

## Retrospective Study

## Epidemiology of children and adolescent eye injuries in British Columbia

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### Abstract

#### AIM

To quantify and characterize children and adolescent eye injuries treated in trauma department.

#### METHODS

A retrospective analysis was conducted of children and adolescent patients (0-19 years of age) with eye injuries using the British Columbia Trauma Registry (BCTR) data. BCTR data was obtained from January 1, 2000 to December 31, 2008. The BCTR provides the most detailed information on severe injuries throughout the province of BC. There are 12 trauma-receiving facilities in BC from which BCTR collects data.

#### RESULTS

A total of 162 patients with eye injuries were registered in BCTR during the data collection period. The highest number of injuries occurred in the 15-19 age group, followed by 10-14 and 5-9 age groups. Seventy-one point six percent of all patients were male. The mean age for all patients was 12.9 (SD = 5.8) years. Vehicular crash was by far the most common mechanism of injury among all patients (42.0%) followed by blunt injury (14.2%) and cuts (12.3%). The child and adolescent eye

injury data set we used for our study indicated that there were in total, 50 patients that were tested for alcohol and drug use. The majority of them were 15-19 years of age ( $n = 38$ ). Among the tested eye injury patients in the 15-19 age group, 47% (18/38) tested positive for alcohol. There were approximately 30 cases of physical fighting (assault) and fighting-related injury among adolescents. Some injuries were caused by use of fire arms and knife during the assaults. Out of all patients, 62 (38%) were seen by an Ophthalmologist on admission, whereas 100 (62%) patients were not seen by an eye specialist on admission. The most common injury diagnosis among the patients not consulted by ophthalmologist was conjunctiva injury (53%), whereas almost 9 out of 10 patients with ophthalmological consultation had laceration of cornea injury diagnoses. Using Glasgow Coma Scale (GCS)-based classification of brain injury severity, 3.7% of all patients were classified with severe brain injury ( $GCS \leq 8$ ), while more than 64% had diagnosed with a mild brain injury ( $GCS \geq 13$ ).

### CONCLUSION

This study suggests that most child and adolescent eye injuries in BC occur at street/highway locations followed by incidents at home. Vehicular crash was by far the most common mechanism of injury among all patients (42%). Sixty-four point two percent of child and adolescent eye injury patients also had mild brain injuries. Further, the child and adolescent eye injury data set we used for our study indicated that there were in total, 50 patients tested for alcohol and drug use. There is an urgent need for a child and adolescent eye injury prevention plan in our province.

**Key words:** Eye injury; Driving; Fight; Assault; Alcohol use; Retrospective study; Brain injury

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**Core tip:** The epidemiology eye injuries among British Columbian children and adolescents have been elucidated using the Trauma Registry data. The finding that approximately 72% eye injury patients in the 15-19 age groups have consumed alcohol prior to injury is unprecedented, important and need a sensible prevention intervention. Moreover, common causes of eye injury in the 15-19 year age group include vehicular crashes, firearm misuse, and assault. Therefore, preventative programs aimed at older children must target the children directly, providing education about potential causes and ramifications of eye injury.

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## INTRODUCTION

Eye trauma accounts for 7% of all bodily injuries and 10%-15% of all eye diseases<sup>[1]</sup>. There are approximately 2.4 million eye injuries reported annually in the United States<sup>[2]</sup>. Previous studies have reported that between 20%-50% of ocular injury hospital admissions are for children<sup>[1]</sup>. Eye trauma is the leading cause of non-congenital monocular blindness among children<sup>[3]</sup>. Further, in severe cases of eye injury, surgical removal of the eye may be necessary. In addition to poor vision in a developing child, this may lead to cosmetic disfiguration and scarring alongside with psychological distress<sup>[4]</sup>. As such, eye injuries constitute a significant burden in terms of medical care cost, productivity loss, and human suffering<sup>[3,5]</sup>.

A retrospective-cohort study was conducted by Podbielski *et al*<sup>[6]</sup>, examining eye injury-related hospital admissions at a major Canadian children's hospital between January 1<sup>st</sup> and December 31<sup>st</sup> of 2002. This is the first Canadian study to look at the types and causes of eye injury in children. The study reports that most children's eye injuries occurred at home (49%) and during the summer months. The study sample consisted of 149 children. The median age of patients was 8 years 8 mo. Most patients (34.2%) were in the 5-9 year age group. Most eye injuries (45%) were related to child play. The study also showed that over 7% of the patients admitted to the emergency department with eye injuries needed surgical treatment to keep their vision. There were 7 open globe lacerations, 3 open globe ruptures, and 1 closed globe injury. The most common and serious injury was eye ruptures. Many eye injuries reported in the study were serious and 60% of the patients ( $n = 86$ ) required a follow-up with an ophthalmologist. In light of these results, the authors suggest increasing awareness and education as means of preventing eye injuries in children.

The purpose of this retrospective study is to describe the epidemiology of children and adolescent eye injuries in British Columbia, Canada.

## MATERIALS AND METHODS

A retrospective analysis was conducted on children and adolescent patients (0-19 years of age) with eye injuries from the British Columbia Trauma Registry (BCTR). BCTR data was obtained for January 1, 2000 and December 31, 2008.

The BCTR provides the most detailed information on severe injuries throughout the province of BC. There are 12 trauma receiving facilities in BC from which BCTR collects data. However, St. Paul's Hospital (data not collected from April 1, 2001 to March 31, 2004), BC Children's Hospital (data not collected from April 1, 2005 to March 31, 2006), Nanaimo Regional General Hospital (data not collected before April, 2007), University Hospital of Northern BC (data not collected before April, 2004) and Abbotsford Regional Hospital did not provide data for

**Table 1** Child and adolescent eye injuries by age groups and sex, British Columbia Trauma Registry, 2000-2008

Age group	Female			Male			Total		
	<i>n</i>	Row %	Col %	<i>n</i>	Row %	Col %	<i>n</i>	Row %	Col %
0-4 yr	10	45.5	21.7	12	54.5	10.3	22	100.0	10.5
5-9 yr	9	36.0	19.6	16	64.0	13.8	25	100.0	15.4
10-14 yr	9	34.6	19.6	17	65.4	14.7	26	100.0	16.0
15-19 yr	18	20.2	39.1	71	79.8	61.2	89	100.0	54.9
Total	46	28.4	100.0	116	71.6	100.0	162	100.0	100.0

**Table 2** Child and adolescent eye injuries by injury mechanism, British Columbia Trauma Registry, 2000-2008

Injury mechanism	<i>n</i>	%
Vehicular crash	68	42.0
Blunt	23	14.2
Cut	20	12.3
Falls	15	9.3
Assault	14	8.6
Stab	9	5.6
Firearm	7	4.3
Burn/crush injury	6	3.7
Total	162	100.0

the entire period. The blood alcohol concentration is the value of the patient's first serum alcohol level measured at the accepting facility. This value is measured in millimole/liter (mmol/L). Toxicology tests are not routinely done. Toxicology tests are often done more selective manner due to inadequate resources, time of presentation, and other administrative guidelines. Therefore, this information is only available for tested patients.

The health records of trauma patients are flagged and analyzed by the BCTR staff and then entered into the BCTR database using DI Collector software. The BCTR patients included in this study have met the following admission criteria: (1) those admitted for treatment of injuries sustained from the transfer of external energy or force; (2) those admitted to the facility within 7 d of injury (prior to April 1, 2007) or within 21 d of injury (April 1, 2007 to December 31, 2008); and (3) patients that had a length of stay greater than 2 d (prior to April 1, 2007) or a length of stay 48 h or more. For a child and adolescent patient aged 15 or less, a minimum length of stay is not required (April 1, 2007 to December 31, 2008), or if they were transfers in to Vancouver General Hospital (VGH) or transfers out of VGH regardless of length of stay (March 31, 2007 to December 31, 2008), or expired.

## RESULTS

A total of 162 patients with eye injuries were registered in BCTR during the data collection period. Seventy-one point six percent of all patients were male. However, the ratio was close to 1:1 in patients of 4 years of age and younger, but increased to a ratio of 4:1 in the 15-19 age group. The mean age for all patients was 12.9 (SD = 5.8) years. The highest number of injuries occurred

in the 15-19 age group and followed by 10-14 and 5-9 age groups (Table 1).

Vehicular crash was by far the most common mechanism of injury among all patients (42.0%) followed by blunt injury (14.2%) and cuts (12.3%) (Table 2).

As previously mentioned, toxicology tests are not routinely performed due to multiple reasons and; therefore, data was only available for tested children and adolescent eye patients. The data set we used in our study revealed that 50 patients were tested for alcohol and drug use. The majority of them were 15-19 years of age ( $n = 38$ ). Among tested eye injury patients in the 15-19 age group, 47% (18/38) tested positive for alcohol. Three cases had multiple drug consumption along with alcohol at the time of the injury.

The most common location to sustain an eye injury was found to be street/highways (32.1%), which is consistent with the most common injury mechanism of a vehicular crash. More than a quarter of eye injuries occurred in home settings due to careless handling or playing with common household items. Twenty-two point two percent of cases happened in areas of sports and athletics and were caused by sports equipment such as volleyballs, paintballs, baseball bats, tennis balls and golf balls. Interestingly, schools were a relatively low risk environment for children eye injury (Table 3).

Using Glasgow Coma Scale (GCS)-based classification of brain injury severity, 3.7% of all patients were classified with severe brain injury ( $GCS \leq 8$ ), while more than 64% had mild brain injury ( $GCS \geq 13$ ) (Classification of trauma in children. Tom Brazelton, MD, MPH, FAAP; Dennis P Lund, MD<sup>©</sup> 2012 Up To Date, Release: 20.7-C20.1) (Table 4).

Out of all patients, 62 were seen by an Ophthalmologist on admission, whereas 100 patients were not seen by an eye specialist on admission [Patients were either consulted on in the ED, admitted by or had a Most Responsible Service of Ophthalmology. Consultations obtained after admission (*i.e.*, after ED) are not captured]. The most common injury diagnosis among the patients not consulted by ophthalmologist was conjunctiva injury (53%), whereas almost 9 out of 10 patients with ophthalmological consultation had laceration of cornea injury diagnoses. Also, only 13.0% of the patients with no consultation had more than one type of eye injury diagnoses, whereas 56.5% of consulted patients had multiple types of eye injury diagnoses (Table 5).

Average length of stay (LOS) for patients seen by an eye specialist on admission was 6.6 d (SD = 11.1),

**Table 3** Children and adolescent eye injuries by place of occurrence, British Columbia Trauma Registry, 2000-2008

Place of injury	<i>n</i>	%
Street/highway	52	32.1
Home	42	25.9
Sports/athletics area	36	22.2
Other specified place of occurrence	22	13.6
School/other institution/public area	6	3.7
Total	158 <sup>1</sup>	

<sup>1</sup>Numbers fewer than 5 were removed from the table due to confidentiality reasons.

whereas for those not seen by an eye specialist on admission was 13.7 d (SD = 19.6). The difference in LOS was statistically significant ( $P < 0.0001$ ).

## DISCUSSION

To our knowledge, this is the first Canadian study to use Trauma Registry based data to describe the key diagnosis and epidemiological information as well as hospital length of stay for non-fatal cases of children and adolescent eye injuries. Unlike the United States, (the United States Eye Injury Registry-<http://www.useir.org/>), currently there is no Canada-wide eye injury surveillance system in place: The current online Canadian eye injury registry depends exclusively on voluntary reporting of the patients. Therefore, Trauma Registry based data can provide valuable clinical epidemiological information. Further, the data will also can be used to develop targeted injury prevention and health promotion programs.

Our finding that boys are at higher risk for eye injuries is echoed in the existing literature. Multiple studies indicate that ocular trauma is more common in boys than in girls<sup>[3,4,7,8]</sup>. Grin *et al*<sup>[4]</sup> (1987) attribute this tendency to boys generally having a more aggressive and violent nature compared to girls. Shoja and Miratashi<sup>[8]</sup> (2006), who conducted a children ocular trauma study in Iran, state that in their society, boys are generally given more freedom, allowed to play outside without parental supervision and are even encouraged to show aggressive behavior in comparison to girls. One United Kingdom study found that the reason for boys being overrepresented in ocular injuries compared to girls is due to the more adventurous and aggressive nature of boys<sup>[9]</sup>. The above could be probable attributable reasons for the disparity of prevalence of eye injuries between the two genders. However, a study in Oman by Lithander *et al*<sup>[7]</sup> (1999) did not show any gender difference in the prevalence of ocular trauma.

The gender distribution in the previously published Canadian study was 73.2% male and 26.8% female<sup>[6]</sup>. It is quite similar to the results of this study (71.6% male and 28.4% female). However, according to Podbielski *et al*<sup>[6]</sup> (2009), the largest number of eye injuries occurred in the 5-9 year age group (34.2%) with lower levels of injuries in other age groups. In the present study, more

**Table 4** Glasgow Coma Scale in admission for children and adolescent patients with eye injuries, British Columbia Trauma Registry, 2000-2008

GCS score	<i>n</i>	%
≤ 8 - severe brain injury	6	3.7
9-12 - moderate brain injury	4	2.5
≥ 13 - mild brain injury	104	64.2
Missing	48	29.6
Total	162	100.0

GCS: Glasgow Coma Scale.

than half of the injuries were found to occur in the 15-19 year age group. Podbielski *et al*<sup>[6]</sup> suggest that the reason for the 5-9 year age group being more prone to eye injuries is because children in this age range are often more independent than preschoolers, but less mature and responsible than teenagers. Another difference from our findings was that Podbielski *et al*<sup>[6]</sup> (2009) reported that most eye injuries tend to occur at home, while our study reported that streets/highways were the most frequent place to sustain an eye injury. Moreover, the number of reported eye injuries was smaller in older age groups in the Podbielski *et al*<sup>[6]</sup> (2009) study. In contrast, the current study found 54.9% injuries prevalent among the 15-19 age group. The current study also found 16% of injuries to be among the 10-14 age group. It is important to note that a higher number of adolescents were present in the current study, which may account for some of the difference. The Podbielski *et al*<sup>[6]</sup> (2009) study also used a different database (ED data) from a different time period (2001-2002). However, more research is needed to determine a comprehensive reason for this difference.

Similar to our findings, Podbielski *et al*<sup>[6]</sup> (2009) also indicated a disproportionately higher incidence of eye injuries in the summer months of June and July. The authors suggest that this may be due to increased activity of children during the summer school holidays; however, the short duration of their study precluded more definite explanations. Ninety percent of all eye injuries are preventable<sup>[2]</sup>. Home is the most common place of injury in all age groups except for the 15-19 age group<sup>[6]</sup>. MacEwen *et al*<sup>[9]</sup> (1999) highlight that the higher risk of injuries at home is an unrecognized public health problem. In general, many younger aged children are injured by toys or domestic utensils found in most homes<sup>[9]</sup>. More than half of child injuries reported in a study by Serrano *et al*<sup>[3]</sup> (2003) and 56.8% of the child injuries indicated in a study by Moreira *et al*<sup>[10]</sup> (1988) were in settings lacking adult supervision when the eye injury occurred<sup>[3,10]</sup>. Since young children do not have well-developed motor skills and are likely to imitate adults without adequately assessing the consequences, parental supervision is a crucial factor in preventing eye injuries<sup>[8]</sup>. In addition, potentially harmful objects must be placed out of reach of young children<sup>[4,7]</sup>. Parents/caregivers must also engage in an ongoing dialogue with children to discuss common

**Table 5** Children and adolescent eye injuries by type of eye injury and by ophthalmology consultation status, British Columbia Trauma Registry, 2000-2008

Type of eye injury	Ophthalmology consultation, <i>n</i>	No ophthalmology consultation, <i>n</i>	Total, <i>n</i>
Eye, conjunctiva injury	19	53	72
Eye, cornea, laceration	54	2	56
Eye, not further specified	7	20	27
Eye, cornea, abrasion	9	17	26
Eye, sclera laceration, involving globe (includes rupture)/eye, cornea, contusion (includes hyphema)	36	5	41
Eye, vitreous injury/eye, canaliculus (tear duct) laceration	14	5	19
Eye, iris laceration/eye, retina laceration/eye, sclera laceration	20	0	20
Other	0	7	7
Total	159	109	268 <sup>1</sup>

Numbers fewer than 5 were excluded from the table for confidentiality reason. <sup>1</sup>The number of eye injuries are more than the number of patients because some patients had more than one injury type.

settings and causes of eye injuries, and discuss the safety precautions that should be exercised when handling common, yet potentially dangerous objects<sup>[4]</sup>. For this purpose, programs aimed at increasing the awareness of parents/guardians about eye injuries in children are warranted<sup>[4,11]</sup>.

Common causes of eye injury in the 15-19 year age group include vehicular crashes, firearm misuse, and assault. Parents and care givers of older children and the adolescents themselves should be educated on the risk of eye injury from motor vehicle crashes, fire arm misuse and physical fights. Further, alcohol usage emerges as a contributing factor in this age group. Therefore, preventative programs aimed at older children must target the children directly, providing education about potential causes and ramifications of eye injury. Older children should also be encouraged to actively practice eye safety precautions, such as wearing protective eyewear during activities associated with a risk of eye injury.

In this study, alcohol consumption was involved in 72% of eye injury patients in the 15-19 age group. According to Health Canada<sup>[12]</sup> (2009), the average age for initiation of alcohol consumption is 15.9 years in Canada. Therefore, educational programs geared towards older children regarding eye injuries must necessarily also discuss the added risk of injury when under the influence of alcohol. For instance, Carr *et al*<sup>[13]</sup> (2009) investigated the effects of alcohol on firearm use, and reported that intoxicated individuals displayed longer response times in tasks that did not require judgment, but displayed shorter response times in tasks that required complex decision making. Impaired motor skills and judgment caused by alcohol intake make individuals more likely to be responsible for vehicular crashes, undergo falls, and to become involved in violent confrontations.

The majority of patients in this study were not seen by an ophthalmologist on hospital admission. There are two possible explanations for this: One is that those cases involved milder eye injuries and emergency physicians did not see a need to consult with a specialist.

This notion is partially supported by the fact that the vast majority of patients with more serious eye injury diagnoses, such as corneal laceration, were seen by an eye specialist, whereas only about half of the patients with mild injury, such as conjunctiva injury diagnoses, had ophthalmological consultation. Another reason for not consulting with an Ophthalmologist was likely the fact that the patients without consultation had more severe co-morbidities, which necessitated urgent admission leaving no time for non-priority consultations. Comparison of the mean lengths of hospital stay (LOS) (which is a proxy indicator of severity) among consulted and not consulted patients supports this notion.

Sports/athletic-related eye injuries, the second most common setting for eye injuries, are largely preventable<sup>[4]</sup>. By using standard and effective eye guards and eye masks, it is possible to protect the eyes from sports injuries<sup>[4]</sup>, and therefore, mandated use of such protective equipment during sport activities has the potential to greatly reduce the overall incidence of eye-related injuries. The American Society for Testing and Materials and the Canadian Standards Association have produced an eye protector for squash and has made its use compulsory<sup>[14]</sup>. Similar protective wear for other racquet sports such as tennis and badminton will help reduce eye injuries caused by these sports. Grin *et al*<sup>[4]</sup> (1987) suggest that children with weak eyesight should avoid sports/activities where eye protection cannot be used (such as boxing). In this study, a number of eye injuries were found to be caused by projectiles from recreational guns (*e.g.*, potato-, pellet- and paintball-guns). Proper safety eyewear must also be emphasized when children are engaged in such activities. According to United States Consumer Product Safety Commission, out of the 3 million non-powder guns sold annually in the United States, half is marketed to young children<sup>[4]</sup>. Grin *et al*<sup>[4]</sup> (1987) suggests banning the sale of air guns to children below 16 years of age in order to prevent gun-related eye injuries in young children.

This study is subject to several limitations as it is exclusively based on an administrative data base. The data represented in the study were collected only in BC

tertiary and district trauma centers. As such, the data may not be representative of all children and adolescent eye injuries in BC because children and adolescent patients may also have visited other healthcare facilities including walk-in clinics. There may be some children, adolescents and their parents/care givers may have chosen not to get medical care for ocular injuries. Data after discharge is also unavailable in this data set and therefore data on long-term visual outcomes are missing. Moreover, not all hospitals consistently reported data to BCTR during our data collection period 2000-2008. For example, BC Children's hospital data was not available for 1 year and two hospitals had 1-3 year gaps in reporting. University Hospital of Northern BC joined BCTR only in 2004 (Please see the methodology section for a detailed description of data collection gaps).

Despite these limitations, the results of this study add valuable clinical and epidemiological information to the children/adolescent eye injury research in Canada. Future studies should be nationally representative and should include eye injury data from other health care settings, including emergency departments, primary care physicians, walk-in clinics, and all other vision care settings. In addition to the current online Canadian eye injury registry, we recommend implementing a more effective nation-wide eye injury surveillance system to capture accurate and reliable data. Additional epidemiological data, such as proximal cause of injury including presence of adult supervision, safety eyewear use, and detailed information of the products involved in the injury and specific mechanism of injury, also need to be collected. It is also important that future studies assess the short and long-term visual outcomes after eye injury.

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## COMMENTS

### Background

Purpose of this research is to understand the epidemiology of children and adolescents eye injuries, retrospectively analyzing the Trauma Registry data. Most eye injuries occurred as a result of road traffic crashes under the influence of alcohol. In addition, the data shows that assaults and fights related eye injuries are common. Types of injuries vary from cornea lacerations, abrasion to eye conjunctiva injury.

### Research frontiers

According to World Health Organization 55 million eye injuries occur each year around the globe and this is the most common cause of unilateral blindness in the world.

## Innovations and breakthroughs

To our knowledge, this is the first Canadian study to use Trauma Registry based data to describe the key diagnosis and epidemiological information as well as hospital length of stay for non-fatal cases of children and adolescent eye injuries. Adolescents' most eye injuries occurred as a result of road traffic crashes under the influence of alcohol.

## Peer-review

This manuscript adds interesting and useful information regarding children and adolescent eye health. The manuscript is well written and structured. The study design and methodology are correct.

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