000.

Cycling was the type of sport and recreation activity with the highest proportion of concussion hospitalizations at 34.7 percent (n=217) (Figure 18). Other leading types include playground, hockey, all terrain vehicles and skis/snowboards.

Figure 17: Sport and Recreation-related concussion hospitalization rates, ages 0-19 years, by age group, BC, 2001/02 - 2010/11

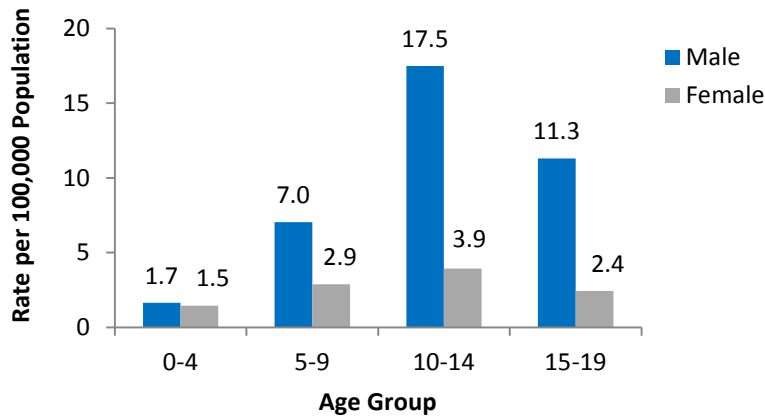
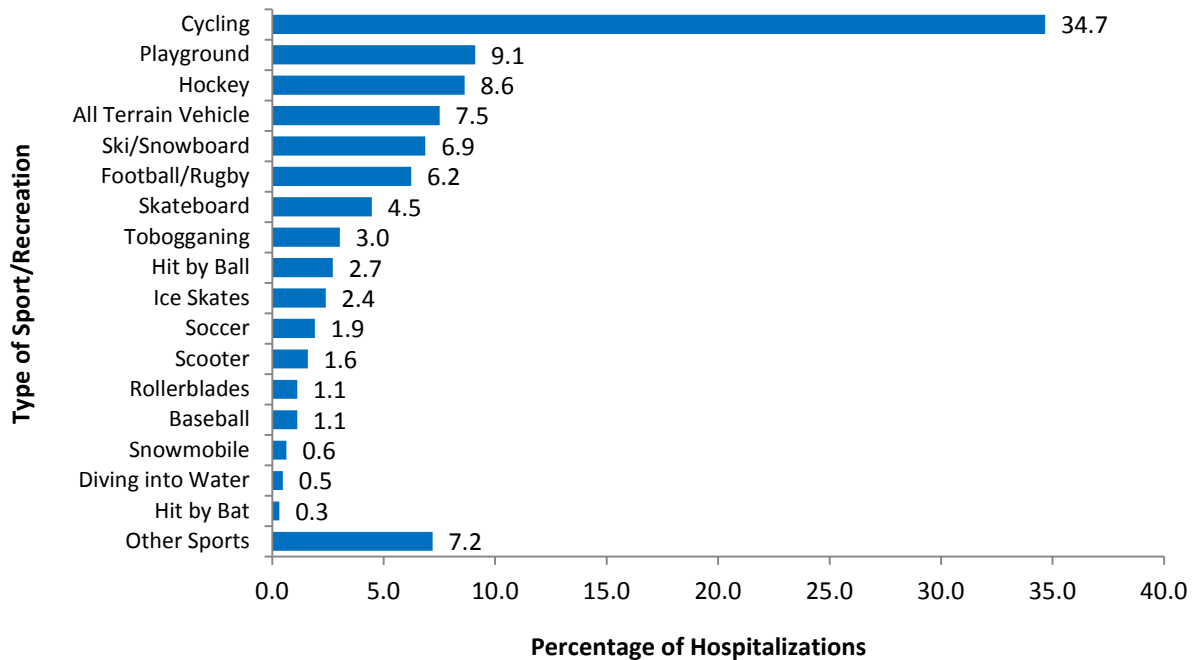


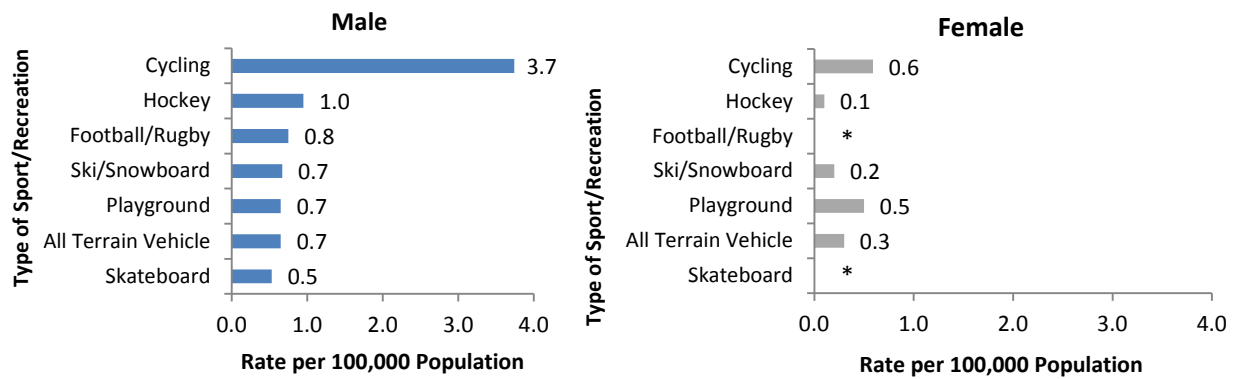
Figure 18: Sport and Recreation-related concussion hospitalization rates, ages 0-19 years, by type of sport/recreation, BC, 2001/02 - 2010/11



The rate of cycling-related concussion hospitalizations for males was 3.7 per 100,000, followed by hockey (1.0/100,000) and football/rugby (0.8/100,000) (Figure 19). For females, highest rates were seen for cycling (0.6/100,000) and playground (0.5/100,000).

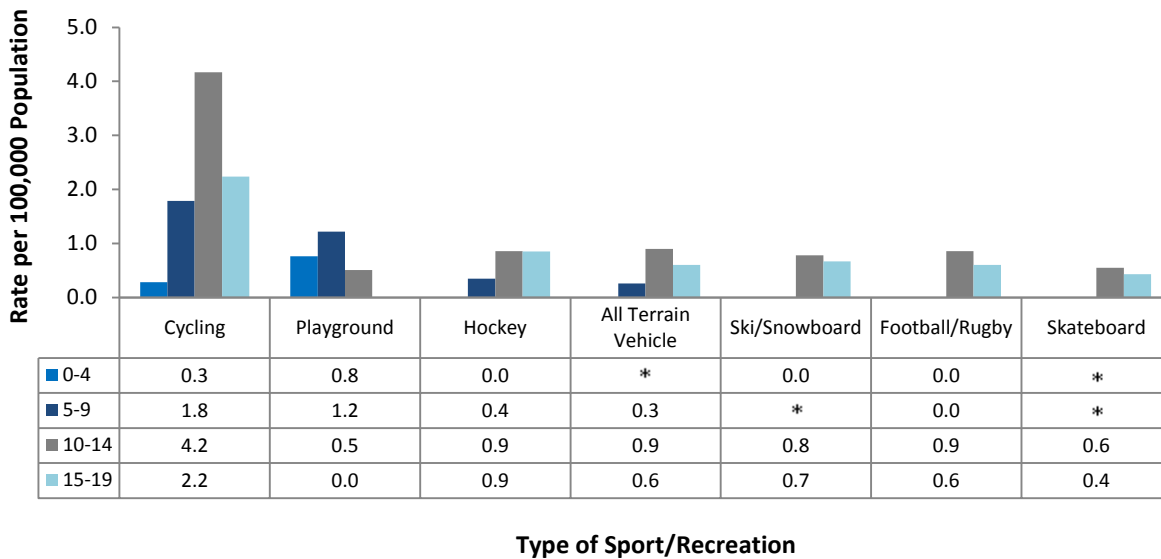
Rates of cycling-related concussion hospitalizations were highest among youth 10 to 14 years (4.2/100,000) and 15 to 19 years (2.2/100,000) (Figure 20). Playground concussion rates were higher among younger children, while generally sport concussion rates were highest among the older youth.

Figure 19: Sport and Recreation-related concussion hospitalization rates, ages 0-19 years, by leading types of sport/recreation and sex, BC, 2001/02 - 2010/11



Note: * Numbers less than 5 suppressed in the chart to maintain confidentiality

Figure 20: Sport and Recreation-related concussion hospitalization rates, ages 0-19 years, by leading types of sport/recreation and age group, BC, 2001/02 - 2010/11



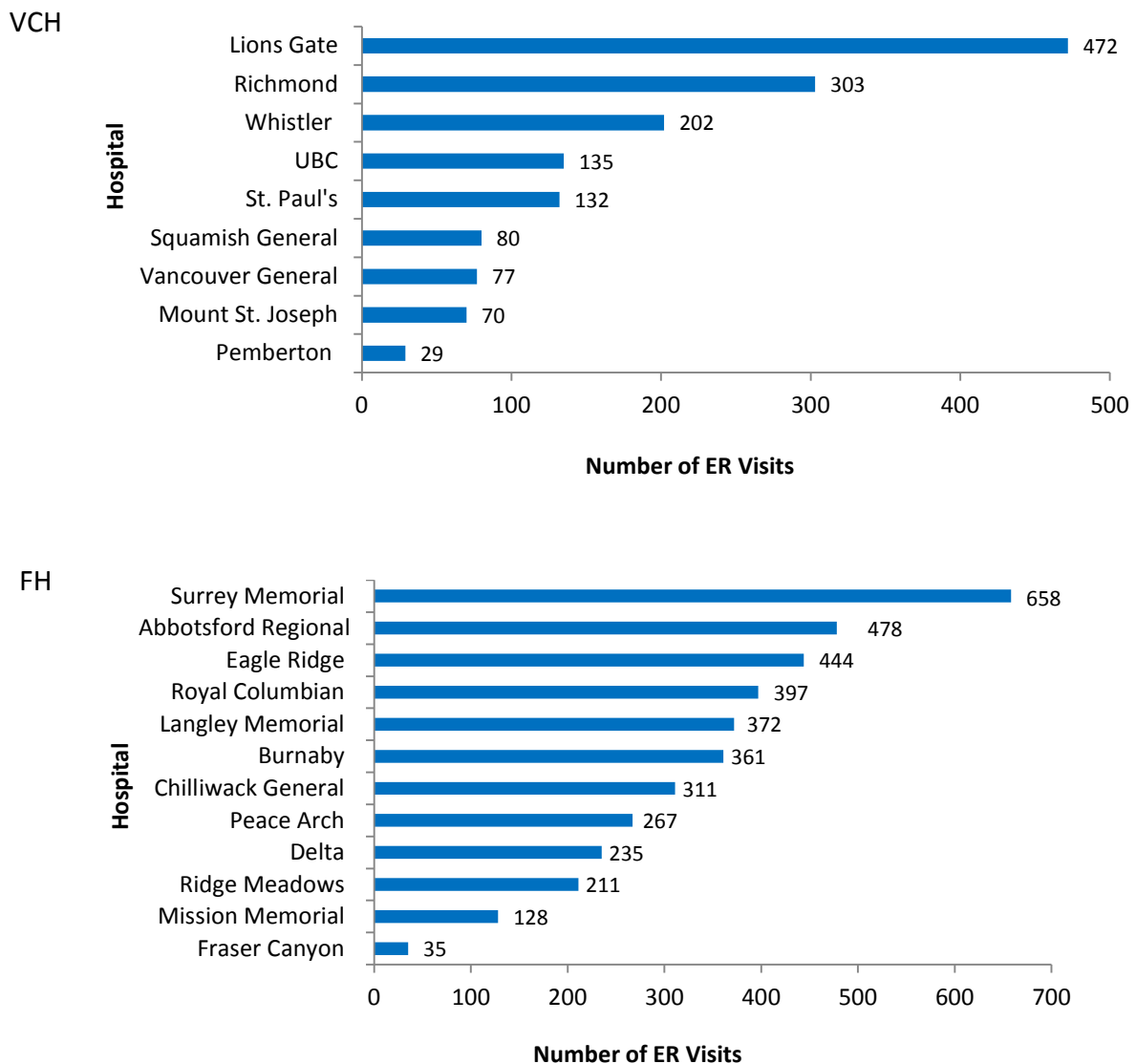
Note: * Numbers less than 5 suppressed in the chart to maintain confidentiality

EMERGENCY DEPARTMENT VISITS FOR CONCUSSIONS, 2011

There were 6,675 concussions among children and youth ages 0 to 19 years seen in emergency departments throughout the BC Lower Mainland in 2011: 1,500 from Vancouver Coastal Health (VCH) (2011); 3,897 from Fraser Health (FH) (2011/12); and a further 1,278 children and youth presenting to BC Children’s Hospital (BCCH) (2009). (See next section for a detailed look at the cases presenting to BCCH.) Males accounted for 63.7 percent of cases (n=4,250).

Of the nine participating VCH hospitals, Lions Gate had the highest number of emergency department visits for children and youth at 472, followed by Richmond (n=303) and Whistler (n=202) (Figure 21). Of the 12 participating FH hospitals, Surrey Memorial had the highest number of emergency department visits at 658, followed by Abbotsford Regional (n=478) and Eagle Ridge (n=444).

Figure 21: Number of concussion-related emergency department visits by attending hospitals, ages 0-19 years, BC Lower Mainland, 2011 (VCH 2011 and FH 2011/12)

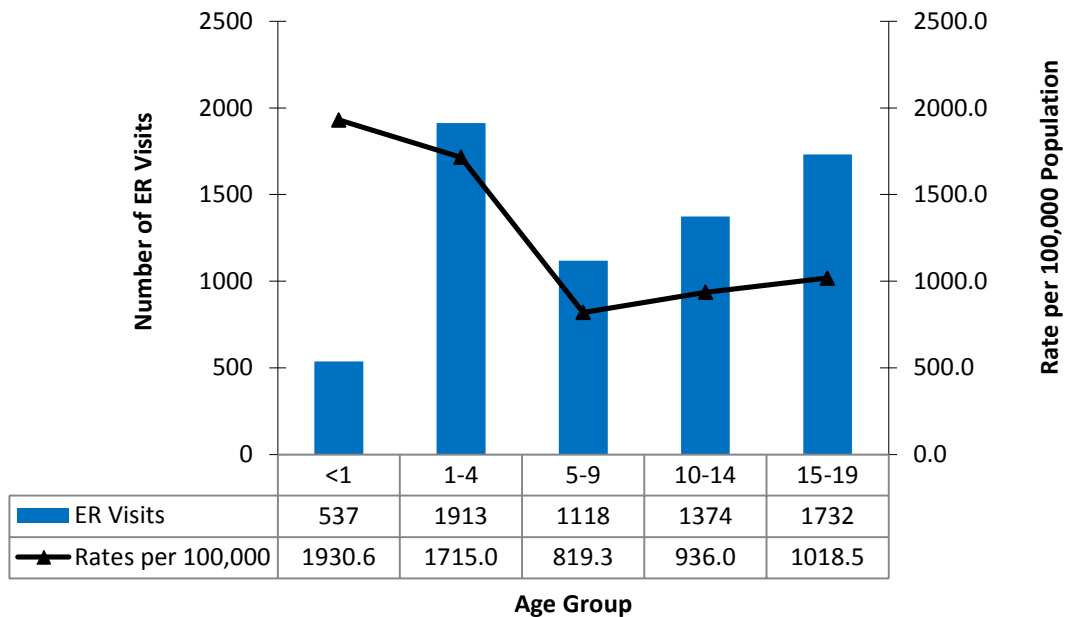


Concussion emergency department rates were highest among infants less than one year of age at 1,930.6 per 100,000, followed by young children ages 1 to 4 years (1,715.0/100,000) (Figure 22). It should be noted that concussion-related emergency department visits among infants less than one year of age was the lowest at 537 when

compared to the other age groups; however the rates per 100,000 population was the highest.

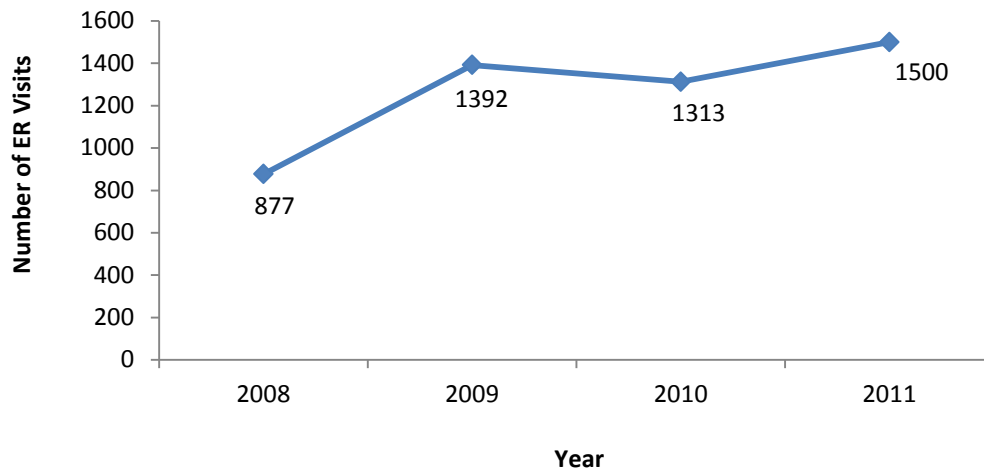
No significant trends in the number of cases were found during the period between 2008 to 2011 (Figure 23).

Figure 22: Concussion-related emergency department rates and cases, ages 0-19 years, by age group, BC Lower Mainland (VCH 2011; FH 2011/12 and BCCH 2009)



Note: Age group was missing for 6 cases

Figure 23: Number of concussion-related emergency department cases, ages 0-19 years, VCH, 2008-2011



Concussion-related emergency department rates among children and youth were highest among female infants less than one year of age at 1,960.7 per 100,000 and young males ages 1 to 4 years at 1,943.0 per 100,000 (Figure 24). Rates were lowest among females 10 to 14 years at 541.6 per 100,000.

The leading cause of a concussion was falls, representing 36.0 percent of cases (n=1,941) in 2011, followed by sports and recreational activities at 28.2 percent (n=1,521) and struck by or against an object at 10.7 percent (n=578) (Figure 25).

Figure 24: Concussion-related emergency department rates, ages 0-19 years, by sex, BC Lower Mainland (VCH 2011; FH 2011/12 and BCCH 2009)

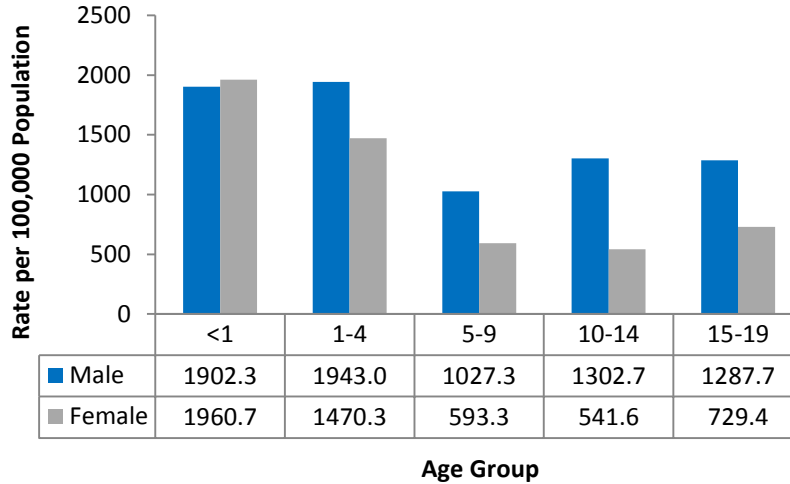
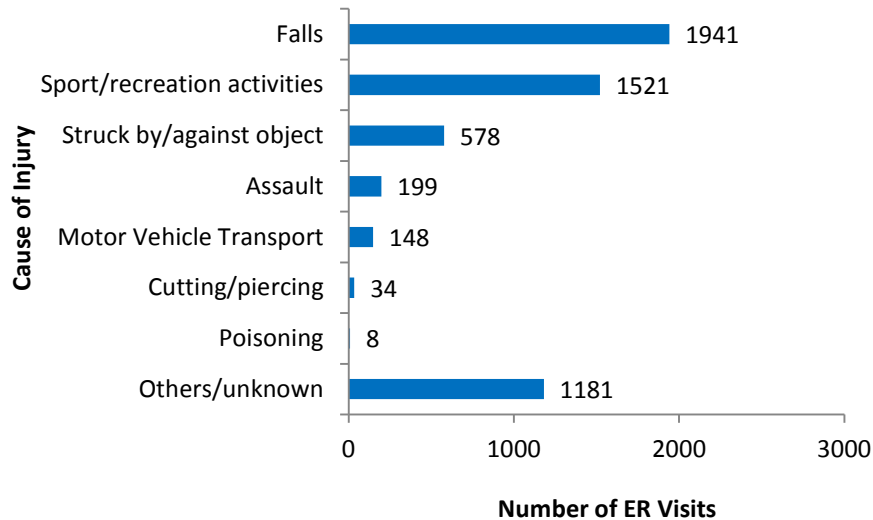


Figure 25: Number of concussion-related emergency department visits, by cause of injury, BC Lower Mainland, 2011 (VCH 2011 and FH 2011/12)



BC CHILDREN'S HOSPITAL EMERGENCY DEPARTMENT VISITS FOR CONCUSSION & MINOR HEAD INJURY, 2001-2009

There were 9,027 children and youth ages 0 to 19 years presenting to BCCH with a concussion or minor head injury over the 9-year period from 2001 to 2009, as captured by the Canadian Hospital Injury Reporting and Prevention Program (CHIRPP). The annual number of presentations increased significantly from 716 in 2001 to 1,402 in 2009 ($p=0.001$) (Figure 26).

Young children ages 1 to 4 years accounted for 36.9 percent of all cases ($n=3,330$); 5 to 9 year olds accounted for 20.0 percent ($n=1,803$); and 10 to 14 year olds accounted for 19.7 percent ($n=1,778$) of all concussion or minor head injury cases presenting to BCCH (Figure 27).

Overall, males accounted for 61.7 percent ($n=5,567$) of cases and were higher than females in each age group (figure is not shown).

Some seasonal variations were observed in frequency of concussion or minor head injury cases. The frequency was higher from April to October with the peak occurring in May. The frequency also varied during the week with a higher frequency occurring on weekends, particularly on Sundays (figure is not shown).

Figure 26: Number of concussion or minor head injury-related emergency department visits, ages 0-19 years, by year, BC CHIRPP, 2001-2009

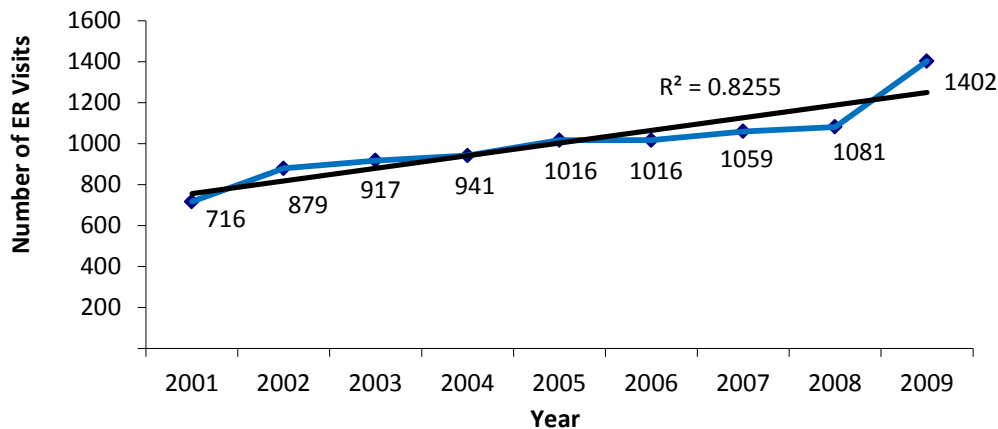
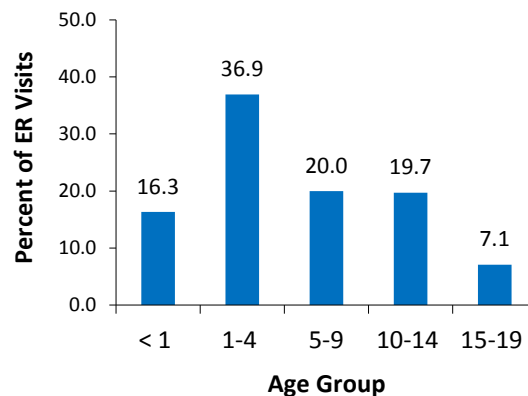


Figure 27: Number and proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by age group, BC CHIRPP, 2001-2009

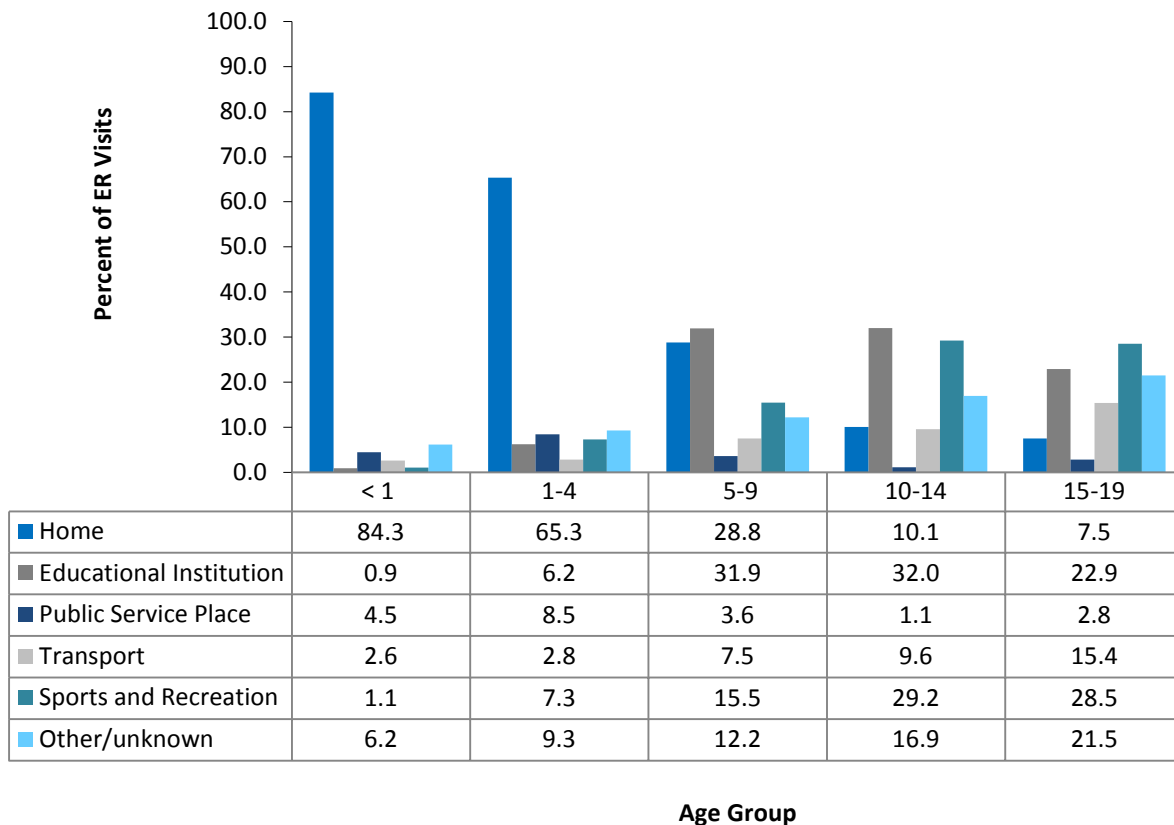


Location & Context of Concussion & Minor Head Injury - CHIRPP

Among infants less than one year of age, 84.3 percent of all concussions or minor head injuries occurred in the home setting (Figure 28). The proportion of concussions or minor head injury occurring at home decreased with age, being 84.3 percent among infants less than one year of age; 65.3 percent among young children 1 to 4 years of age; 28.8 percent among 5 to 9 year olds; 10.1 percent among 10 to 14 year olds; and 7.5 percent among teens 15 to 19 years old.

Concussion or minor head injury occurring in educational institutions and places of sport and recreation increased with age. The highest proportion of cases occurring at educational institutions (32.0%) and sport and recreation facilities (29.2%) were both among children 10 to 14 years of age. The highest proportion of transport-related cases were among teens 15 to 19 years old which included injuries sustained on a vehicle, train or plane, on the highway and on other roads (15.4%).

Figure 28: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by location and age group, BC CHIRPP, 2001-2009

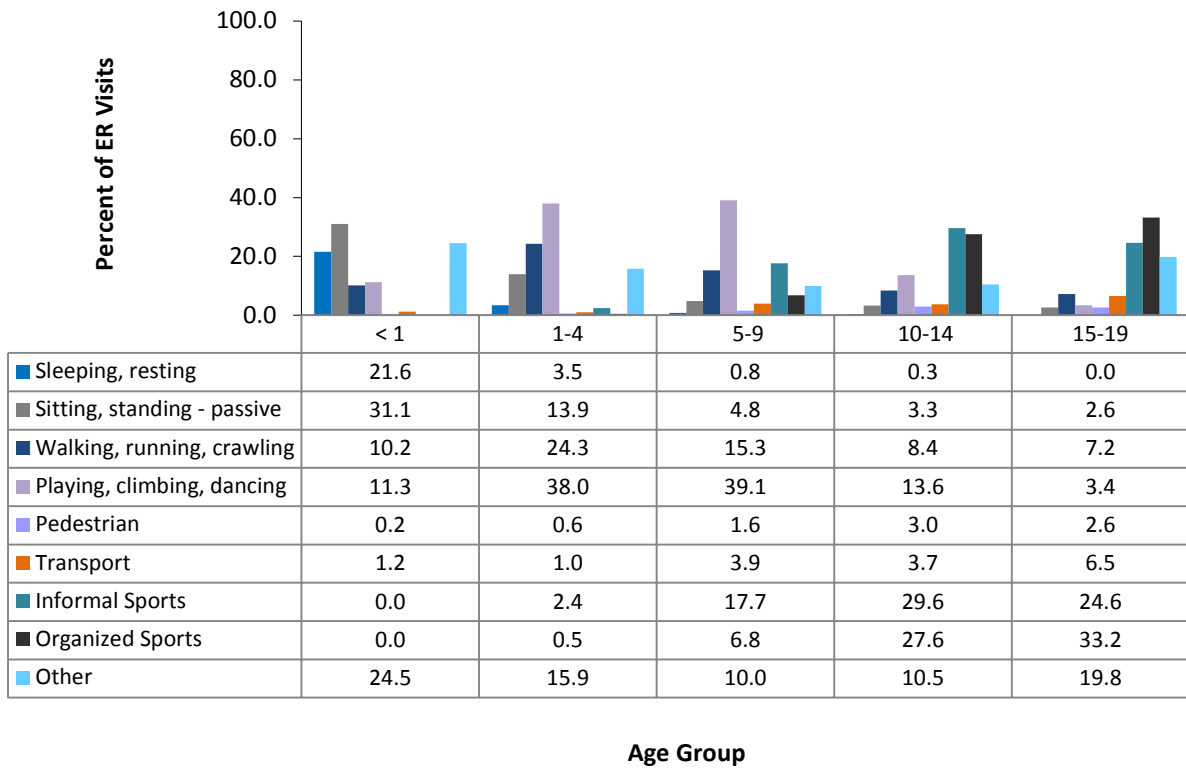


Note: Other includes mine, farm house, cemetery, railway track, underdeveloped place and unknown location

The context of the injury event, or activity engaged in at the time of injury varied with age. The highest proportion of concussion and minor head injury among infants less than one year of age occurred during activities involving sitting or standing positions (31.1%), followed by sleeping or resting (21.6%) (Figure 29). Among young children ages 1 to 4 years and 5 to 9 years, playing, climbing and dancing lead to the highest proportion of

concussions or minor head injury (38.0% and 39.1%, respectively), followed by walking, running and crawling for 1 to 4 year olds (24.3%) and informal sports for 5 to 9 year olds (17.7%). Among youth 10 to 14 years of age, informal sports account for the largest proportion (29.6%), while among teens 15 to 19 years, organized sports account for the highest proportion of concussion or minor head injury (33.2%).

Figure 29: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by context and age group, BC CHIRPP, 2001-2009



Note: Informal sport includes bicycling. Pedestrian includes those on roller skates, scooters and skateboards on the road at the time of the injury event. Other includes food preparation, cooking, cleaning, moving furniture, gardening/yard work and personal activities such as washing, showering, eating and drinking.

When examining concussion or minor head injury by activity and location together, the highest numbers of injuries were sustained in the home while playing, climbing and dancing (n=1,276), walking, running and crawling (n=921) and sitting, standing-passive (n=797) (Table 1). Playing, climbing and dancing accounted for 506 concussions or minor head injuries occurring in educational institutions and 277 occurring at sports

and recreation locations. Organized sports accounted for 430 concussions or minor head injuries occurring in sport and recreation locations and 248 occurring in educational institutions. Informal sport activities accounted for 288 injuries occurring in sport and recreation locations and 239 occurring in educational institutions.

Table1: Number of concussion or minor head injury-related emergency department visits, ages 0-19 years, by activity and location, BC CHIRPP, 2001-2009

Location	Context									
	Pedestrian (n)	Bicycle (n)	Transport (n)	Informal Sports (n)	Organized Sports (n)	Sleeping, resting (n)	Walking, running, crawling (n)	Sitting, standing-passive (n)	Playing, climbing, dancing (n)	Other (n)
Public Service Place	0	*	5	*	0	9	84	206	63	79
Educational Institution	*	21	*	239	248	*	241	95	506	155
Sports and Recreation	0	61	10	288	430	0	75	44	277	55
Transport	91	107	158	34	0	*	56	32	17	41
Other	20	68	68	149	164	11	144	130	189	182
Home	*	44	6	61	*	428	921	797	1,276	628
Total	114	302	249	775	843	452	1,521	1,304	2,328	1,140

Note: * Numbers less than 5 suppressed in the chart to maintain confidentiality. Pedestrian includes those on roller skates, scooters and skateboards on the road at the time of the injury event.

Leading Causes of Concussion & Minor Head Injury - CHIRPP

Leading causes of concussion-related emergency department cases presenting to BCCH were falls, at 70.3 percent, followed by struck by/against an object (Figure 30).

Looking at these two leading causes by age group, the proportion of falls cases is seen to be highest among 2 to 4 year olds (25.7%), whereas proportions of struck by/against an object cases are highest among 10 to 14 year olds (35.2%) (Figure 31).

Figure 30: Proportion of concussion or minor head injury-related emergency department visits by cause, ages 0-19 years, BC CHIRPP, 2001-2009

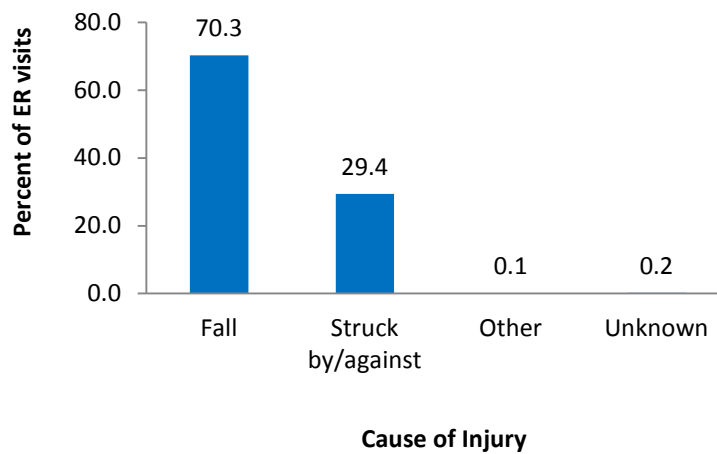
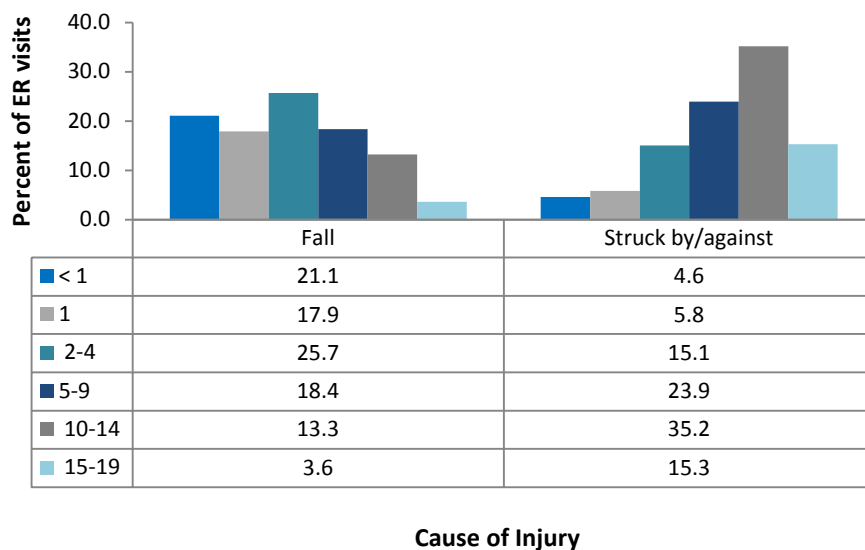


Figure 31: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by cause and age group, BC CHIRPP, 2001-2009

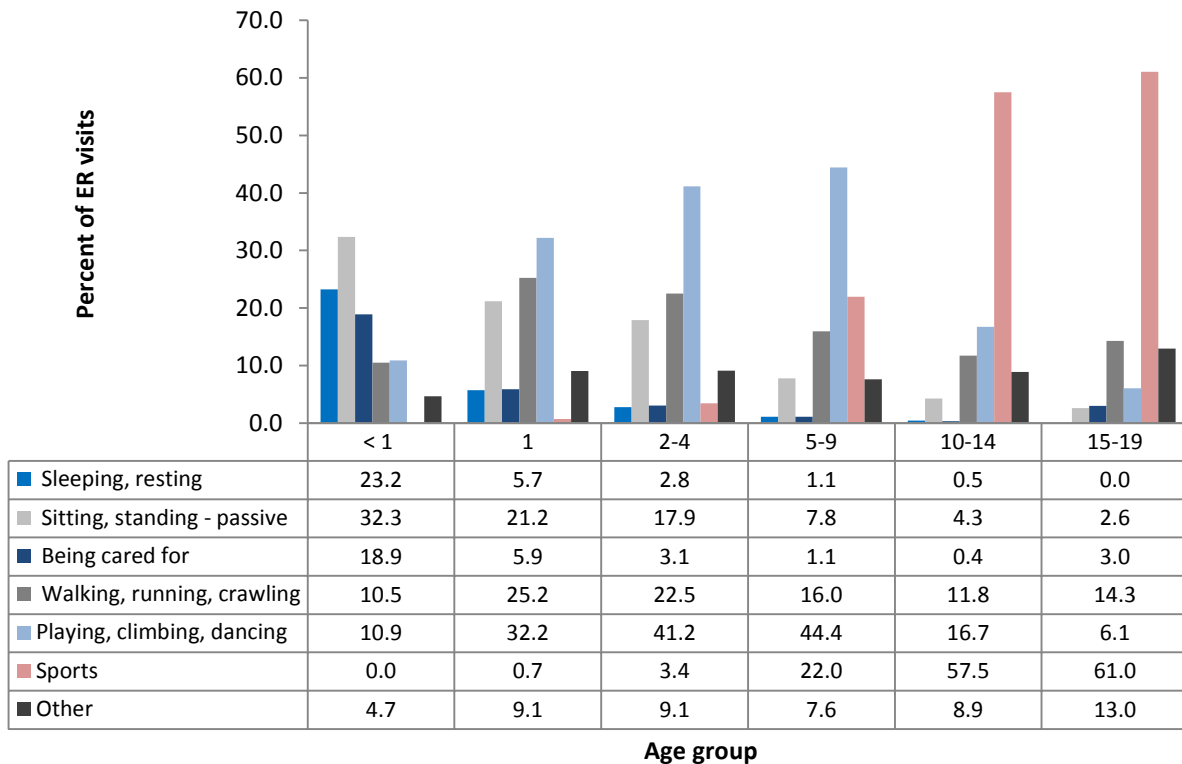


Fall-Related Concussion & Minor Head Injury - CHIRPP

The highest proportion of fall-related concussions or minor head injury among infants less than one year of age occurred during activities involving sitting or standing positions (32.3%), followed by sleeping or resting (23.2%) (Figure 32).

Playing, climbing and dancing lead to the highest proportion of concussions or minor head injury among young children ages one year, 2 to 4 years and 5 to 9 years (32.2%, 41.2% and 44.4%, respectively), followed by walking, running and crawling for the 1-year-olds and 2-4 year olds (25.2% and 22.5%, respectively), and sports for the 5 to 9 year olds (22.0%). Sports accounted for the majority of concussions or minor head injury among youth 10 to 14 and 15 to 19 years of age (57.5% and 61.0%, respectively).

Figure 32: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by type of fall and age group, BC CHIRPP, 2001-2009



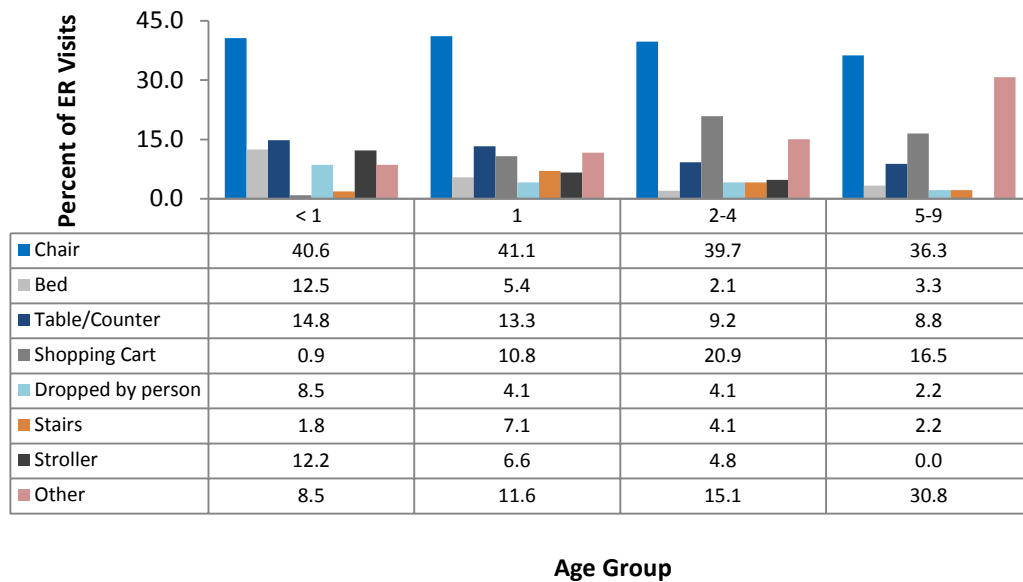
Note: Sports include informal, organized, bicycling. Other includes recreation/hobby activities, other personal activities and other activities not specified.

Fall-related concussion or minor head injury among 0 to 9 year olds resulting from sitting and standing positions was mostly due to falling from chairs, with the highest being among 1-year-olds (41.1%) and the lowest among 5 to 9 year olds (36.3%) (Figure 33). Falls from tables/ counters and from beds were more common among the younger age

groups, whereas falls from shopping carts were more common among 2 to 9 year olds.

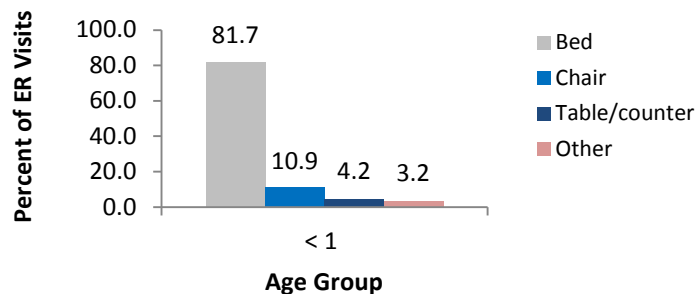
Among infants less than one year of age, fall-related concussion or minor head injury that occurred while sleeping and resting were mostly as a result of falling from beds (including bassinets and cribs) (Figure 34).

Figure 33: Proportion of concussion or minor head injury-related emergency department visits, ages 0-9 years, by type of fall from sitting, standing-passive positions and age group, BC CHIRPP, 2001-2009



Note: Other includes slipped, tripped, railing, window, balcony and fence.

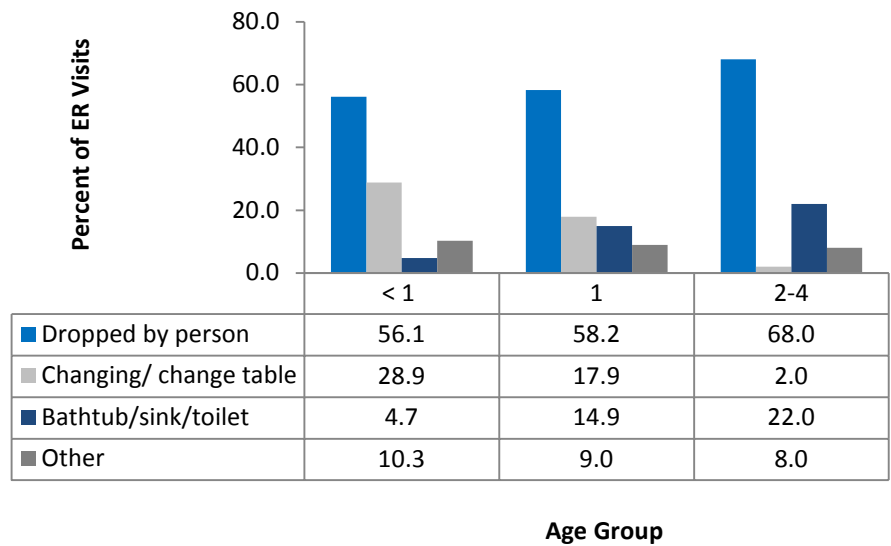
Figure 34: Proportion of concussion or minor head injury-related emergency department visits, less than one year of age, by type of fall during sleeping and resting, BC CHIRPP, 2001-2009



Note: Bed includes crib, bed and bassinet. Chair includes all types of chair: high chair, bench, sofa, and stool. For the table/counter: desk, coffee table, changing table, kitchen and bath counters.

Fall-related concussion or minor head injury occurring during care of children ages 0 to 4 year olds mostly resulted from being dropped by a person, where 56.1 percent were among infants less than one year of age, 58.2 percent among one year olds, and 68.0 percent among 2 to 4 year olds (Figure 35). Falls from change tables were more common among infants and one-year-olds, whereas falls involving bathtub/sink/toilet were more common among young children ages 2 to 4 years.

Figure 35: Proportion of concussion or minor head injury-related emergency department visits, ages 0-4 years, by type of fall during care and age group, BC CHIRPP, 2001-2009

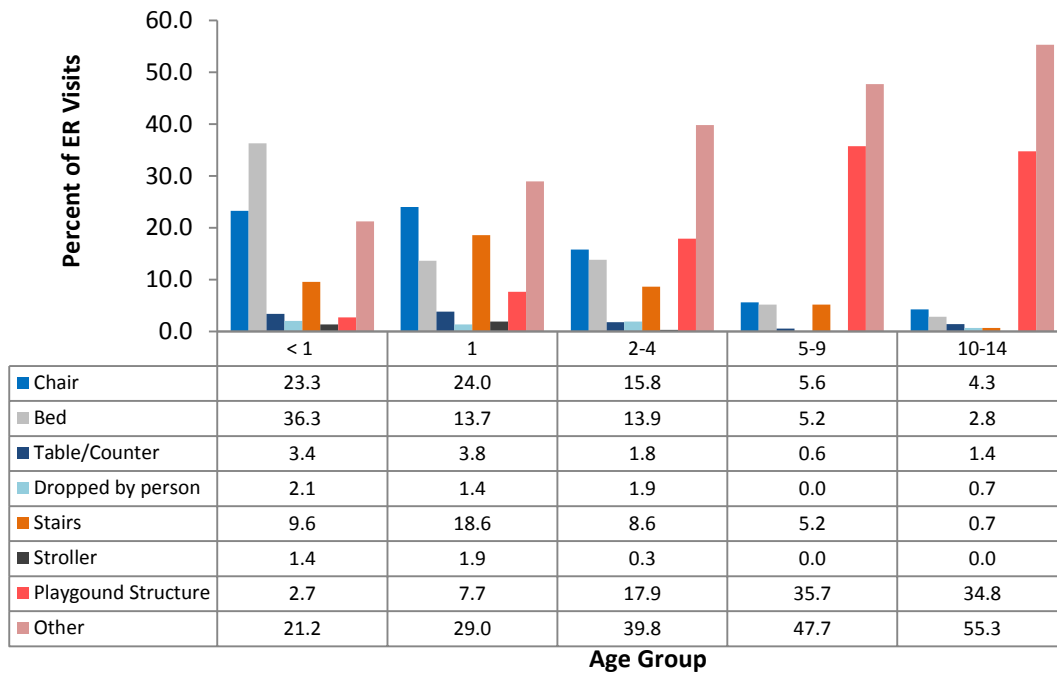


Note: Other includes bed, car seat, chair and stairs.

The type of fall-related concussion or minor head injury that occurred during playing, climbing and dancing activities varied by age. Falls from beds accounted for the majority of cases among infants (36.3%), falls from chairs were most common among one year olds (24.0%), and falls from playground structure were most common among 2 to 4, 5 to 9, and 10 to 14 year olds (17.9%, 35.7% and 34.8%, respectively) (Figure 36).

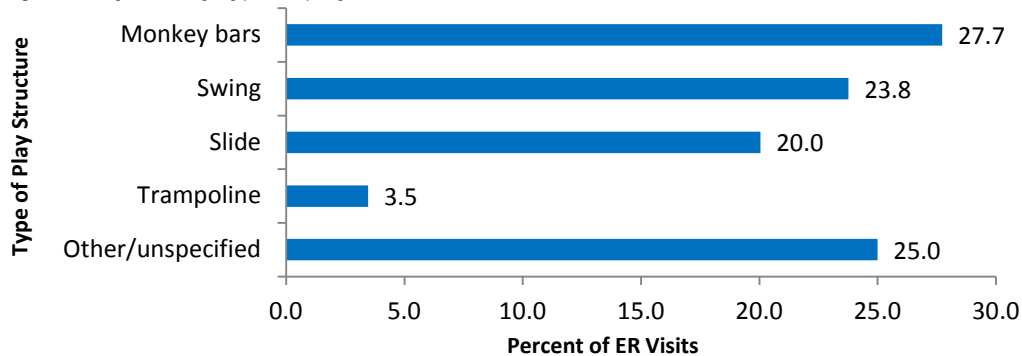
Monkey bars, swings and slides were the most common structure types that accounted for falls from playground structures (27.7%, 23.8% and 20.0%, respectively) (Figure 37).

Figure 36: Proportion of concussion or minor head injury-related emergency department visits, ages 0-14 years, by type of fall during playing, climbing, dancing and age group, BC CHIRPP, 2001-2009



Note: Other includes slipped, tripped and other unspecified.

Figure 37: Proportion of concussion or minor head injury-related emergency department visits resulting from falls, ages 0-19 years, by type of play structure, BC CHIRPP, 2001-2009



Note: Other includes bouncy castle, jungle gym, teeter-totter, etc.

Struck by/against an object-related Concussion & Minor Head Injury - CHIRPP

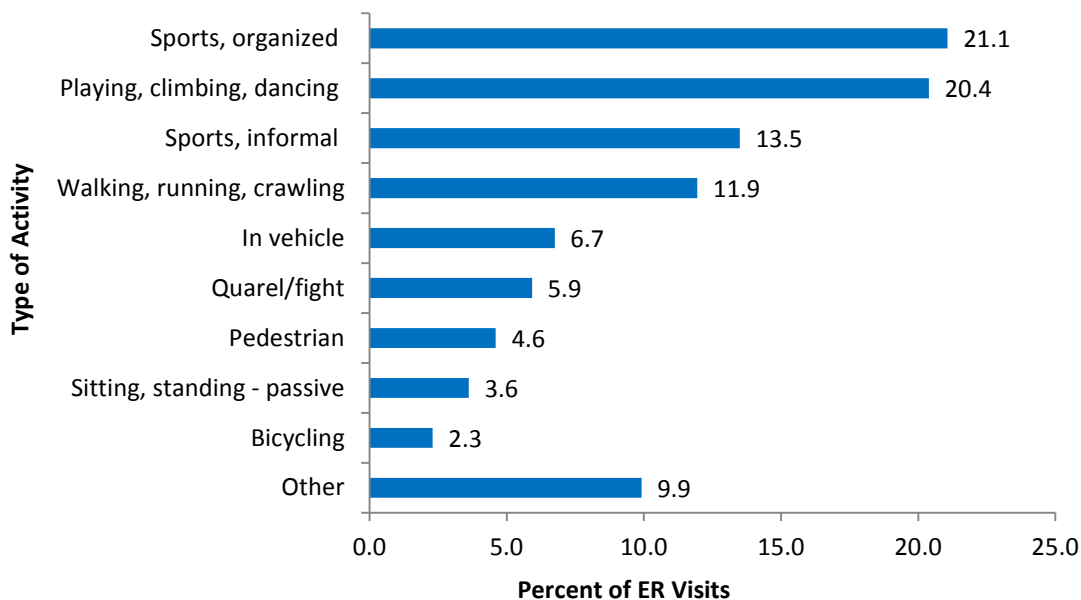
The highest proportion of concussion or minor head injuries as a result of being struck by/against an object occurred during organized sports (21.1%), followed by playing, climbing and dancing activities (20.4%), and informal sports (13.5%) (Figure 38).

Concussion or minor head injuries as a result of being struck by/against an object among infants less than one year of age occurred mostly during sitting and standing activities (23.6%) followed by playing, climbing and dancing (16.3%), being cared for (13.0%) and in a car/passenger van/jeep (9.8%) (figure is not shown). The remaining concussion cases were caused from activities such as walking, running and crawling, dressing, sleeping or resting. In addition, about 11 percent of cases reported as unspecified activity (figure is not shown).

Majority of concussion or minor head injury as a result of being struck by/against an object among 1 to 4 year olds occurred while playing, climbing and dancing (45.9%) and walking, running and crawling (28.1%) (figure is not shown).

For children 5 to 14 years of age, playing, climbing, dancing (29.4%), sports (26.5) and walking or running (14.0%) were the leading activities that resulted in concussion or minor head injury. From 10 to 19 years of age, sport activities (53.5%) were the leading activity, followed by a quarrel/fight (11.2%) (figure is not shown).

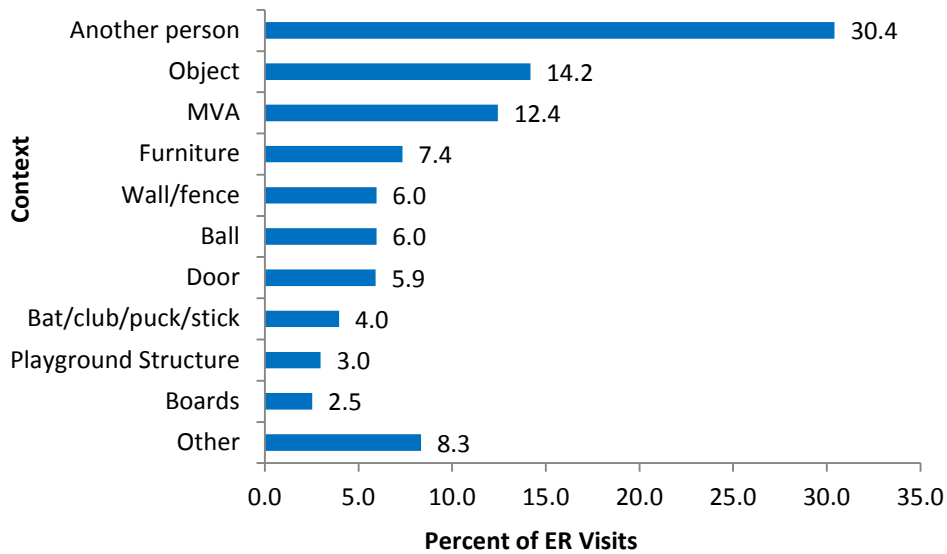
Figure 38: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by activity conducted when being struck by/against an object, BC CHIRPP, 2001-2009



Note: Other includes cleaning, moving furniture, gardening/yard work, or other personal activities such as sleeping/resting, washing, showering, dressing, eating or drinking.

The highest proportion of concussion or minor head injury from being struck by/against an object was mostly due to struck by or against another person (30.4%), followed by struck by or against an object (14.2%) and struck in the context of a motor vehicle crash (12.4%) (Figure 39).

Figure 39: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by context of struck by/against an object, BC CHIRPP, 2001-2009



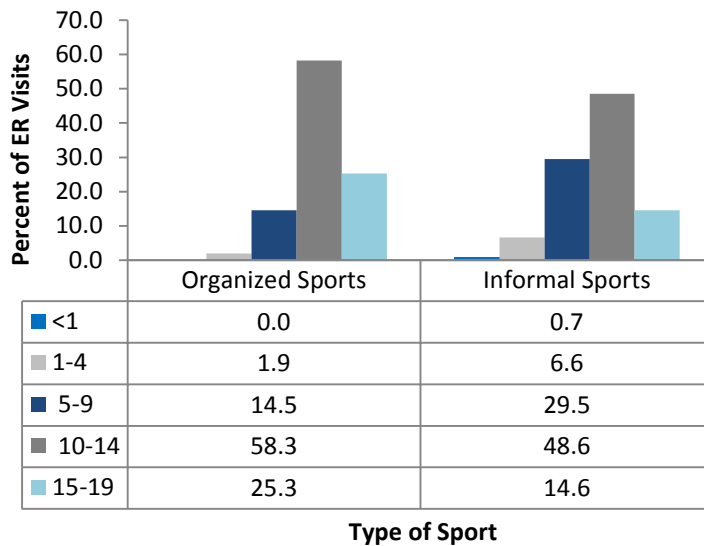
Note: Other includes stairs, railings/ramp, bicycle, bathtub, sink, toilet and animal

Sport-Related Concussion & Minor Head Injury - CHIRPP

In both organized and informal sports, children aged 10 to 14 years sustained the highest proportion of sport-related concussion and minor head injuries as compared to other age groups (organized sports 58.3% and informal sports 48.6%) (Figure 40).

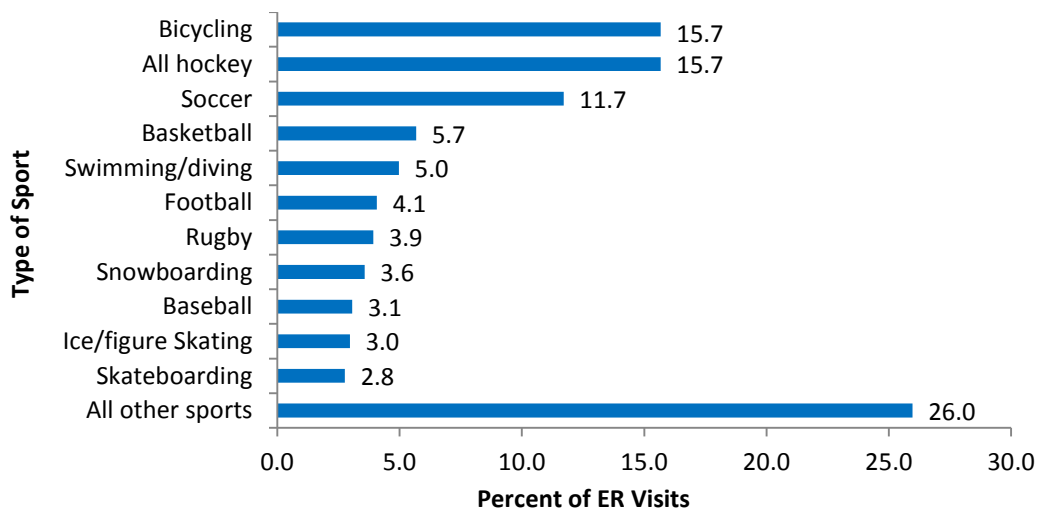
Bicycling and hockey each accounted for 15.7 percent of sport-related concussions, followed by soccer (11.7%) (Figure 41).

Figure 40: Proportion of concussion or minor head injury-related emergency department visits, ages 0-19 years, by organized and informal sports and age group, BC CHIRPP, 2001-2009



Note: Informal includes bicycling

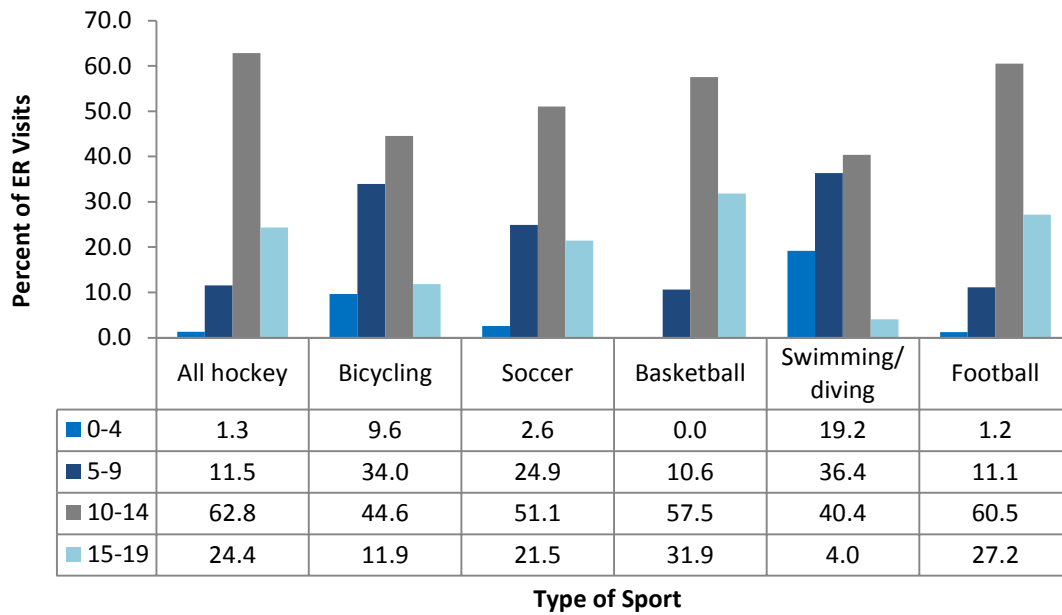
Figure 41: Proportion of concussion or minor head injury-related emergency department visits, 0-19 years old, by type of sport, BC CHIRPP, 2001-2009



Note: All hockey includes ice hockey, field hockey, floor hockey, roller hockey, street hockey and not specified hockey types.

Children and youth ages 10 to 14 years accounted for the majority of all sport-related concussions, including 62.8 percent of all hockey cases, 60.5 percent for football, 57.5 for basketball, 51.1 percent for soccer, 44.6 percent for bicycling, and 40.4 percent for swimming/diving (Figure 42). Teens aged 15 to 19 years ranked second for basketball, football, and hockey. Children ages 5 to 9 years ranked second for swimming/diving, bicycling, and soccer.

Figure 42: Proportion of concussion or minor head injury-related emergency department visits, 0-19 years old, by the leading type of sport and age group, BC CHIRPP, 2001-2009

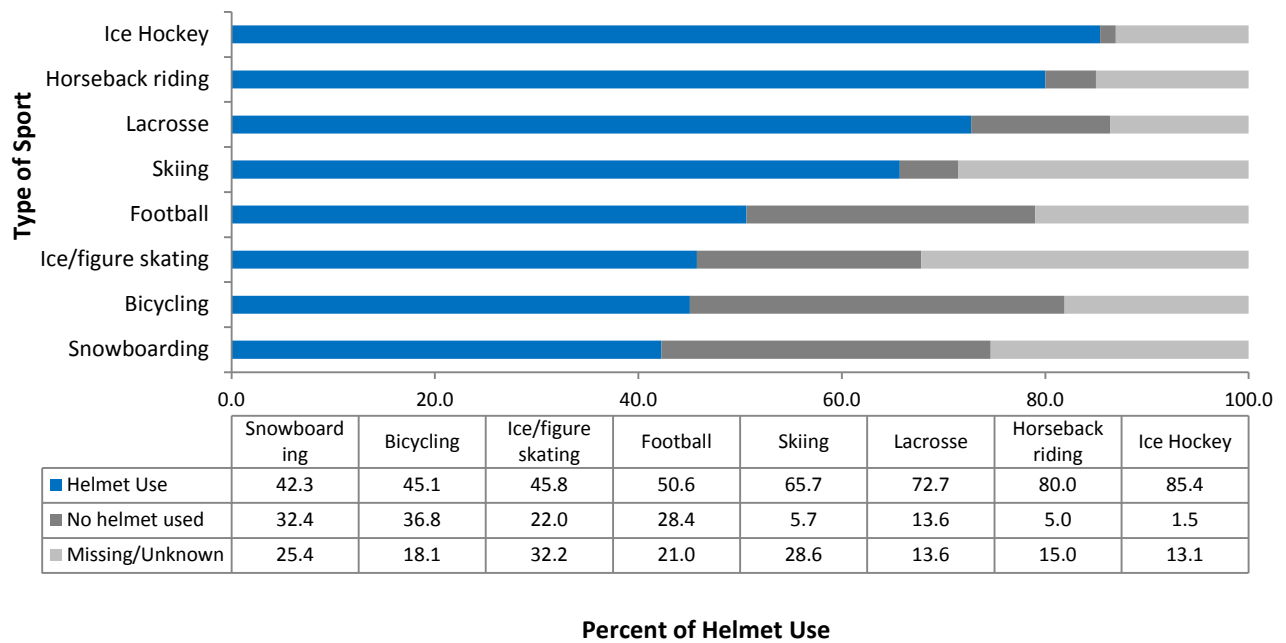


Safety Equipment Use for Concussion & Minor Head Injury - CHIRPP

Concussions or minor head injuries sustained while engaging in sports activities, either organized sports or other sports and recreation activities, demonstrate a variation in helmet use. Injuries sustained while playing ice hockey (85.4%) had the highest proportion of helmet use, followed by horseback riding (80.0%) and lacrosse (72.7%) (Figure 43).

Among children and youth ages 0 to 19 years sustaining a concussion or minor head injury while in transit, 56.9 percent of were using a safety device (seat belt/car seat) whereas 17.8 percent used none while 25.3 percent of cases were missing (figure is not shown).

Figure 43: Proportion of concussion or minor head injury-related emergency department visits, 0-19 years old, by type of sport and helmet use, BC CHIRPP, 2001-2009



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