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CONCUSSION AMONG CHILDREN & YOUTH: FRASER HEALTH AUTHORITY

BC INJURY research and
prevention unit

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 in the Evidence to Innovation theme within the Child and Family Research Institute (CFRI) and supported by the Provincial Health Services Authority (PHSA) 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".

Acknowledgements: The BC Injury Research and Prevention Unit (BCIRPU) would like to acknowledge the contributions of Child Health BC in the development of this report. In particular, BCIRPU would like to acknowledge Jennifer Scarr, Provincial Lead, Health Promotion, Prevention and Primary Care, Child Health BC, who assisted in obtaining the National Ambulatory Care Reporting System data and provided the maps. Child Health BC is a network of BC 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.

Authors: Rachel Ramsden, Marina Wada, Fahra Rajabali, Kate Turcotte, Shelina Babul

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For any questions regarding this report, contact:

BC Injury Research and Prevention Unit
F508-4480 Oak Street
Vancouver, BC V6H 3V4
Email: bcinjury1@cw.bc.ca
Phone: (604) 875-3776 Fax: (604) 875-3569
Web page: www.injuryresearch.bc.ca

Suggested Citation:

Ramsden R, Wada M, Rajabali F, Turcotte K, Babul S. Concussion in Children and Youth: Fraser Health Authority. Vancouver, BC: BC Injury Research and Prevention Unit; 2016.

KEY HIGHLIGHTS

The purpose of this report is to provide details on the burden of concussion hospitalizations among children and youth in Fraser Health Authority. This report is targeted to health care providers and community stakeholders in the health authority 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 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 cases, neuropsychiatry.

It is important to note that an individual is 3-times more likely to sustain a second concussion while recovering from the primary concussion. Furthermore, while a rare occurrence, a condition known as second-impact syndrome (SIS) may occur if a second injury to the brain is sustained within a day or two after the first 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 around 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, as this report does not capture concussions treated at physicians' offices, walk-in clinics, or those not recognized and treated at all.

Highlights include but are not limited to the following:

- From 2001/02-2013/14 there were 722 concussion hospitalizations among children and youth ages 0 to 19 years who reside within Fraser Health.

- Male children and youth in Fraser Health had twice the rates of concussion hospitalizations as females (19.3/100,000 vs. 9.4/100,000).
- The leading causes of child and youth concussion hospitalizations in Fraser Health were due to falls (43%) and transport-related events (39%).
- Among children and youth aged 0 to 19 years in Fraser Health, those under the age of five had the highest rates of fall-related concussion hospitalizations (10.2/100,000) and older youth aged 15 to 19 years had the highest rates for transport-related concussions (10.3/100,000).
- Older children in Fraser Health 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 (34.8%), hockey (11.4%) and playground (9.2%) activities were the greatest contributors for sport and recreation-related concussion hospitalizations in Fraser Health among both males and females of all ages 0 to 19 years.
- Child and youth residents within Fraser East had the highest rates of concussion hospitalizations (22.6/100,000), with 84.6 percent admitted to Fraser Health hospitals.
- Leading causes of child and youth fall-related concussion hospitalizations in Fraser Health were 'fall on the same level' (16.2%) and 'fall involving skates, skis and skateboards' (13.1%).
- The local health areas of Mission (36.7/100,000) and Hope (27.0/100,000) exhibited much higher rates of concussion hospitalizations than the other local health areas within Fraser Health.
- Rates of emergency department visits were highest among males and among children aged 0 to 4 years of age within Fraser Health.
- Surrey Memorial Hospital reported the highest number of concussion emergency department visits (711 visits) in 2013/14 within Fraser Health.

Concussions remain a significant health issue for children and youth in Fraser Health, and require further attention given the potential for 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.

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INTRODUCTION

Children and youth are at greater risk of concussion 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 definition of a concussion and the presence of misconceptions among the general public on the symptoms of concussion [1]. The rate of concussion hospitalization in the adult at-risk population has been measured at 1 to 3 per 1,000 in the United States, but it is estimated that the true concussion rate could be as high as 6 per 1,000 [2]. 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, 3]. 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 years [1, 4]. Comparable Canadian data are not available.

Concussion, also known as mild traumatic brain injury (mTBI), occurs 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, dizziness, emotional changes, and may or may not be accompanied by loss of consciousness or seizures [1, 5, 6].

Evidence exists that children and youth take longer than adults to recover following a concussion [1], and that concussion 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 protocol are 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 cases neuropsychiatry. It is important to note that an individual is 3-times more likely to sustain a second concussion while in recovery from a concussion [7]. Also, while rare, a condition known as second-impact syndrome (SIS) may occur if a second injury to the brain is sustained within a day or two of the first concussion event, where swelling of the brain that can result in brain damage causing severe disability or even death [8].

Purpose

The purpose of this report is to provide details on the burden of unintentional concussion hospitalizations and emergency department visits among children and youth living within or attending any of the hospitals in Fraser Health Authority. This report will be used to facilitate discussion of the need for standardized concussion prevention, diagnosis and management 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.

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 includes external causes of injury classified according to *International Classification of Disease (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 be attributed to some hospitals still converting to the new coding structure. Unintentional concussion hospitalizations were also extracted separately using ICD-10 CA code S06. The hospitalization data include all acute, rehab and day surgery cases. The data are based on hospital separations rather than on patient, 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 in two segments. The first is using all emergency department visits from hospitals within Fraser Health, and the second is emergency department visits to the BC Children's Hospital by residents of Fraser Health. Data were obtained from Decision Support Services, Provincial Health Services Authority (PHSA). The emergency department data are part of the National Ambulatory Care Reporting System (NACRS). Data were available for fiscal years 2013/14 to 2014/15 by age, sex and type of injury. Unintentional concussion emergency department visits were extracted separately using ICD-10 CA code S06. External codes for injury were not available and data by cause of injury are therefore not presented for emergency department visits. Data for emergency department visits to BC Children's Hospital by residents of Fraser Health were extracted using postal code information that represented the residence of the patient. Data

for BC Children's hospital was available from April 1, 2012 to May 21, 2015.

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 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 within Fraser Health. Rates presented by region are based on the patients' residence and not the location of injury occurrence.

Emergency department rates for Fraser Health residents were calculated per 100,000 population for the region and rates for each hospital were calculated per 100,000 emergency department visits for all diagnoses.

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). In addition, Z tests for proportions were conducted to test significance between age groups and region.

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.

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.

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

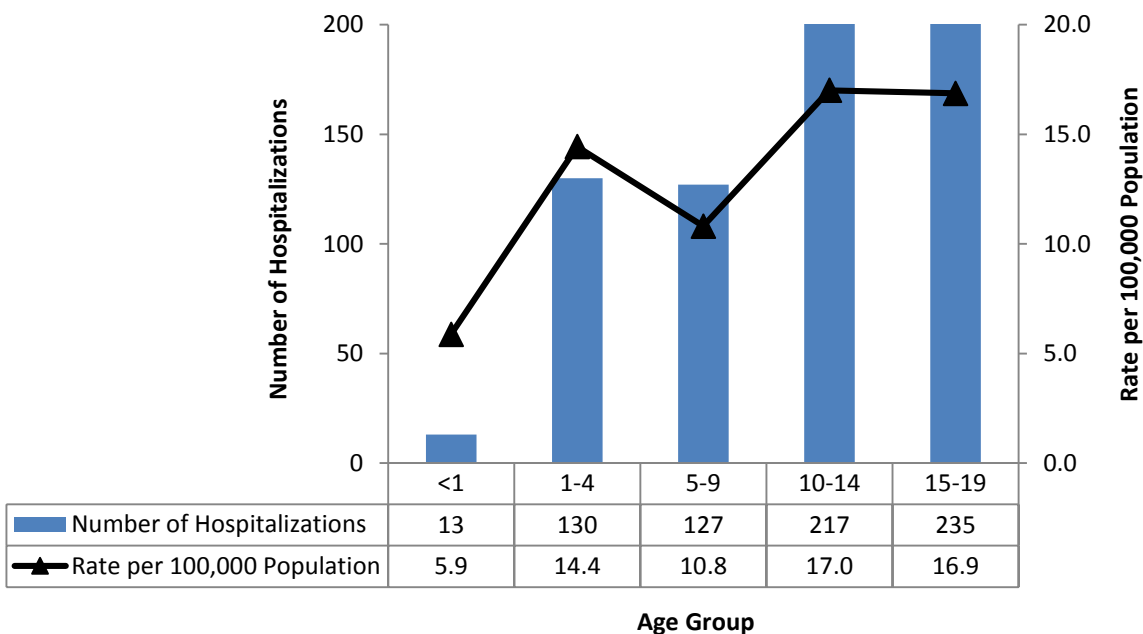
Hospitalization data can vary over time and between areas for factors not related to health, such as accessibility of treatment, and medical or administrative decisions that may affect the number of hospitalizations and lengths of hospital stay [9, 10].

CONCUSSION HOSPITALIZATION

There were 722 hospitalizations among children and youth aged 0 to 19 years resulting from concussion within Fraser Health over the 13-year period from 2001/02 to 2013/14. Concussion hospitalization rates were lowest among infants

less than one year of age (5.9/100,000), and highest among 10 to 14 year olds (17.0/100,000), followed by youth 15 to 19 years of age (16.9/100,000) (Figure 1).

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



Concussion hospitalization rates among children and youth were seen to vary from 2001/02 to 2013/14 (Figure 2). Rates peaked in 2004/05 at 18.5 per 100,000 and were lowest in 2008/09 at 10.2 per 100,000. Concussion hospitalization rates were consistently higher among males than females from 2001/02 to 2013/14.

Concussion hospitalization rates peaked for males aged 0 to 19 years in 2004/05 at 27.8 per 100,000, and were lowest in 2008/09 at 12.0

per 100,000 (Figure 2). Rates peaked for females in 2001/02 at 13.8 per 100,000 and were lowest in 2010/11 at 5.4 per 100,000.

Males accounted for 69.0 percent (n=498) of all concussion hospitalizations among children and youth. 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 than females for all concussion hospitalizations.

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

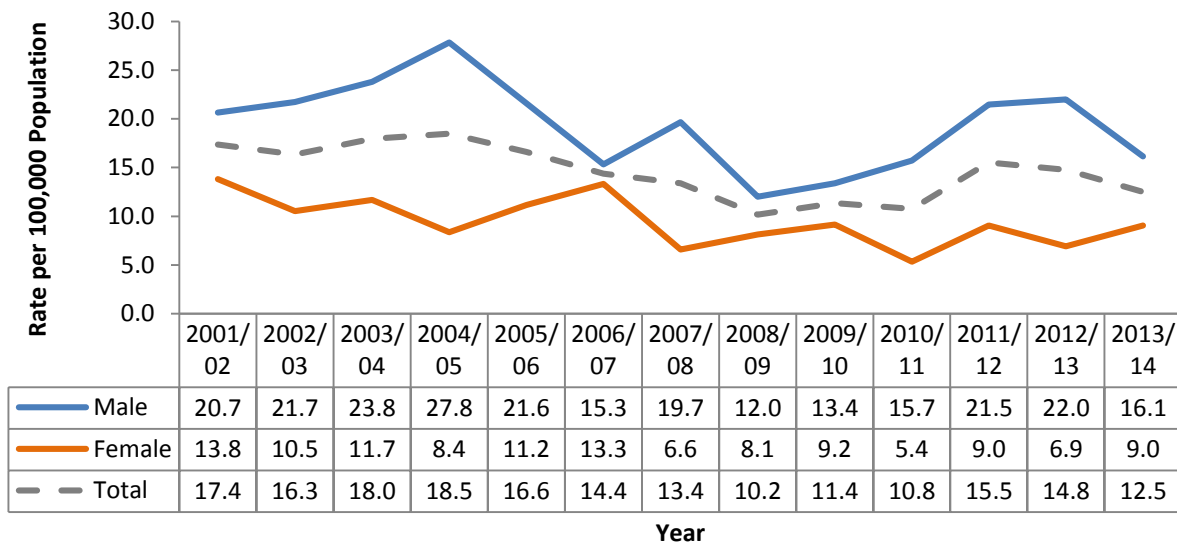
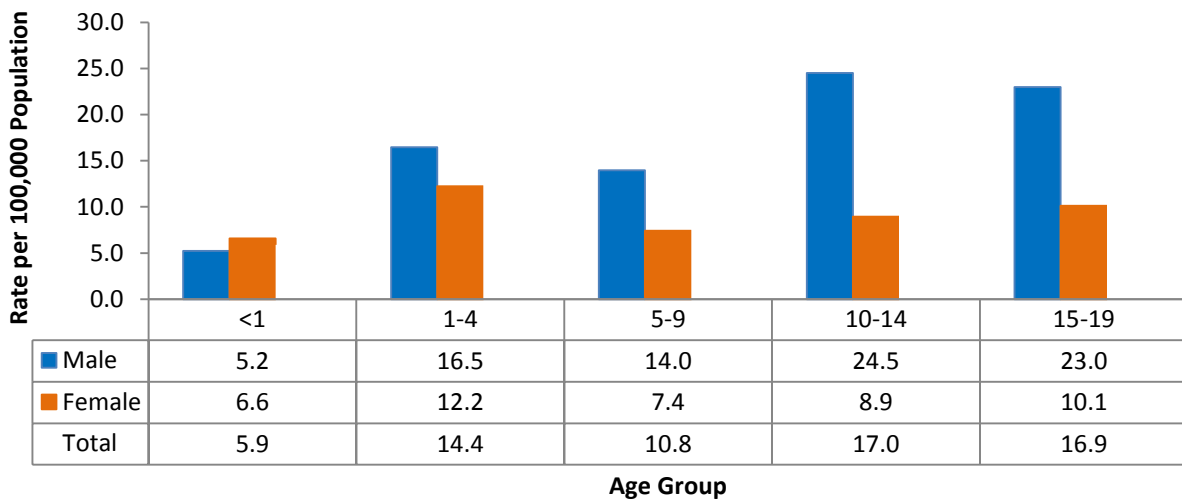


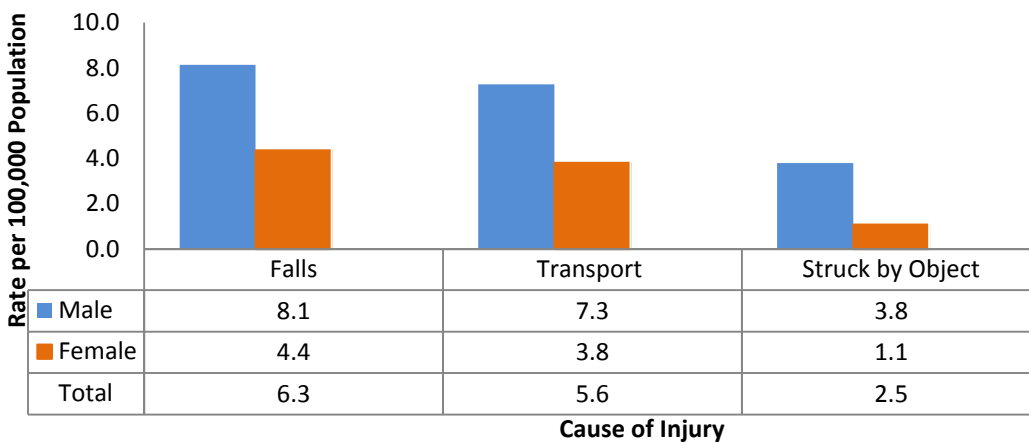
Figure 3: Concussion hospitalization rates by age group and sex, ages 0-19 years, Fraser Health, 2001/02 - 2013/14.



Leading causes of concussion hospitalization among children and youth included falls, transport-related events, and struck by/against an object (Figure 4). Fall-related concussion hospitalization was the leading cause for both males and females at 8.1 per 100,000 and 4.4 per 100,000, respectively. Of those concussions caused by struck by/against an object, 73.4 percent occurred during sport and recreation activities.

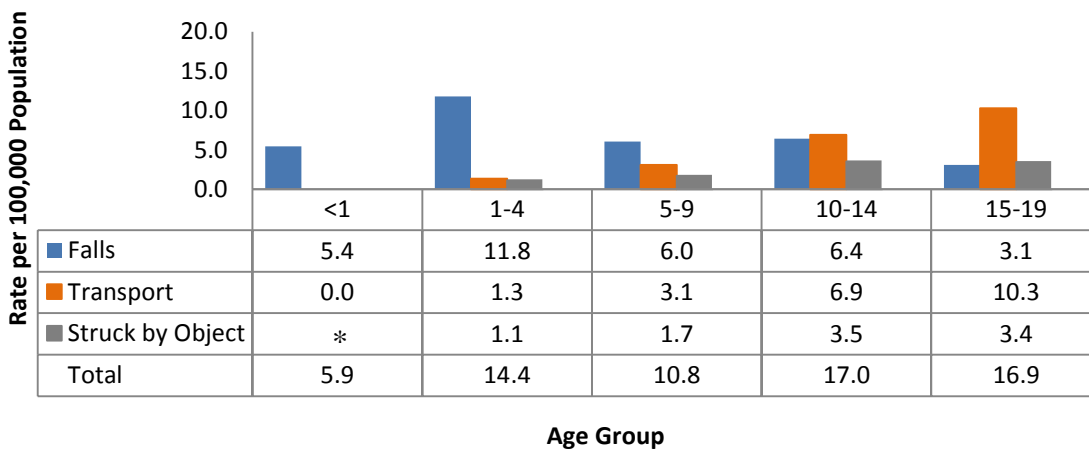
Leading causes varied by age group, with falls being the leading cause for 0 to 9 year olds, while transport-related events were the leading cause of concussion hospitalizations for 10 to 19 year olds (Figure 5). Concussion hospitalization rates for falls were highest among 1 to 4 year olds (11.8/100,000), while transport-related concussion rates were highest among 15 to 19 year olds (10.3/100,000). The rate for transport-related concussion among 15 to 19 year olds was significantly higher than the rates among children aged 10 to 14 years (p -value < 0.05).

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



Note: * Represents fewer than 5 cases; Total also includes other causes of concussion hospitalizations which are not shown as there are no or fewer than 5 cases.

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



Note: * Represents fewer than 5 cases; Total also includes other causes of concussion hospitalizations which are not shown as there are no or 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 (16.2%, n=51), falls involving skates, skis and skateboards (13.1%, n=41), and falls from furniture and from high levels, both at 9.6% (n=30) (Figure 6). Nearly one third of cases were classified as “other and unspecified” falls (30.9%, n=97). Concussion-related falls from furniture was most common

among infants less than one year of age (2.3/100,000). Among young children 1 to 4 years, falls from furniture and falls on the same level were the leading causes of fall-related concussion (2.2/100,000 and 1.6/100,000, respectively) (Figure 7). Falls involving skates, skis and skateboards resulting in a concussion were more common among older youth aged 10 to 14 years (1.5/100,000) and 15 to 19 years (1.3/100,000).

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

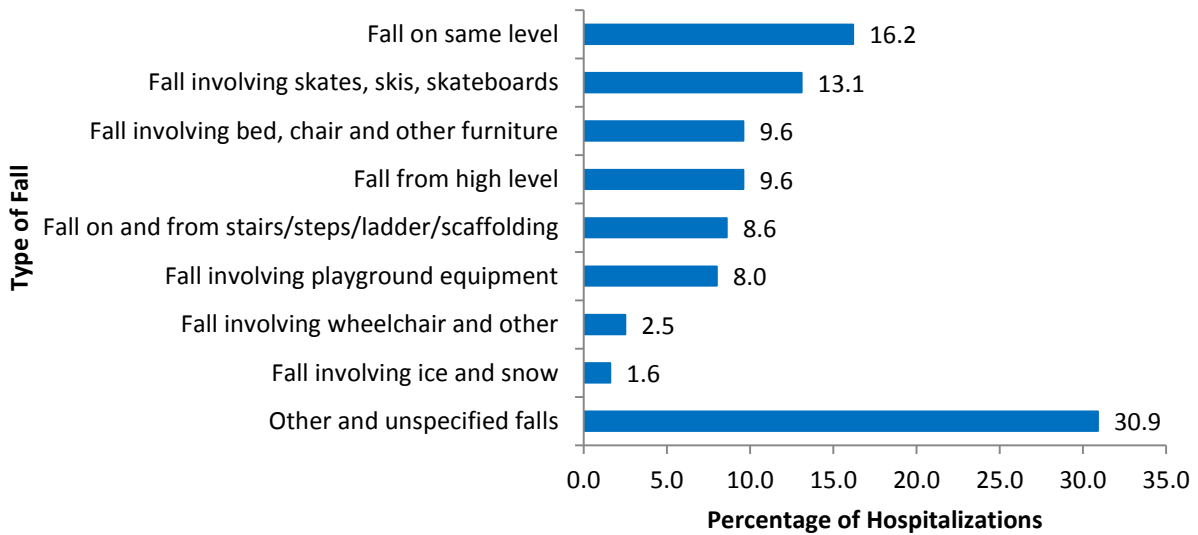
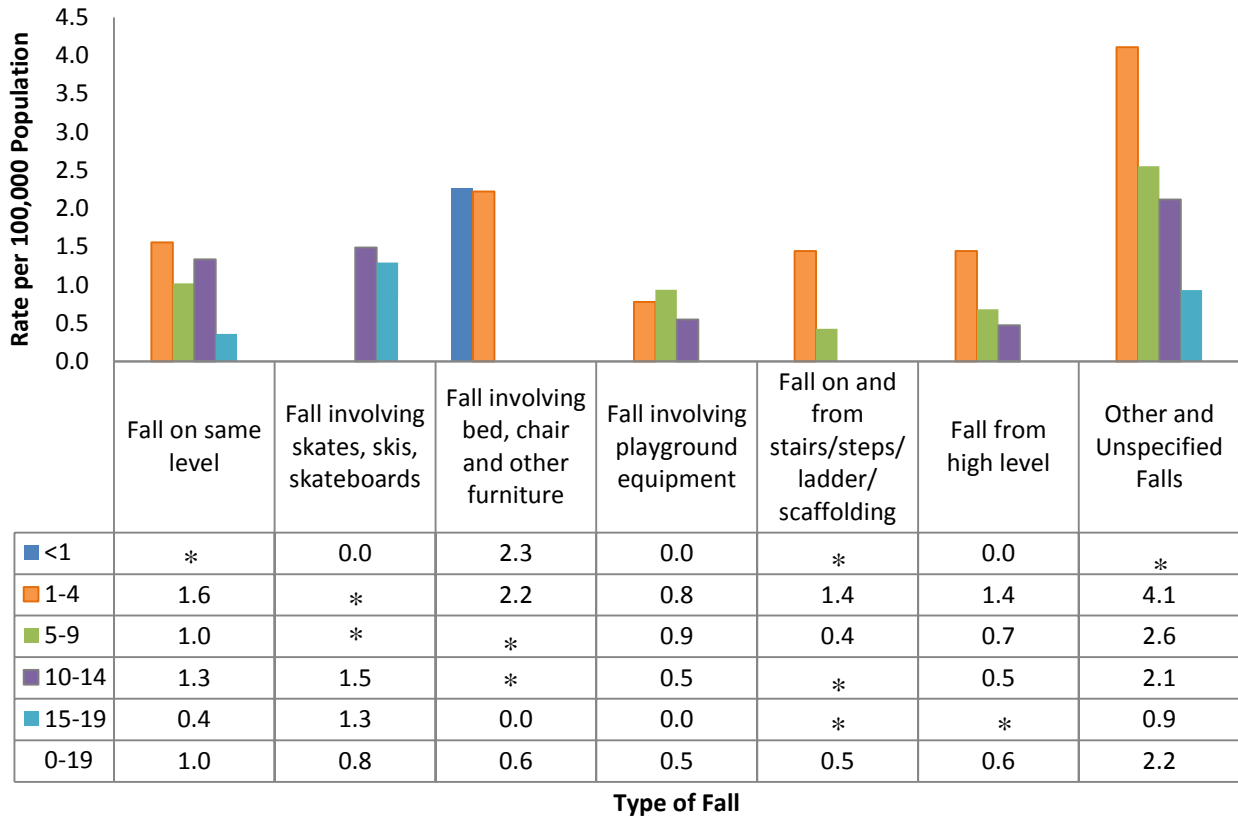


Figure 7: Fall-related concussion hospitalization rates by type of fall and age group, ages 0-19 years, Fraser Health, 2001/02 - 2013/14.



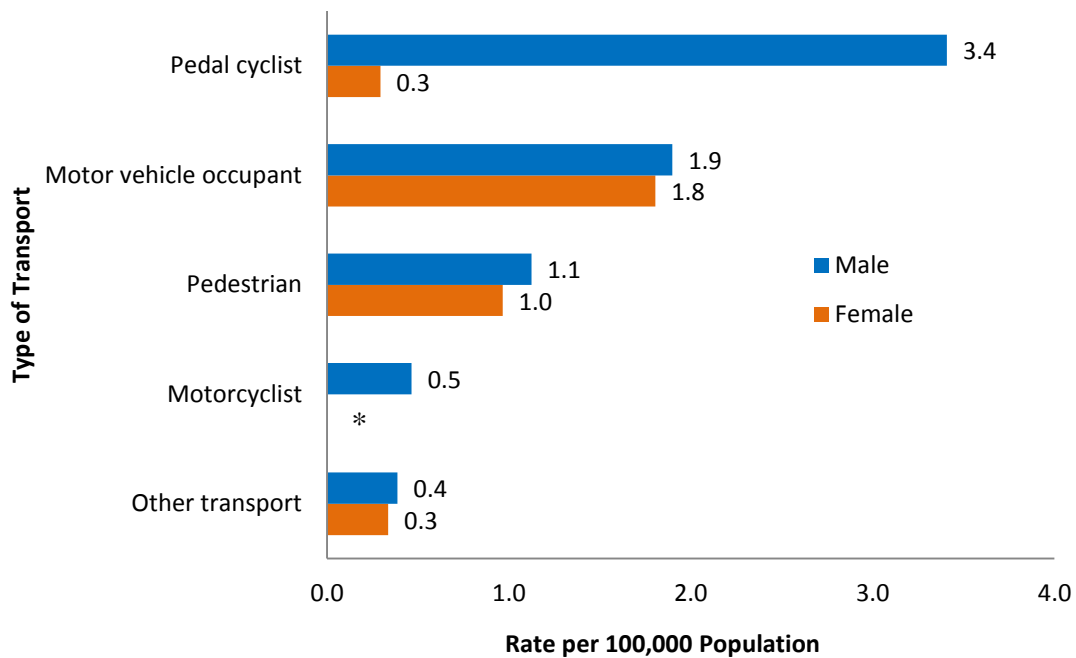
Note: * Represents fewer than 5 cases; 'Other and unspecified falls' includes fall involving ice and snow and fall involving wheelchair.

Transport-related Concussion Hospitalization

Concussion hospitalization rates from transport-related injuries among children and youth were generally higher among males than females (Figure 8).

Rates among males were highest for pedal cyclists (3.4/100,000) and motor vehicle occupants (1.9/100,000), while highest rates among females were for motor vehicle occupants (1.8/100,000) followed by pedestrians (1.0/100,000).

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

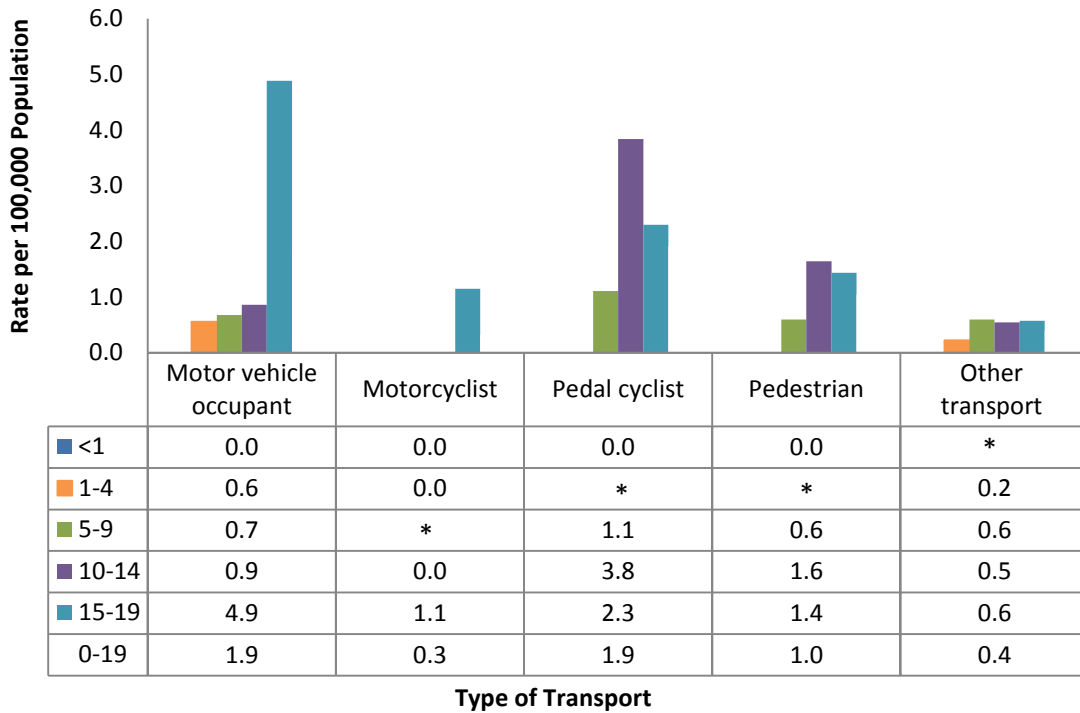


Note: * Represents fewer than 5 cases; 'Other transport' includes concussion hospitalizations due to off-road vehicle, other land transport, and water transport.

Rates of motor vehicle occupant-related concussion hospitalization were highest among youth 15 to 19 years (4.9/100,000) while pedal cyclist rates were highest among 10 to 14 year olds (3.8/100,000) (Figure 9).

Across all age groups, highest rates were observed for either pedal cyclist or motor vehicle occupant concussion hospitalizations compared to any other transport type.

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



Note: * Represents fewer than 5 cases; 'Other transport' includes concussion hospitalizations due to off-road vehicle, other land transport, and water transport.

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 aged 10 to 14 years (15.7/100,000) and 15 to 19 years (11.1/100,000) (Figure 10). Rates for females were highest for children aged 10 to 14 years at 2.9 per 100,000.

Cycling was the sport and recreation activity with the highest proportion of concussion hospitalizations among children and youth, at 34.8 percent (n=90) (Figure 11). Other leading types included hockey, playground, skis/snowboards and skateboards.

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

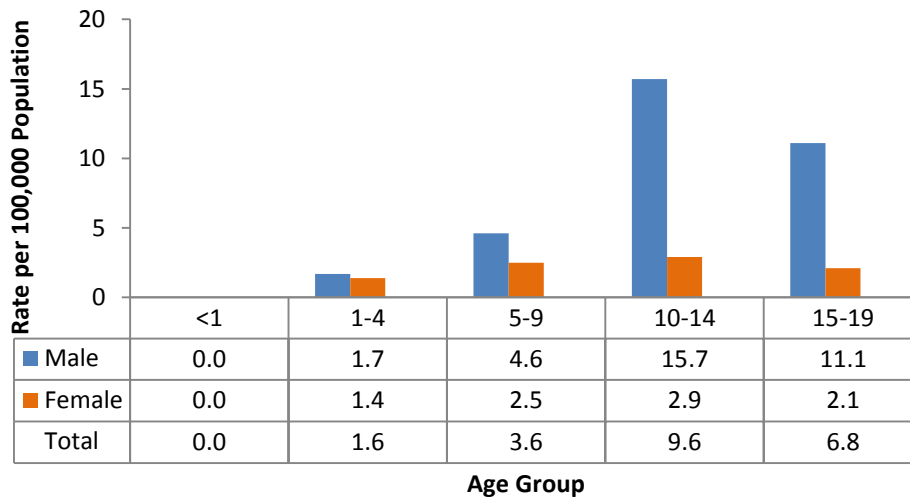
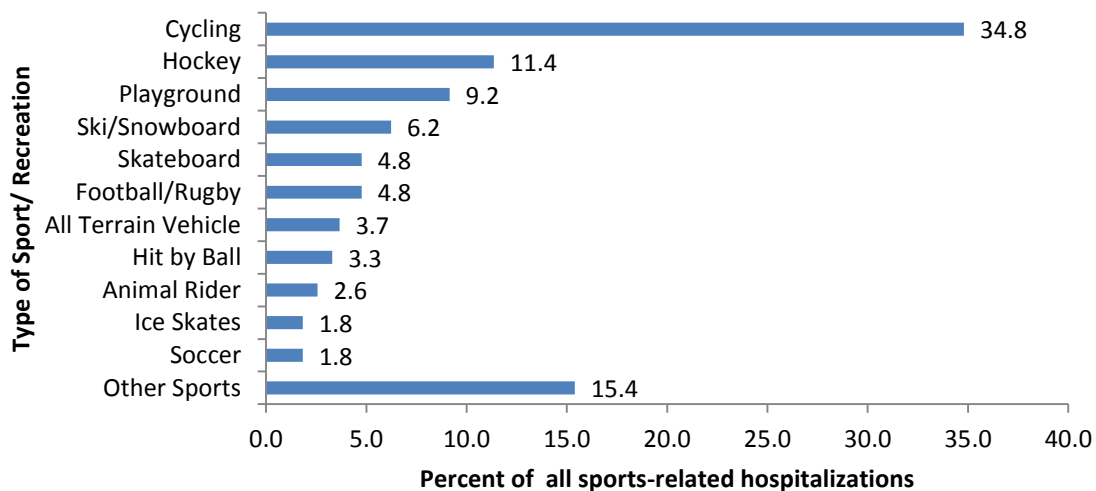


Figure 11: Sport and recreation-related concussion hospitalization rates by type of sport/recreation, ages 0-19 years, Fraser Health, 2001/02 - 2013/14.

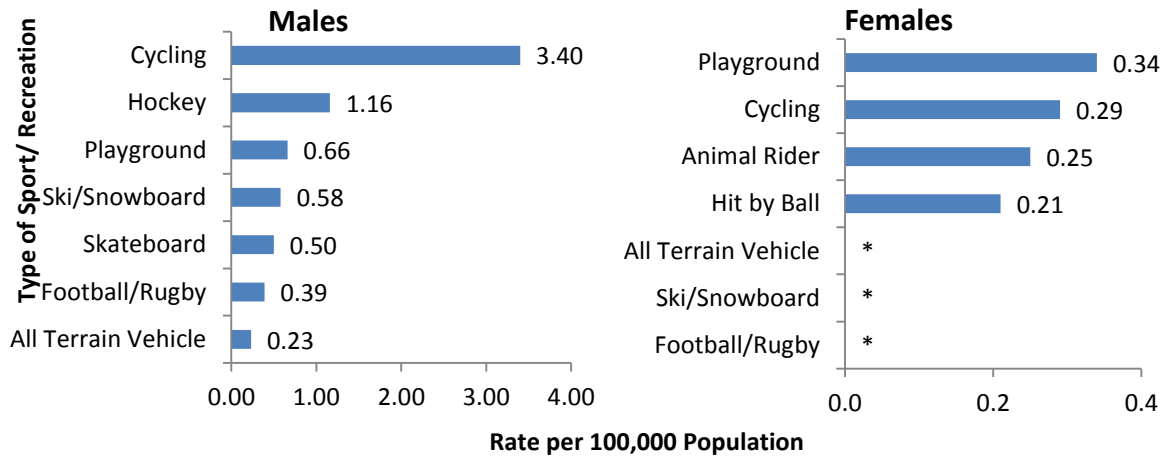


Note: Other sports include diving into water, hit by bat, drowning, tobogganing, baseball, roller blades, and scooter related activities.

The rate of cycling-related concussion hospitalizations for males was 3.40 per 100,000, followed by hockey (1.16/100,000) and playground (0.66/100,000) (Figure 12). For females, highest rates were seen for playground (0.34/100,000) and cycling (0.29/100,000).

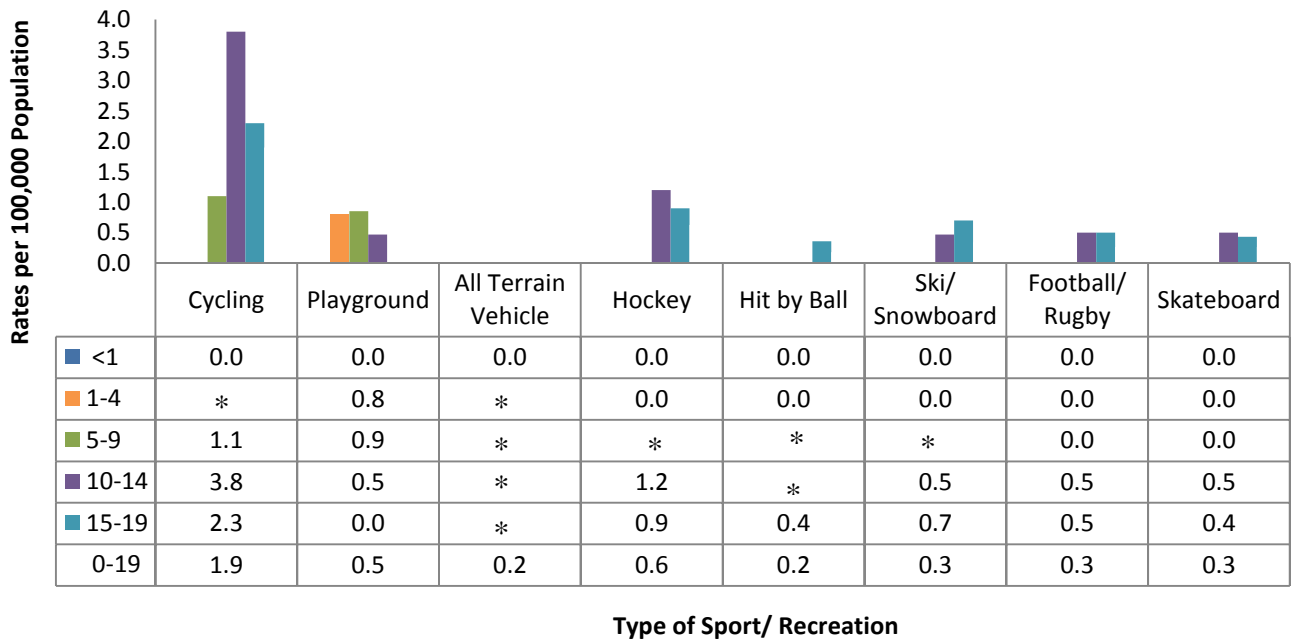
Rates of cycling-related concussion hospitalizations were highest among youth 10 to 14 years (3.8/100,000) and 15 to 19 years (2.3/100,000) (Figure 13). Playground concussion rates were higher among younger children, while generally sport concussion rates were highest among the older youth.

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



Note: * Represents fewer than 5 cases

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



Note: * Represents fewer than 5 cases

Concussion Hospitalization between Health Service Delivery Areas

Fraser Health consists of three Health Service Delivery Areas (HSDAs): Fraser East, Fraser North and Fraser South. The majority of Fraser Health child and youth residents who were hospitalized for concussion sought treatment within the Fraser Health Authority (Table 1). About 85 percent of Fraser East residents were admitted in hospitals within Fraser Health for concussion; a higher proportion than for residents of both Fraser North and Fraser South (71.9% and 76.7%, respectively). Provincial Health Services Authority (PHSA) was the next leading Health Authority providing hospital care for Fraser Health residents with concussion.

Concussion hospitalization rates were highest among residents of Fraser East (22.6/100,000) and lowest among residents of Fraser South (12.3/100,000) (Figure 14). The highest number of concussion hospitalization cases was within Fraser South (283 cases). Statistical testing yields significant differences between Fraser East and Fraser South, and between Fraser East and Fraser North (p -value <0.05).

Concussion hospitalization rates within Fraser East were highest among all age groups except for infants less than one year of age (Figure 15). The rates in Fraser East were also the highest when compared to the other HSDAs. Fraser South had the highest rate of concussion hospitalizations for infants less than one year of age (8.0/100,000).

Table 1: Concussion hospitalization counts by health service delivery area of patient's residence and health authority in which treatment sought, ages 0-19 years, Fraser Health, 2001/02-2013/14.

Health Authority in which treatment sought	Health Service Delivery Area of patient's residence		
	Fraser East #	Fraser North #	Fraser South #
Fraser Health	187 (84.6%)	164 (71.9%)	217 (76.7%)
Interior Health	*	9	11
Vancouver Coastal Health	*	11	8
Island Health	0	*	6
Northern Health	0	0	*
Provincial Health Service Authority ⁺	17 (7.7%)	37 (16.2%)	39 (13.8%)
Out-of-Province	*	*	*
Grand Total	221	228	283

Note: * Represents fewer than 5 cases; ⁺Provincial Health Services Authority refers to BC Children's Hospital.

Figure 14: Concussion hospitalization counts and rates by health service delivery area, ages 0-19 years, Fraser Health, 2001/02-2013/14.

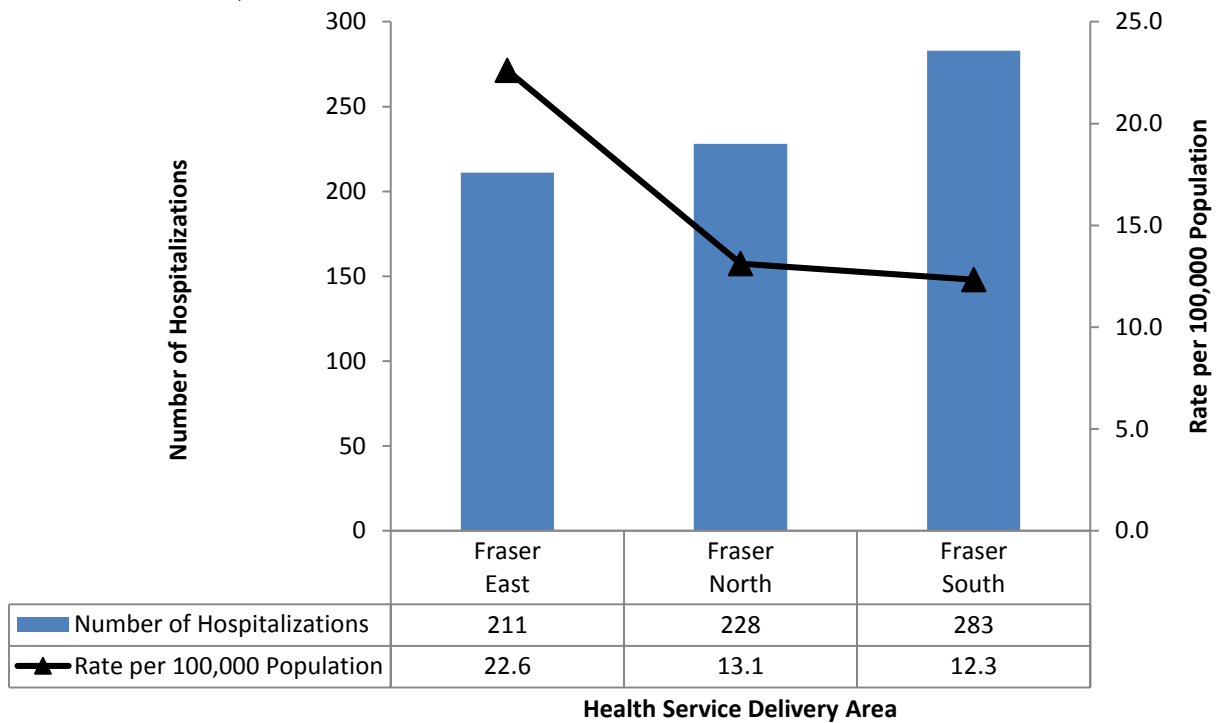
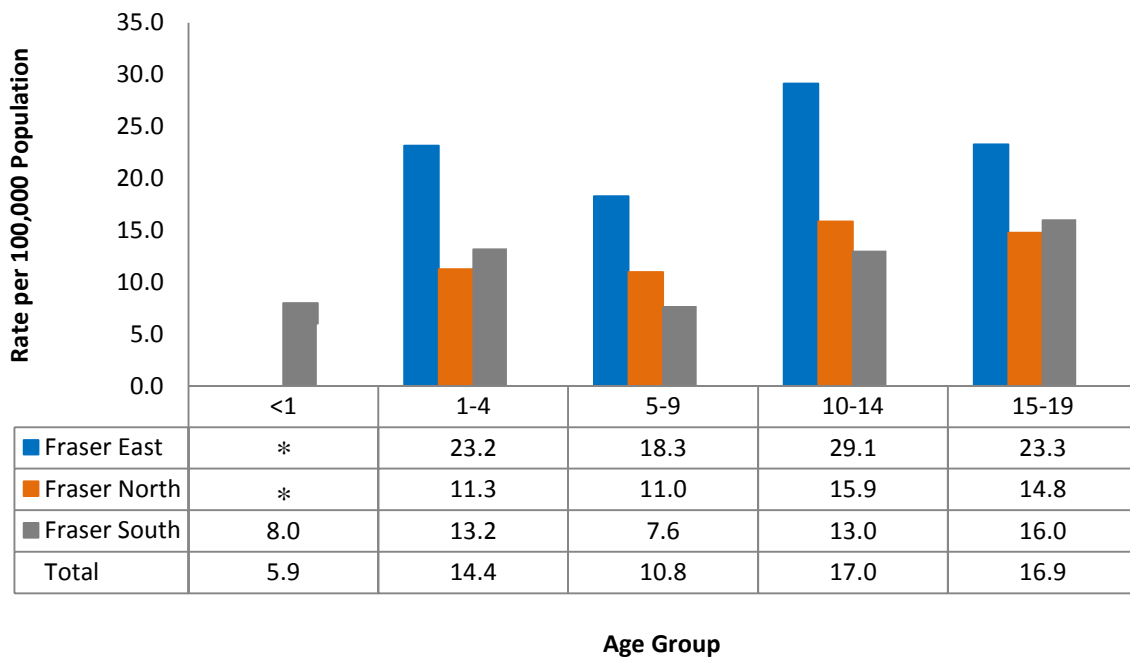


Figure 15: Concussion hospitalization rates by health service delivery area and age group, ages 0-19 years, Fraser Health, 2001/02-2013/14.

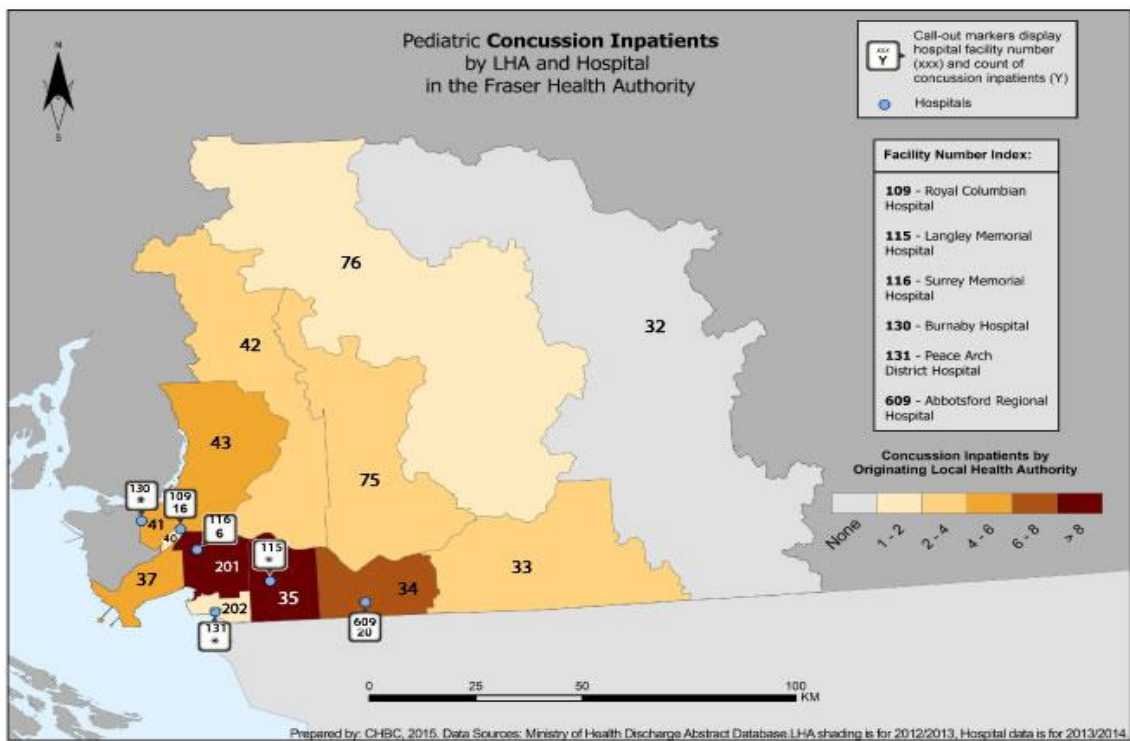


Note: * Represents fewer than 5 cases

The number of child and youth concussion inpatients was highest in the Fraser South residence, followed by the Fraser North residence in 2013/14 (Figure 16). The municipality of White Rock and all areas of Fraser East, excluding the municipality of Abbotsford, report the lowest number of concussion inpatients from their regions.

The number of concussion inpatients was highest at Abbotsford Regional Hospital (20 cases) and Royal Columbian Hospital (16 cases) in the 2013/14 year (Figure 16).

Figure 16: Pediatric concussion Inpatients by local health area and hospital in the Fraser Health Authority, 2013/14.



Note: * Represents fewer than 5 cases

Note: 32: Hope, 33: Chilliwack, 34: Abbotsford, 35: Langley, 37: Delta, 40: New Westminster, 41: Burnaby, 42: Maple Ridge, 43: Coquitlam, 75: Mission, 76: Agassiz-Harrison, 201: Surrey, 202: Surrey/White Rock

Concussion Hospitalization by Health Service Delivery Area: Fraser South

A total of 283 concussion hospitalizations were reported for Fraser South between 2001/02 and 2013/14. Among all age groups, 15 to 19 year olds had the highest rate of concussion, most of which comprised of transport-related cases.

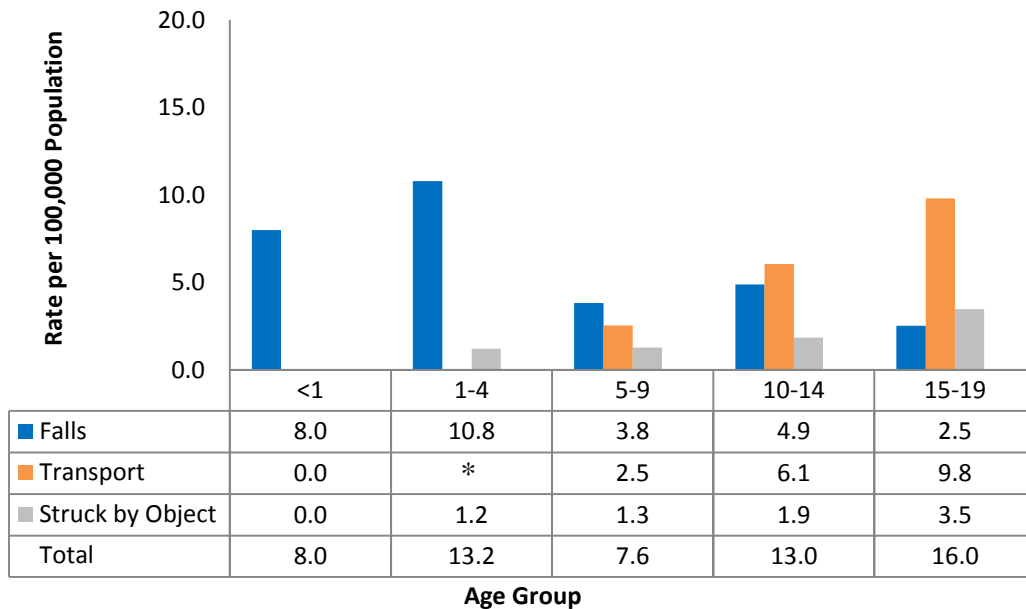
Rates of fall-related child and youth concussion hospitalization in Fraser South were highest among children and infants under the age of five years (Figure 17).

Fraser South is split into four Local Health Areas (LHAs): Surrey, Delta, Langley and South Surrey/White Rock. Rates of child and youth concussion hospitalization were highest in Langley (17.7/100,000) and lowest in Surrey (9.9/100,000) (Figure 18).

Concussion hospitalization rates were higher among males than females within all LHAs. The highest rate among males was found in Langley (22.0/100,000) and the lowest rates in Surrey (12.9/100,000). The highest rate among females was found in Langley (13.1/100,000) and the lowest rate in Surrey (6.5/100,000) (Figure 19).

Within South Surrey/White Rock, the highest rate of concussion hospitalization among children was among those aged 1 to 4 years (18.2/100,000), while Delta, Surrey and Langley had the highest rates for ages 10 to 19 years. Langley had the highest concussion hospitalization rates for 15 to 19 year olds (27.4/100,000) (Figure 20).

Figure 17: Concussion hospitalization rates by cause and age group, ages 0-19 years, Fraser Health: Fraser South, 2001/02-2013/14.



Note: * Represents fewer than 5 cases; Total also includes other causes of concussion hospitalizations which are not shown as there are no fewer than 5 cases.

Figure 18: Concussion hospitalization count and rate by local health area, ages 0-19 years, Fraser Health: Fraser South, 2001/02-2013/14.

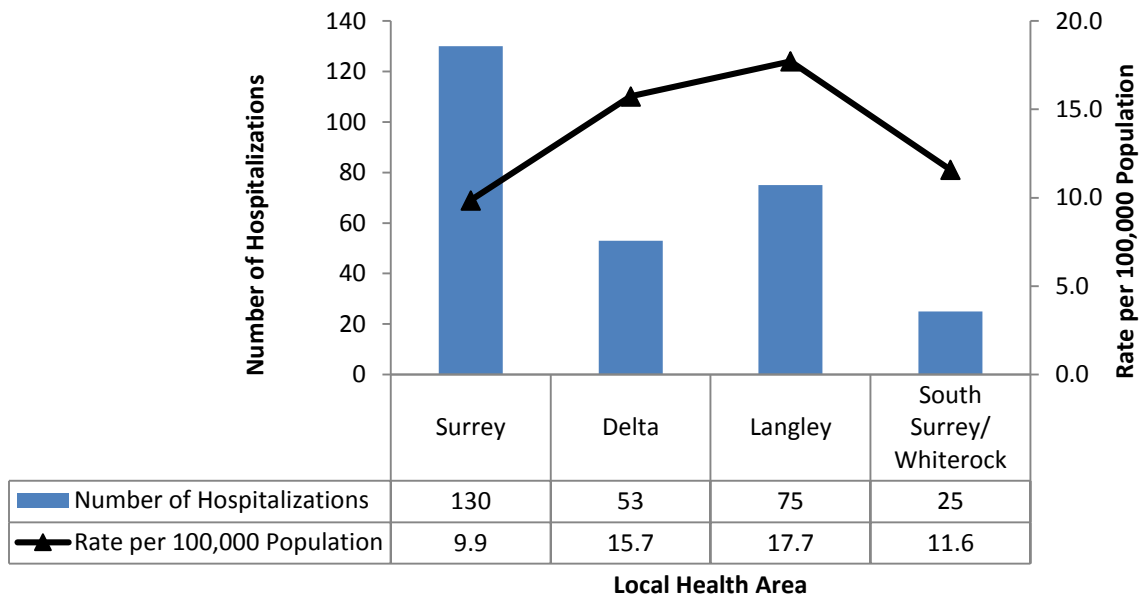


Figure 19: Concussion hospitalization rates by local health area and sex, ages 0-19 years, Fraser Health: Fraser South, 2001/02-2013/14.

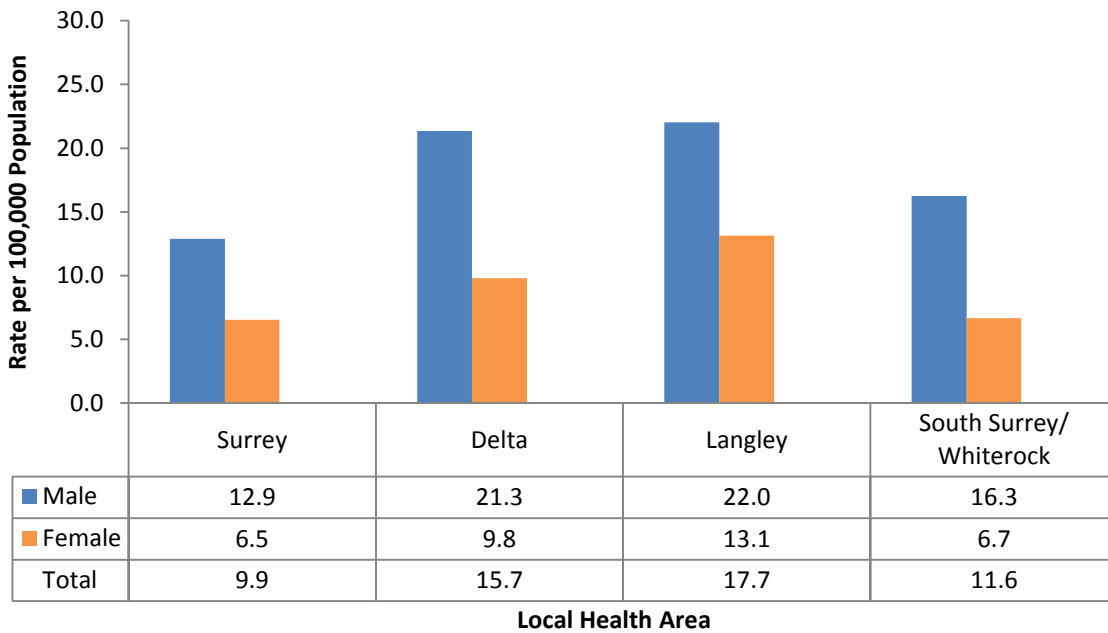
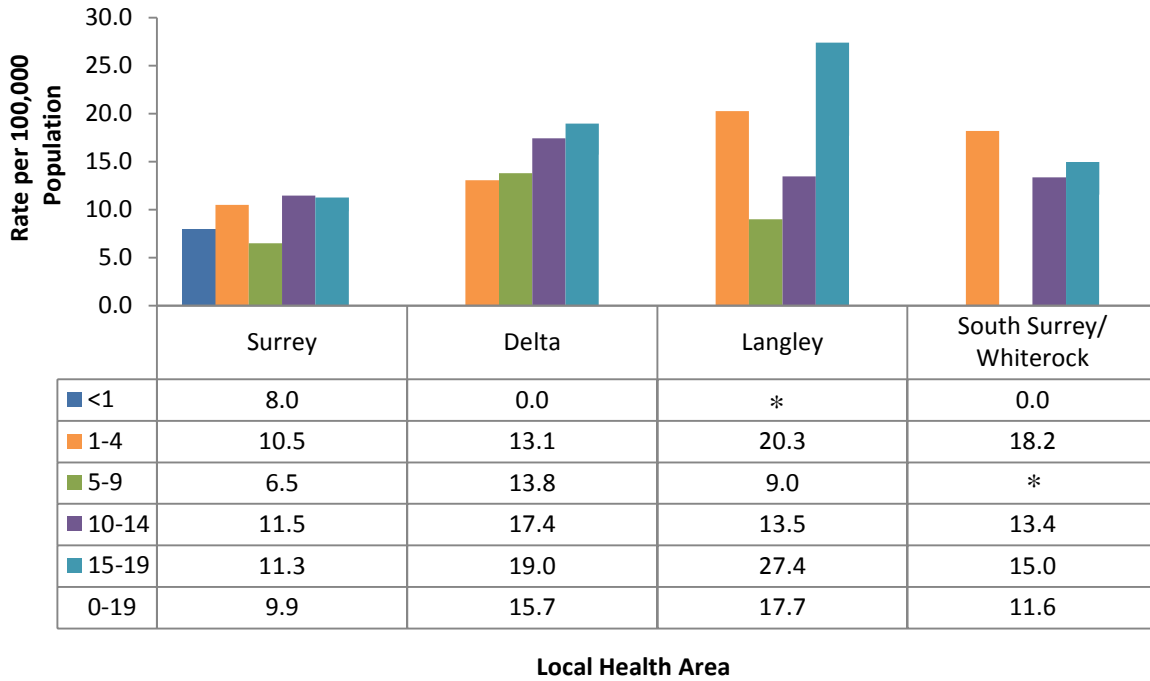


Figure 20: Concussion hospitalization rates by local health area and age group, ages 0-19 years, Fraser Health: Fraser South, 2001/02-2013/14.



Note: * Represents fewer than 5 cases

Concussion Hospitalization by Health Service Delivery Area: Fraser East

A total of 211 concussion hospitalizations were reported for Fraser East between 2001/02 and 2013/14. Among all age groups, 10 to 14 year olds had the highest rate of concussion, most of which comprised of fall-related cases.

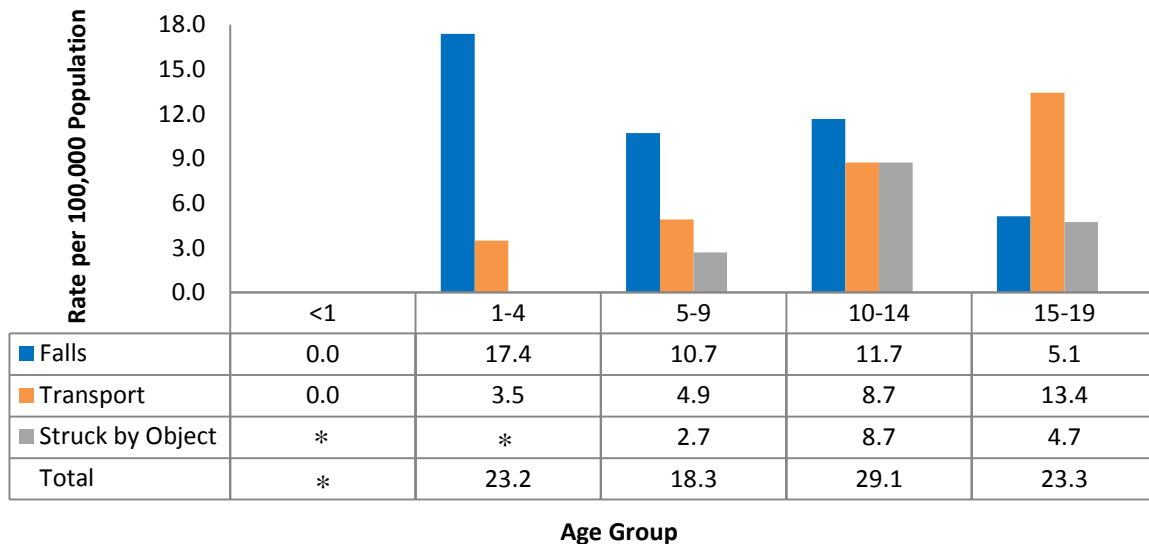
Rates of child and youth fall-related concussion hospitalizations in Fraser East were highest among children aged 1 to 4 years (17.4/100,000), while transport-related concussion hospitalization rates were highest among youth aged 15 to 19 years (13.4/100,000) (Figure 21).

Fraser East is split into five LHAs: Mission, Abbotsford, Chilliwack, Agassiz-Harrison and Hope. The concussion hospitalization rate was highest in Mission (36.7/100,000) and lowest in Agassiz-Harrison (15.1/100,000). The total numbers of hospitalization cases within Fraser East were lowest in Agassiz-Harrison and Hope (Figure 22).

Concussion hospitalization rates were higher among males than females within all LHAs of Fraser East. The highest rates among males and females were both in Mission (38.0/100,000 and 35.3/100,000, respectively) (Figure 23).

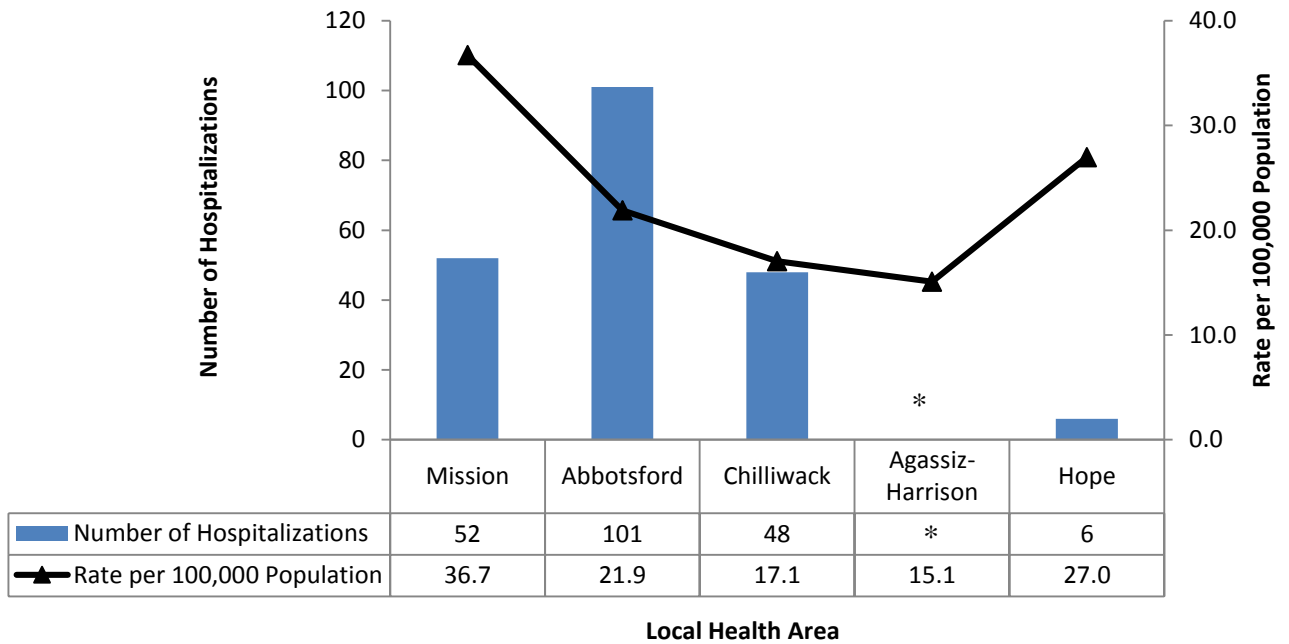
Concussion hospitalization rates were particularly high among 1 to 4 and 10 to 14 year olds in Mission (40.7/100,000 and 52.8/100,000, respectively). All LHAs within Fraser East reported low rates of concussion hospitalization among infants less than one year of age, where there were fewer than five cases reported to no cases (Figure 24).

Figure 21: Concussion hospitalization rates by cause and age group, ages 0-19 years, Fraser Health: Fraser East, 2001/02-2013/14.



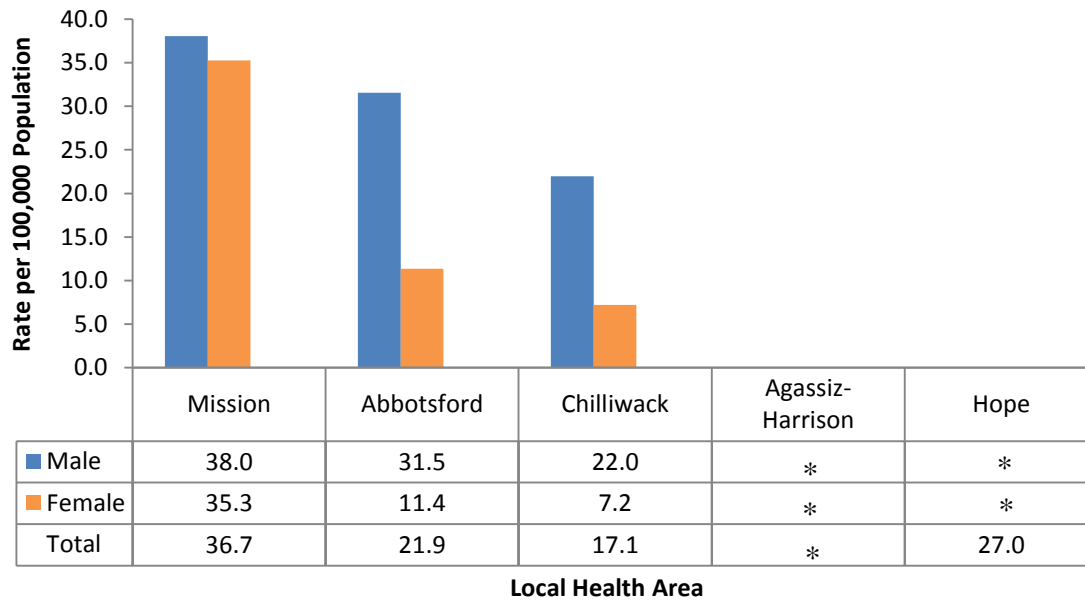
Note: * Represents fewer than 5 cases; Total also includes other causes of concussion hospitalizations which are not shown as there are no or fewer than 5 cases.

Figure 22: Concussion hospitalization counts and rates by local health area, ages 0-19 years, Fraser Health: Fraser East, 2001/02-2013/14.



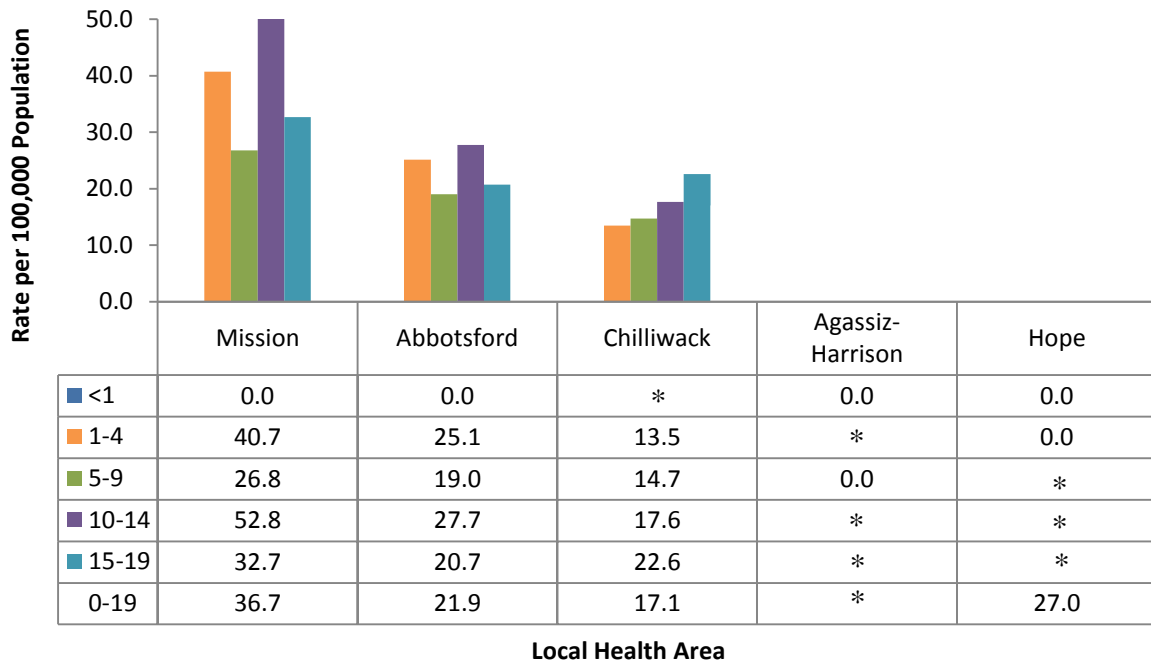
Note: * Represents fewer than 5 cases

Figure 23: Concussion hospitalization rates by local health area and sex, ages 0-19 years, Fraser Health: Fraser East, 2001/02-2013/14.



Note: * Represents fewer than 5 cases

Figure 24: Concussion hospitalization rates by local health area and age group, ages 0-19 years, Fraser Health: Fraser East, 2001/02-2013/14.



Note: * Represents fewer than 5 cases

Concussion Hospitalization by Health Service Delivery Area: Fraser North

A total of 228 concussion hospitalizations were reported for Fraser North between 2001/02 and 2013/14. Among all age groups, 10 to 14 year olds had the highest rate of concussion, most of which comprised of transport-related cases.

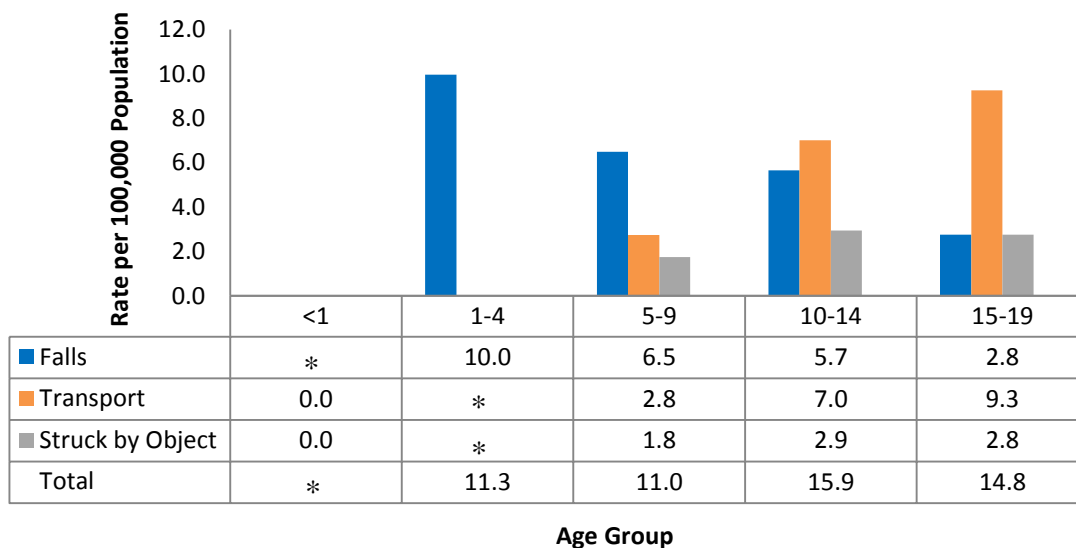
Child and youth fall-related concussion hospitalization rates in Fraser North were highest among children aged 1 to 4 years (10.0/100,000) (Figure 25).

Fraser North is split into four LHAs: Maple Ridge, Coquitlam, New Westminister and Burnaby. Concussion hospitalization rates were highest in Maple Ridge (21.7/100,000) and lowest in New Westminister (9.4/100,000) (Figure 26).

Concussion hospitalization rates were higher among males than females for all LHAs of Fraser North. The highest rates among males and females were found in Maple Ridge (32.1/100,000 and 10.6/100,000, respectively) (Figure 27).

Concussion hospitalization rates were lowest in Fraser North, across all LHAs, among infants less than one year of age, where there were fewer than five cases reported to no cases. Maple Ridge had the highest rates of concussion hospitalizations among children and youth of all age groups (Figure 28).

Figure 25: Concussion hospitalization rates by cause and age group, ages 0-19 years, Fraser Health: Fraser North, 2001/02-2013/14.



Note: * Represents fewer than 5 cases; Total also includes other causes of concussion hospitalizations which are not shown as there are no or fewer than 5 cases.

Figure 26: Concussion hospitalization counts and rates by local health area, ages 0-19 years, Fraser Health: Fraser North, 2001/02-2013/14.

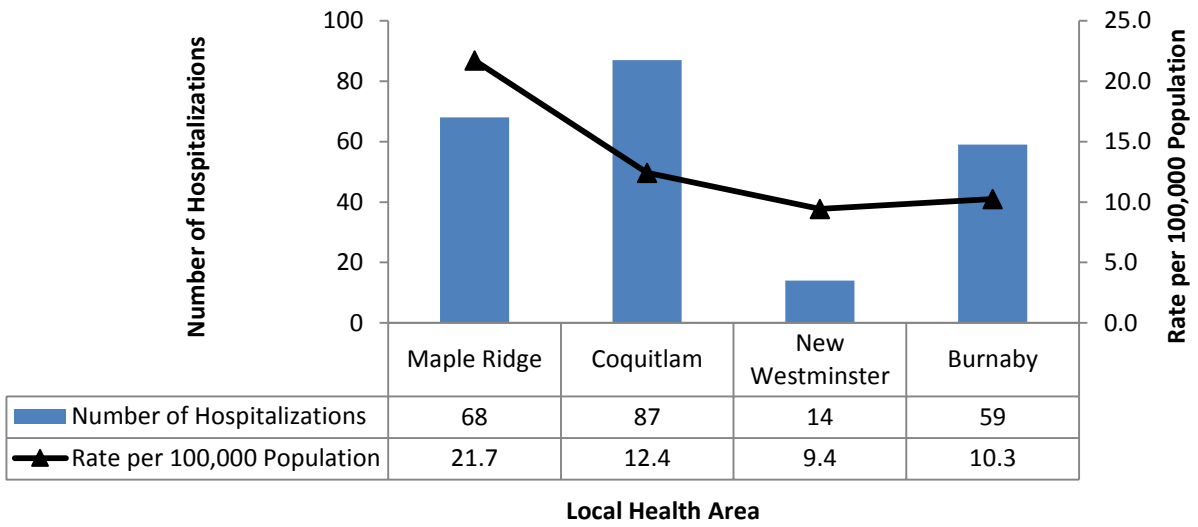
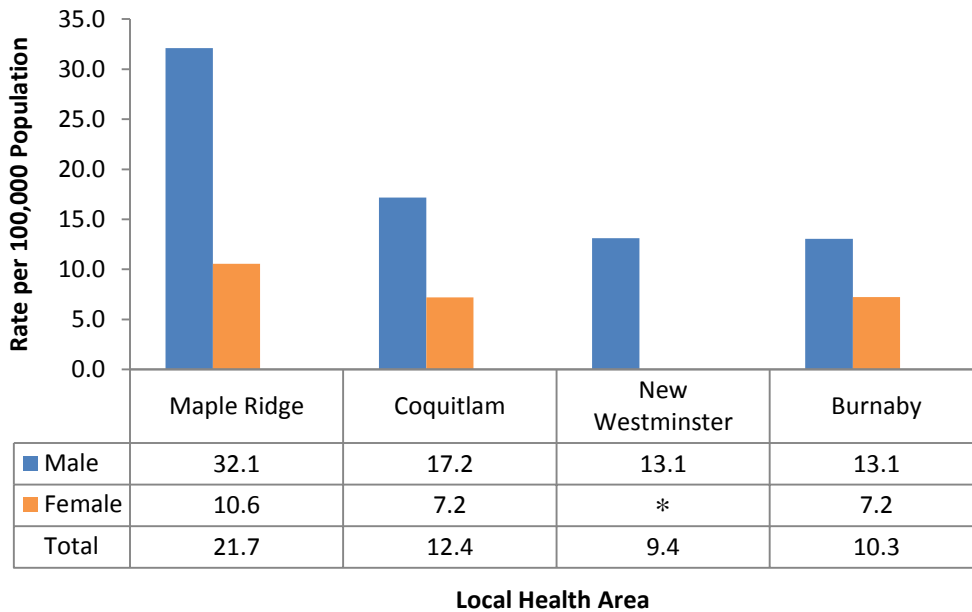


Figure 27: Concussion hospitalization rates by local health area and sex, ages 0-19 years, Fraser Health: Fraser North, 2001/02-2013/14.



Note: * Represents fewer than 5 cases

Figure 28: Concussion hospitalization rates by local health area and age group, ages 0-19 years, Fraser Health: Fraser North, 2001/02-2013/14.



Note: * Represents fewer than 5 cases

CONCUSSION EMERGENCY DEPARTMENT VISIT RATES

There were a total of 6,233 concussion emergency department visits by child and youth residents of Fraser Health between the years 2013/14 and 2014/15. Emergency department rates for Fraser Health residents were calculated per 100,000 population for the region.

Rates of emergency department visits for concussion were highest in Fraser East (834.2/100,000). Fraser East exhibited the highest rates among both males (979.9/100,000) and females (676.2/100,000) in Fraser

Health. Lowest rates of concussion emergency department visits were seen in Fraser North (767.1/100,000) (Figure 29). Concussion-related visits to the emergency department within Fraser Health were highest among children under the age of five years. Rates within Fraser East, Fraser North and Fraser South were highest among infants less than one year (1,503.8/100,000, 1,596.5/100,000 and 1,618.6/100,000, respectively) (Figure 30).

Figure 29: Concussion emergency department visit rates by health service delivery area and sex, ages 0-19 years, residents of Fraser Health, NACRS, 2013/14-2014/15

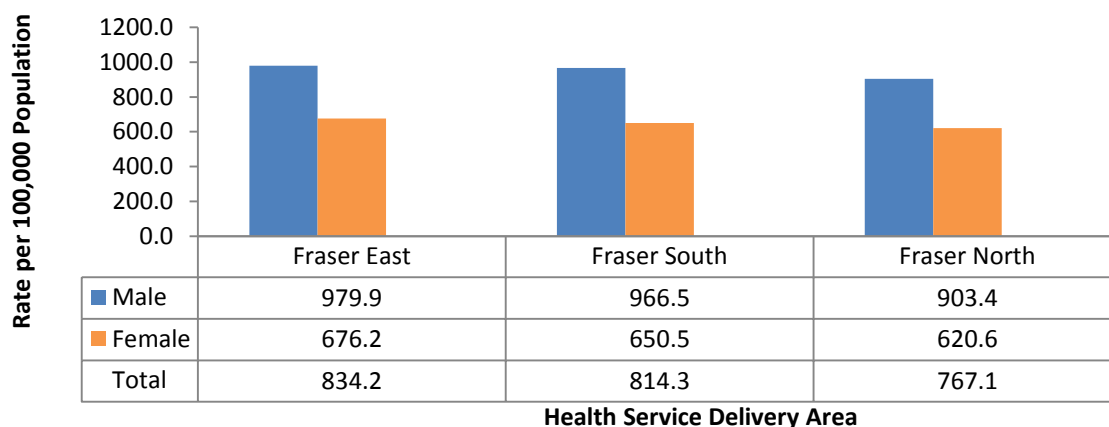
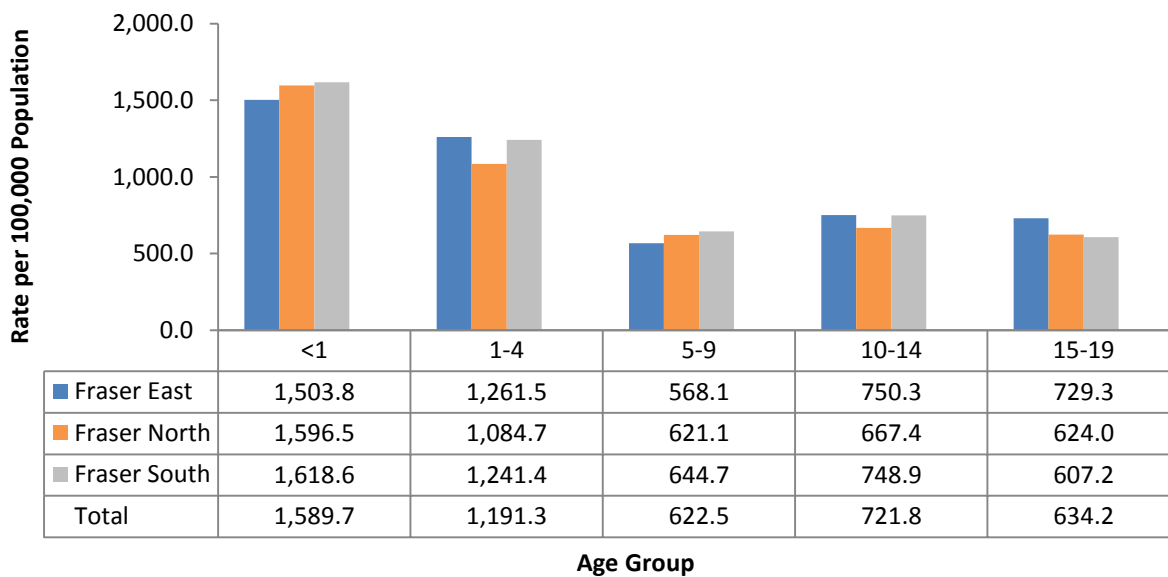


Figure 30: Concussion emergency department visit rates by health service delivery area residence and age group, ages 0-19 years, residents of Fraser Health, NACRS, 2013/14-2014/15



Fraser Health Authority has 12 principal hospitals with recorded concussion emergency department visits: Abbotsford Regional, Burnaby, Chilliwack General, Delta, Eagle Ridge, Fraser Canyon, Langley Memorial, Mission Memorial, Peace Arch, Ridge Meadows, Royal Columbian and Surrey Memorial. Rates for each hospital were calculated per 100,000 emergency department visits for all diagnoses.

There were a total of 5,634 child and youth concussion emergency department visits to these hospitals between the years 2013/14 and 2014/15 (Table 2). During this period, Langley Memorial reported the highest rate of concussion emergency department visits per 100,000 emergency department visits, among all hospitals in the Fraser Health Authority at 3,905.8 per 100,000 visits (Figure 31). Lowest rates of emergency department visits due to concussion within the Fraser Health region were seen at Mission Memorial (1,169.8/100,000). Langley Memorial also reported the highest rates of concussion emergency department

visits for both males and females (4,423.6/100,000 and 3,315.9/100,000, respectively). Males exhibited higher rates than females among all Fraser Health hospitals. Lowest rates for both males and females were reported at Mission Memorial (1,376.9/100,000 and 935.4/100,000, respectively) (Figure 31).

When looking at emergency department visits from concussions by month between April 1, 2013 and March 31, 2015, the number of cases presented were highest during the months of February (570 visits), March (564 visits) and November (530 visits). Rates of concussion emergency department visits per 100,000 emergency department visits peaked during October and November (3,039.4/100,000 and 3,051.4/100,000, respectively). The number of concussion emergency department visits were lowest during July (357 visits) and August (368 visits). Lowest rates were reported during December and January (2,194.6/100,000 and 2,329.2/100,000, respectively) (Figure 32).

Figure 31: Concussion emergency department visit rates by hospital and sex, ages 0-19 years, Fraser Health, NACRS, 2013/14-2014/15

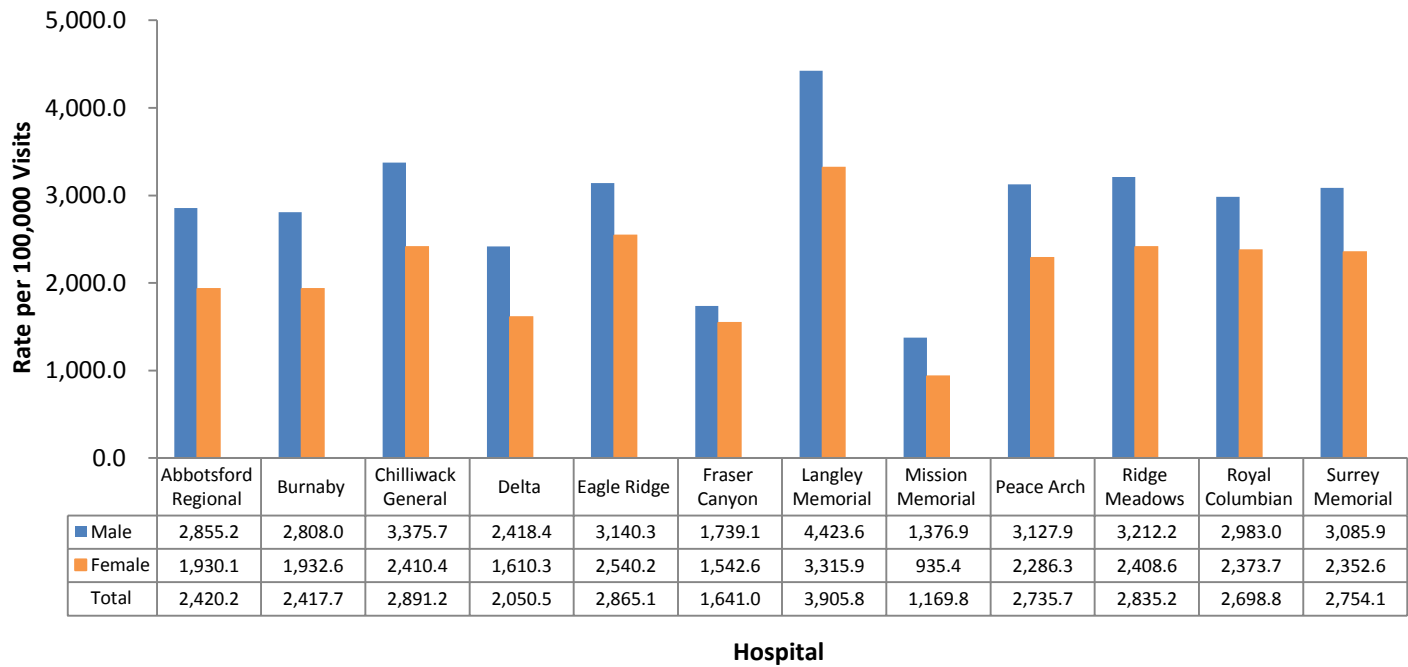
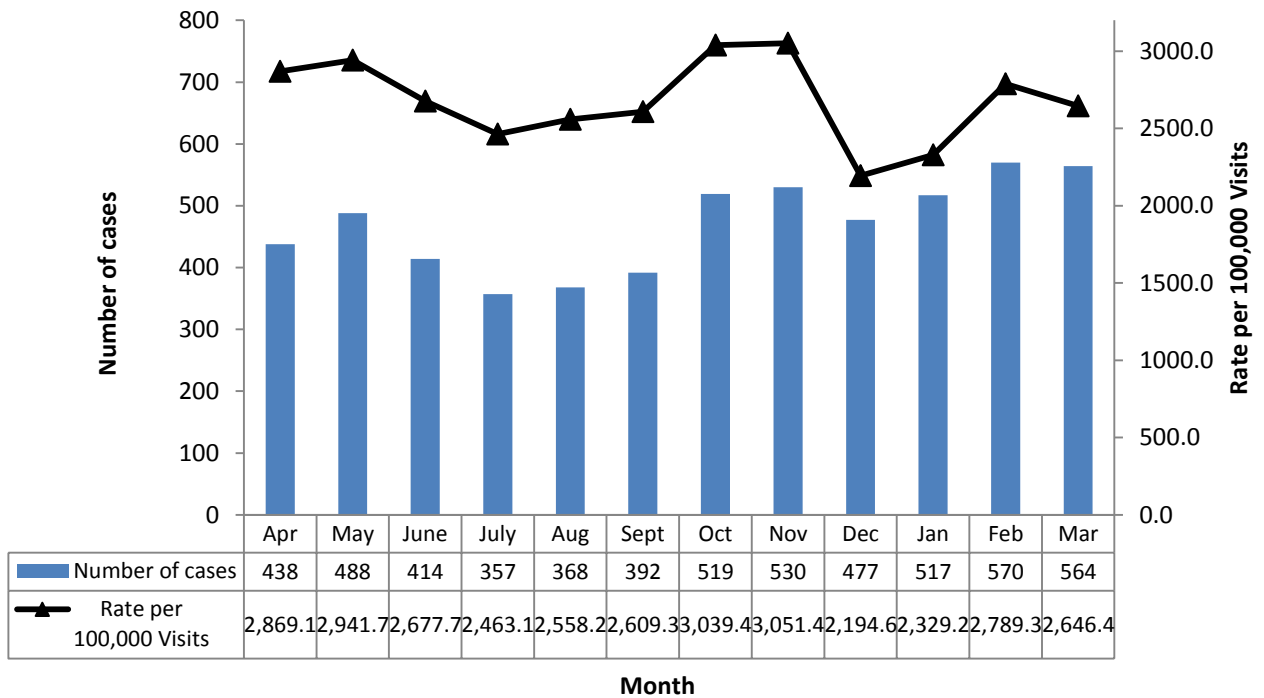


Figure 32: Concussion emergency department visit rates and number of cases by month, ages 0-19 years, all Fraser Health Hospitals, NACRS, 2013/14-2014/15



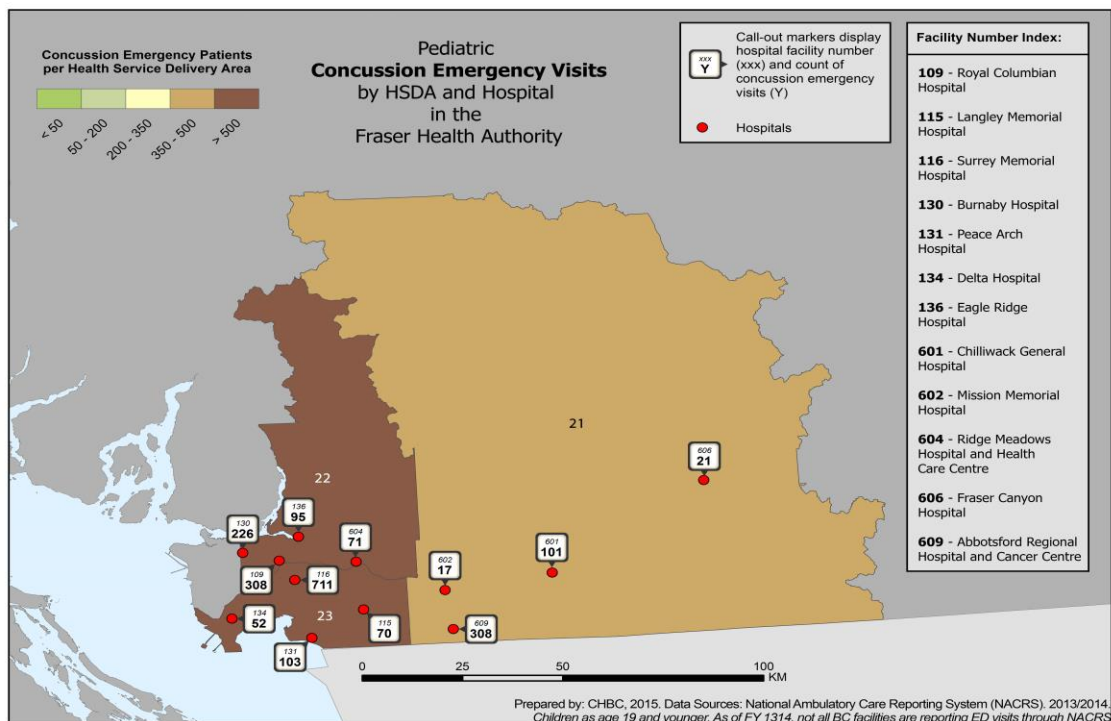
The total numbers of child and youth emergency department visits for concussion at Fraser Health treating hospital facilities were highest for Surrey Memorial from 2013/14 to 2014/15 (1,687 cases) (Table 2). The highest proportions of emergency department visits attributed to child and youth concussion were seen at Langley Memorial and Chilliwack General (3.91% and 2.89%, respectively). Low numbers of visits were seen at Mission Memorial (56 visits) and Fraser Canyon (49 visits). These two hospitals also reported the lowest proportion of concussion emergency department visits as a proportion of overall emergency department visits. Across all treating hospitals, Fraser Health saw an average 2.67 percent of all child and youth emergency departments visits attributed to concussion-related injury (Table 2).

During the 2013/14 year alone, emergency department visits occurring at hospital locations within Fraser Health were highest at Surrey Memorial, which saw 711 concussion emergency department visits. Emergency department visits were also high at Abbotsford Regional and Royal Columbian, each recording 308 concussion visits. The lowest numbers of child and youth emergency department visits recorded in 2013/14 were seen at Mission Memorial (17 visits) and Fraser Canyon (21 visits) (Figure 33).

Table 2: Concussion emergency department visit proportions by hospital, ages 0-19 years, Fraser Health, NACRS, 2013/14-2014/15

	Number of ER concussion visits	Total ER visits	% of concussion ER visits
Langley Memorial Hospital	383	9,806	3.91
Chilliwack General Hospital	466	16,118	2.89
Eagle Ridge Hospital	389	13,577	2.87
Ridge Meadows Hospital and Health Care Centre	291	10,264	2.84
Surrey Memorial Hospital	1,687	61,255	2.75
Peace Arch Hospital	334	12,209	2.74
Royal Columbian Hospital	629	23,307	2.70
Abbotsford Regional Hospital and Cancer Centre	680	28,097	2.42
Burnaby Hospital	505	20,888	2.42
Delta Hospital	165	8,047	2.05
Fraser Canyon Hospital	49	2,986	1.64
Mission Memorial Hospital	56	4,787	1.17
Grand Total	5,634	211,341	2.67

Figure 33: Pediatric concussion emergency department visits by local health area and hospital in the Fraser Health Authority, NACRS, 2013/14



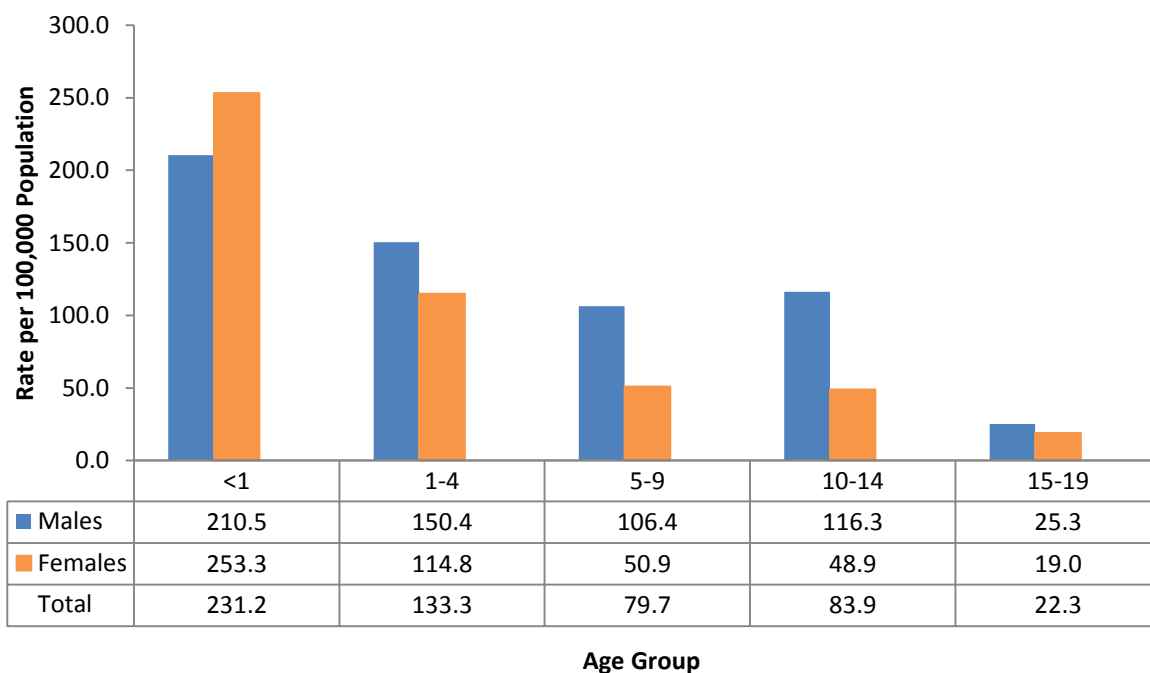
Note: 21: Fraser East, 22: Fraser North, 23: Fraser South

EMERGENCY DEPARTMENT VISITS AT BC CHILDREN'S HOSPITAL

Among child and youth residents of Fraser Health, rates of emergency department visits to BC Children's Hospital were highest among males and females less than one year of age for concussion (Figure 34). Rates were lowest among males and females 15 to 19 years of age

(25.3/100,000 and 19.0/100,000, respectively). Overall concussion emergency department visit rates at BC Children's Hospital among children residing in Fraser Health were highest in infants less than one year of age (231.2/100,000) and in children 1 to 4 years old (133.3/100,000).

Figure 34: Concussion emergency department visit rates at BC Children's Hospital by age group and sex, ages 0-19 years, residents of Fraser Health, NACRS, April 1, 2012 - May 21, 2015



CONCLUSION

The Fraser Health region exhibited low overall rates of child and youth concussion hospitalization. The highest rates of concussion hospitalizations were seen among the 15 to 19 year old age group, largely due to transport-related causes. The majority of these hospitalizations were due to the involvement of pedal cyclists and motor vehicle occupants. Among children under the age of five years, falls remained the leading cause of concussion hospitalization. The leading cause of falls within this age group was falls from furniture.

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

Transport-related concussion hospitalizations maintained similar patterns and trends across all HSDAs within Fraser Health, with rates increasing as age increases. Out of all HSDAs, Fraser East displayed the highest rates of transport-related concussion hospitalization across most age groups.

Fall-related concussion hospitalization rates varied with age within each HSDA. Children aged 1 to 4 years displayed the highest rates of fall-related concussion hospitalization within all three HSDAs. Out of all HSDAs, Fraser East had the highest rate of fall-related concussion hospitalization for the 1 to 4 year old age category.

Few to no cases of fall-related concussion hospitalization among infants less than one year of age were experienced by two of the three HSDAs compared to other HSDAs. Fraser South

had higher hospitalization rates of fall-related concussion among infants.

There was a large discrepancy in rates among LHAs. Mission, Maple Ridge and Hope exhibited much higher rates of concussion hospitalizations than most regions in Fraser Health, while Surrey, South Surrey/White Rock and New Westminster reported low rates of child and youth concussion hospitalizations.

Emergency department visits related to concussion rates were higher among males than females residing within Fraser Health. Rates were also higher among children less than five years of age. Overall, rates of concussion emergency department visits among 0 to 19 year olds were highest among residents in Fraser East and Fraser South.

Between April 1, 2013 and March 31, 2015, Langley Memorial Hospital had the highest rate of child and youth concussion emergency department visits per 100,000 visits among all hospitals within the Fraser Health Authority, while Mission Memorial Hospital had the lowest rate.

The months of October and November reported the highest rates of concussion emergency department visits per 100,000 visits, while the months of February and March recorded the highest numbers of concussion emergency department visits.

This report provides a comprehensive glance at the burden of concussion among children and youth within Fraser Health, both at a regional and hospital level. With this information, Fraser Health can work towards reducing the occurrence and burden of concussions among children and youth in BC.

REFERENCES

1. Guskiewicz KM & Valovich McLeod TC. (2011). Pediatric Sports-related Concussion. *PM&R* 2011;3(4):353-364.
2. Cassidy JD, Carroll L, Peloso P, Borg J, Von Holst H, Holm L., Kraus J, Coronado VG. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *J Rehabil Med* 2004; Suppl. 43: 28–60.
3. Kelly KD, Lissel HL, Rowe BH, Vincenten JA, Voaklander DC. Sport and Recreation-Related Head Injuries Treated in the Emergency Department. *Clin J Sport Med* 2001;11(2): 77-81.
4. Bakhos LL, Lockhart GR, Myers R, Linakis JG. Emergency Department Visits for Concussion in Young Child Athletes. *Pediatrics* 2010; 126(3): 550-556.
5. McCrory P, Meeuwisse W, Aubry M, Cantu R, Dvorak Jj, Echemendia R, Engebretsen L et al. Consensus Statement on Concussion in Sport – The 4th International Conference on Concussion in Sport Held in Zurich, November 2012. *Clin J Sport Med* 2013; 47:250-258.
6. Erlanger D, Kaushik T, Cantu R, Barth JT, Broshek DK, Freeman JR, Webbe FM. Symptom-Based Assessment of the Severity of a Concussion. *J Neurosurg* 2003;98(3):477-484.
7. Guskiewicz, K.M., Weaver, N.L., Padua, D.A., Garrett, W.E Jr. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;28(5):643-650.
8. CBC News. Kelly Crow. Q&A Concussion: Q&A with Dr. Charles Tator. Posted Feb 22, 2011.
9. Walsh SS & Jarvis SN. Measuring the frequency of “severe” accidental injury in childhood. *J Epidemiol Community Health* 1992;46:26-32.
10. Chevalier S, Choiniere R, Ferland M, Pageau M, Sauvageau Y. *Community Health Indicators: Definitions and Interpretations*. Ottawa: Canadian Institute for Health Information; 1995.