AN EPIDEMIOLOGICAL INVESTIGATION OF CONCUSSION IN YOUTH ICE HOCKEY

by

Ian James Sinclair Williamson
B.Sc., Simon Fraser University, 2003

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

In the
School
of
Kinesiology

SIMON FRASER UNIVERSITY

Summer 2006

Approval

Name: **Ian James Sinclair Williamson**

Degree: **Master of Science**

Title of Research Project: **An Epidemiological Investigation of Concussion in Youth Ice Hockey**

Examining Committee:

Chair: **Dr. Stephen Robinovich**
Associate Professor of Kinesiology

Dr. David Goodman
Senior Supervisor
Professor of Kinesiology

Dr. Donald Voaklander
Supervisor
Associate Professor of Epidemiology
University of Alberta

Dr. Wade Parkhouse
Supervisor
Professor of Kinesiology

Dr. Carl Schwarz
External Examiner
Professor of Statistics

Date Defended/Approved: Jun. 20/06

SIMON FRASER UNIVERSITY library

STATEMENT OF ETHICS APPROVAL

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

(a) Human research ethics approval from the Simon Fraser University Office of Research Ethics,

or

(b) Advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University;

or has conducted the research

(c) as a co-investigator, in a research project approved in advance,

or

(d) as a member of a course approved in advance for minimal risk human research, by the Office of Research Ethics.

A copy of the approval letter has been filed at the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Burnaby, BC, Canada

Abstract

There has been limited investigation of concussion in youth hockey. This project aimed to: (a) estimate incidence; (b) determine risk factors; and (c) examine symptoms experienced by players, how their concussions were managed, and when they returned to play. Data were acquired from four surveillance strategies: (a) official injury reports, (b) team volunteer reports, (c) reports by trained observers, and (d) retrospective self-reports by players.

Incidence estimates varied across surveillance strategies from 0.07 to 15.60 probable concussions (incidents) per 1000 athlete exposures (AE), and there was evidence of significant ($p < .05$) under-reporting by players to team personnel and team personnel to BC Hockey. Age division was a significant ($p < .05$) predictor of volunteer-identified incidents. Most incidents resulted from direct interaction between players and the majority did not draw penalties. There was no evidence of improvements in player-identified incident reporting or adherence to concussion guidelines between 2001 and 2004.

Keywords: concussion, mild traumatic brain injury, head injury, sport injury

To my father, Nairne E. Plaxton, who did what the best dads do,

he built a better road for me than the one he had to tread.

"Keep your head up."

- Hockey dads everywhere

Acknowledgements

This thesis is the result of the ingenuity and efforts of many people to whom I am indebted. It would not have been possible without the participation of hundreds of minor hockey executives, volunteers, and players. Thanks to Hockey Canada, BC Hockey, the PCAHA, the OMAHA, and their respective member associations.

I owe a great deal to my senior supervisor, Dr. David Goodman, who is a source of insightful guidance and who provides enviable opportunities in engaging research. Thank you for helping me to achieve my goals. Thanks to Dr. Don Voaklander for helping me understand the principles of epidemiology and thank you also to Dr. Wade Parkhouse and Dr. Carl Schwarz for their thoughtful comments and recommendations.

Several students have made substantial contributions to this research. Flavio Oliveira, Jeremy Hamm, Nori Bradley, Travis Schisler, and Kirsten Willms have proven reliable coworkers, astute scholars, and good friends. Thanks also to Brent Gall, David Lim, Dawson Elliott, Eric Lee, and Jill Meanley.

My grandparents, Charles and Martha Hutchinson taught me the value of a higher education and my mother, Margaret Plaxton, who is an unwavering source of love and support, helped me to attain one. My siblings, Kevin and Aileen Williamson, relented to my quirky study habits and my father, Nairne Plaxton, was my first teacher and best friend; I'm proud to be his son. To my love, Lynda, who waited patiently while I pursued my dreams: your smile stirs my heart and gives me strength and faith.

This research was funded by a grant from the Canadian Institutes of Health Research and a Canada Graduate Scholarship Master Award.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AE	Athlete Exposures
CI	Confidence Interval
DIOC	Doctor-confirmed Incidents of Concern
FIOC	Formal Incidents of Concern
HHIHA	Hockey Head Injury History Assessment
Inc	Incidence
IOC	Incidents of Concern
PIOC	Player-identified Incidents of Concern
PGH	Player Game Hours
SSHH	Significant Symptomatic Head Hit
OIOC	Observer-identified Incidents of Concern
VIOC	Volunteer-identified Incidents of Concern

Chapter 1:
An Investigation of the Incidence of Probable Concussion in Youth Ice Hockey Using Multiple Surveillance Strategies

1.1 Introduction

Concussions are typically generated by the rapid acceleration, deceleration or rotation of the head, leading to compressive, tensile and shearing forces on the brain.[1] The deleterious effects associated with the injury may include neuropsychological deficits, temporary impairments in information processing and cognition, and a variety of symptoms associated with post concussion syndrome (PCS).[1-6] There is also emerging evidence supporting the cumulative detrimental effects of multiple concussions, the lingering of PCS for periods of a year or longer, and the risk of coma or death following concussive injuries.[1,3-5,7-12]

The occurrence of concussion in youth ice hockey is well established and perhaps not surprising given the speeds at which players travel, the enclosed environment in which they compete, and the collisions, including body checks, that are frequently used as an elemental tactic in game play.[13-26] Epidemiologic assessment of concussion in youth hockey is critical to determine the need for prevention and control measures, and various professional and semi-professional hockey leagues now have surveillance systems in place (e.g. National Hockey League, Ontario Hockey League, etc.). However, the incidence of concussion in youth hockey is not firmly established. While a small number of risk estimates have been calculated, most studies are confined to reporting prevalence,

which offers some insight into the occurrence of concussion but does not provide as clear a picture of the risk posed to exposed populations.[13-23,27]

Among those investigations that are able to report incidence, estimates are often obtained from different data sources and are often based on different methods of surveillance, making comparisons difficult. Moreover, epidemiological studies of concussion in youth ice hockey typically only use prospective injury reporting by athletic trainers or sports medicine physicians to establish the frequency of injury.[13,14,16-18,20,22,23,27,28] While this is may be the preferred methodological approach for the clinical diagnosis of concussions, it relies almost entirely on hockey players reporting their injuries to team personnel. In circumstances when a concussion presents with loss of consciousness (LOC), noticeable post-traumatic amnesia (PTA), or severe disorientation, this may not be an issue, but the vast majority of concussive injuries are considered mild (no LOC or PTA) and difficult to diagnose.[1,29] In these instances, players would need to recognize and report their symptoms to team personnel before the incident is going to be appropriately recognized and managed. Only a small number of studies have incorporated player reports of concussive injuries into the design and the degree to which prospective studies underreport the occurrence of concussions is unknown.[14,21,30,31]

Given the large numbers of North American and European youths currently participating in ice hockey, it is important that we obtain an accurate estimate of the incidence of concussion so that players and parents can begin to make informed decisions about participation, and administrators can be guided to control parameters that may affect their occurrence. In this study we present evidence to suggest there is a considerable underreporting of concussions in youth ice hockey and that rate estimates

calculated from official injury reports woefully underestimate the true incidence. We compare rate estimates of incidents of concern (or probable concussions) calculated from the British Columbia Amateur Hockey Association's (BCAHA) official injury forms, reports from minor hockey team volunteers, youth hockey players, and trained hockey observers.

1.2 Methods

Concussions are ideally diagnosed following a medical professional's assessment, but the majority of potentially concussed hockey players do not seek medical advice.[30,32] To maximize the capture of concussions we broadened injury inclusion criteria and conducted multiple types of surveillance of samples of the BC youth hockey population.[33] Head incidents of concern (IOC), or head injuries indicative of concussions, were considered proxies for concussions confirmed by health care professionals.

Four different strategies were used to estimate the rate of concussion in youth hockey: (a) official injury reports, (b) reports from team volunteers (e.g. coaches, managers, etc.), (c) retrospective self-reports from players, and (d) reports from trained hockey observers. All data were collected from youth teams and games in the BCAHA, a provincial governing branch of Hockey Canada, during the 2003-2004 season. The Office of Research Ethics at Simon Fraser University and the BCAHA Executive approved all aspects of each observation strategy. Participation was completely voluntary and all data were kept strictly confidential.

1.2.1 Observation Strategies

1.2.1.1 Official Injury Reports

The BCAHA provided all official reports of injuries sustained during the 2003-2004 season. According to Hockey Canada, official injury reports are to be completed "for each case where an injury is sustained by a player ... at a sanctioned hockey activity."[34] These reports are filed by team personnel and collected by the BCAHA on an ongoing basis for insurance purposes. Similar sources have been used for tracking injuries in other studies.[25,35-37]

Team personnel could use the Hockey Canada Injury Report or the BCAHA Mutual Aid Form to report injuries. (Copies of these forms are provided in Appendices A and B.) These official injury reports included descriptive information about the injured player, the details of the event, and the nature of the injury. A researcher reviewed forms for explicit reports of concussions sustained by hockey players during game play within the pee wee (11 and 12 years), bantam (13 and 14 years), and midget (15 through 17 years) age divisions. Official reports of concussions were categorized as Formal Incidents of Concern (FIOC).

1.2.1.2 Volunteer Reports

During the 2003-2004 season, minor hockey volunteers (coaches, managers, or safety personnel) in two districts of the BCAHA (Lower Mainland and Okanagan-Mainline) were asked to record and report the details of potential concussions sustained by their team's players during games. These Volunteer-identified Incidents of Concern (VIOC) were defined as injuries indicative of a concussion based on observed and reported signs and symptoms. It was assumed that team personnel were able to identify

and report potential concussions. Most coaches and all safety personnel have passed the Canadian Hockey Safety Program, which includes information addressing concussion symptomatology and assessment, and lay people appear able to recognize the common symptoms associated with minor head injury.[38] Although the signs and symptoms associated with concussion may be linked with other conditions, when presented after rapid acceleration or deceleration of the head, they are considered indicative of concussion and diagnosis with symptomatology has been an integral component of many investigations.[4,15,29,30,35,39-43]

One hundred twenty-seven team volunteers (from a pool of 619 teams) from the pee wee, bantam, and midget age divisions agreed to participate in response to e-mail and phone call soliciting by researchers. Volunteers were provided packages detailing their reporting responsibilities, the symptoms and risks associated with concussions, and the VIOC inclusion criteria: any incident that resulted in a player expressing the signs and symptoms usually demonstrated by concussed athletes. (A copy of this package is provided in Appendix C.) Researchers followed up (by phone or e-mail) with volunteers reporting VIOC to determine if the injured player had seen a doctor and if the doctor had confirmed the injury to be a concussion. Those VIOC that received a confirmatory diagnosis were also labelled Doctor-confirmed Incidents of Concern (DIOC) and represented the VIOC that met the inclusion criteria of other investigations: confirmation by a doctor or athletic therapist or athletic trainer.[13,14,16-18,20,22,27,28]

In order to track exposure, participants were asked to report the dates and outcomes (VIOC or no VIOC) of all games played for the first and second halves of each month for the duration of the season. However, to accommodate for anticipated

discrepancies in bi-monthly game reporting official game schedules were also obtained, thereby allowing researchers to track each team's exposure independent of bi-monthly reports and providing the opportunity for two approaches to the analyses. Approach A assumed that all volunteers were active participants for the duration of the season and that a non-report indicated no VIOC occurred; all scheduled games were included in the analysis. Approach B assumed that only bi-monthly reports from study participants appropriately described player exposure.

VIOC reporting forms gathered the epidemiological details associated with each VIOC and the bi-monthly reporting forms ascertained each game's injury outcome. Both standardized forms could be submitted by mail, fax, or an online web page.

1.2.1.3 Player Reports

The Hockey Head Injury History Assessment (HHIHA) was developed to survey players about their history of hockey-related head injuries. The HHIHA ascertains whether an athlete has ever sustained "a significant hit to the head while playing hockey" and, when applicable, the details associated with their most recent significant hit to the head and the symptoms they encountered. Retrospective injury surveys have been used in numerous studies to estimate concussion or head injury incidence and to assess the risk factors associated with these injuries.[15,21,30,36,44]

Male hockey players attending the BCAHA Best Ever tournaments in 2004 were invited to participate. These athletes were selected by BCAHA-appointed personnel at their respective district assessment camps and arguably represent the most skilled youth hockey players in the province. There are two annual male tournaments categorized according to age: Under-16 and Under-17 years, respectively. HHIHAs were completed

under the supervision of a researcher and a member of each district team's personnel. Participation was completely voluntary and all individual data were kept strictly confidential. (A copy of the HHIHA is provided in Appendix D.)

Reports of significant hits to the head that were followed by the presentation of concussion symptoms were classified as Player-identified Incidents of Concern (PIOC). In order estimate the incidence of PIOC sustained within a single season, only those sustained during the 2003-2004 season were included in further analyses.

1.2.1.4 Observer Reports

During the 2003-2004 season, nine research assistants were trained to recognize events with a potential to generate concussions based on the impact mechanism, the player's response, and attention provided to the player by team personnel. Research assistants participated in a training session that included taped footage of incidents of concern and instruction in the use of a standardized reporting form. These researchers, called "observers", were randomly assigned to watch cluster samples of pee wee, bantam, and midget hockey games in the Lower Mainland district of the BCAHA and reported incidents were labelled Observer-identified Incidents of Concern (OIOC). Similar strategies have been used in previous studies.[45,46] (Copies of the observer package and reporting form is provided in Appendix E.)

1.2.2 Incidence of Incidents of Concern

To facilitate comparisons across observation strategies, only IOC sustained during pee wee, bantam, and midget regular season and playoffs games were included in the analysis. Incidence was calculated using approximations of athlete exposures (AE). For the purposes of this investigation, each AE represented a player's participation in a game

where the player is exposed to the possibility of injury. The incidence of IOC per 1000 AE was calculated as: (number of IOC/ estimated cumulative AE) × 1000. Whenever possible, separate estimates are calculated for players and goalies.

Approximate binomial confidence intervals were calculated using the Agresti-Coull method for FIOC, VIOC, DIOC, and PIOC.[47,48] Exact Poisson confidence intervals were calculated for OIOC using the method recommended by Ulm (1990).[49,50]

1.3 Results

1.3.1 Exposure Estimates

1.3.1.1 Official Injury Reports

A total of 43 FIOC were sustained by pee wee-, bantam-, and midget-aged players during 2003-2004 regular season and playoff games. The total number of BCAHA players registered in the pee wee, bantam, a midget age divisions during the season was 22,491* and the average number of regular season and playoff games across all three age divisions was 28.7 per player,† for a total estimated exposure of 645,492 AE. Because player position was not effectively tracked by the BCAHA, only a cumulative estimate for all players could be calculated.

1.3.1.2 Volunteer Reports

Fifty-four VIOC met the inclusion criteria for analysis: 53 (98%) were sustained by players and 1 (2%) by a goalie. Fifteen DIOC were included: 14 (93%) were sustained by players and 1 (7%) by a goalie. The average numbers of players and goalies per team

* Total number of players obtained from the BCAHA Registrar.
† Average number of games played obtained from a sample of BCAHA season schedules.

across all age divisions and skill categories were 14.79 and 1.24,[‡] respectively, and the total numbers of regular season and playoff games were 3,642 in Approach A and 1,455 in Approach B. Thus, estimates of exposure for Approach A were 53,865 AE for players and 4,516 AE for goalies and estimates for Approach B were and 21,519 AE for players and 1,804 AE for goalies.

1.3.1.3 Player Reports

Nineteen PIOC were included in the analysis: 17 (89%) were sustained by players and 2 (11%) by goalies. The total numbers of players and goalies surveyed in 2004 were 134 and 14, respectively, and the average number of regular season and playoff games played by midget representative players was 22.84.[§] Thus, estimates of exposure were 3,061 AE for players and 320 AE for goalies.

1.3.1.4 Observer Reports

Twenty-eight OIOC were included in the analysis: 26 (93%) were sustained by players and 2 (7%) by goalies. The average numbers of players and goalies per team across all age divisions and skill categories were 14.79 and 1.24,[‡] respectively, and the total number of regular season and playoff games sampled was 112. Thus, estimates of exposure were 1,656 AE and 139 AE for players and goalies, respectively.

1.3.2 Incidence Estimates

Table 1.1 illustrates there were no significant ($p > .05$) differences among the incidence estimates of players and goalies in all observation strategies; therefore, observation strategies can be compared by total incidence estimates. There were

[‡] Average number of players obtained from a sample of BCAHA team rosters.
[§] Average number of games played obtained from a sample of BCAHA midget representative schedules.

significant ($p < .05$) differences among the total incidence estimates of most observation strategies and between VIOC by Approaches A and B, VIOC by Approach A and DIOC by Approach A, and VIOC by Approach B and DIOC by Approach B. However, there were no significant ($p > .05$) differences between the DIOC incidence estimates from Approaches A and B, or between the VIOC estimate by Approach A and the DIOC estimate by Approach B.

Table 1.1 IOC Incidence Estimates per 1000 AE and 95% CI for Each Observation Strategy

	FIOC	DIOC		VIOC		PIOC	OIOC
		A	B	A	B		
Total							
IOC	43	15	15	54	54	19	28
AE	645,492	58,381	23,232	58,381	23,323	3,381	1,795
Inc[a]	0.07	0.26	0.64	0.93	2.31	5.62	15.60
CI[b]	0.05, 0.09	0.16, 0.42	0.39, 1.06	0.71, 1.21	1.78, 3.02	3.60, 8.76	10.37, 22.35
Player							
IOC		14	14	53	53	17	26
AE		53,865	21,519	53,865	21,519	3,061	1,656
Inc[a]		0.26	0.65	0.98	2.46	5.55	15.70
CI[b]		0.15, 0.44	0.39, 1.09	0.75, 1.29	1.88, 3.22	3.47, 8.88	10.26, 23.01
Goalie							
IOC		1	1	1	1	2	2
AE		4,516	1,804	4,516	1,804	320	139
Inc[a]		0.22	0.55	0.22	0.55	6.25	14.39
CI[b]		0.04, 1.25	0.10, 3.13	0.04, 1.25	0.10, 3.13	1.72, 22.52	1.74, 51.98

Note. Unable to calculate player and goalie estimates for FIOC because information not available.
[a]Incidence. [b]Confidence interval.

1.4 Discussion

Table 1.1 illustrates the range of total incidences per 1000 AE of FIOC, DIOC, VIOC, PIOC, and OIOC. Based on the PIOC estimate, players can recognize and report significant hits to the head that present signs and symptoms of concussion, yet the majority of these incidents do not appear to be reported (or perhaps even recognized) by team volunteers and fewer still are reported to the BCAHA. This is despite Hockey

Canada's Coach and Safety Person Protocol, which recommends that all players demonstrating signs of concussion be removed from play and not permitted to return until advised by a physician.[51]

The differences (up to a factor of 80) among the PIOC estimate and those from FIOC, VIOC, and DIOC, may be indicative a dramatic under-reporting of concussion in youth ice hockey. This is a point of concern. If players do not report concussions to their team personnel they may also be returning to play without evaluation and when still symptomatic, possibly putting themselves at greater risk of repeat injury and the cumulative effects of multiple concussion.[7,9,10,12,15] Moreover, if team personnel are not reporting concussions to the BCAHA, rates based on official injury reports may woefully under-estimate the true incidence and any decisions based on these estimates may be misinformed.[37]

The significant ($p < .05$) differences between estimates of VIOC and DIOC within each Approach to estimating exposure demonstrate that the use of broader inclusion criteria, which did not require a physician's confirmation of concussion, captured well over 3-fold more IOC. Because all VIOC included in this study presented signs or symptoms of concussion they were, in the very least, indicative of mild traumatic brain injuries and warranted evaluation.[52] The significant ($p < .05$) differences in VIOC and DIOC estimates suggest that studies relying exclusively on reports from medical professionals may miss a substantial number of probable concussions. This may have serious implications for the determination of the risk of concussion in youth ice hockey and may illustrate a need for a multi-faceted approach to surveillance in future investigations.

Though there was no significant ($p > .05$) difference between estimates of DIOC when using Approach A and B, the difference was significant ($p < .05$) within VIOC. This may indicate that Approach A, which relies on season schedules as a proxy for volunteer reports and the assumption that no report indicates no IOC occurred, may not accurately track exposure.[53] Future investigations should receive confirmation of whether an IOC occurred following each exposure.

Figure 1.1 provides a graphic representation of the total incidences of IOC across observation strategies. As might be expected, there is an increase in the incidence estimates (and their associated 95% CI) as the injury inclusion criteria become more lenient. Though we have interpreted this as an indicator of the under-reporting of concussion in youth ice hockey, it may also illustrate that the capacity of each surveillance method to capture concussions dramatically influences incidence estimates.[54,55] The apparent variability observed in this study reiterates calls to standardize epidemiological surveillance measures and methods in ice hockey.[55-60]

Figure 1.1 Concussion incidence estimates and 95% CI across observation strategies.

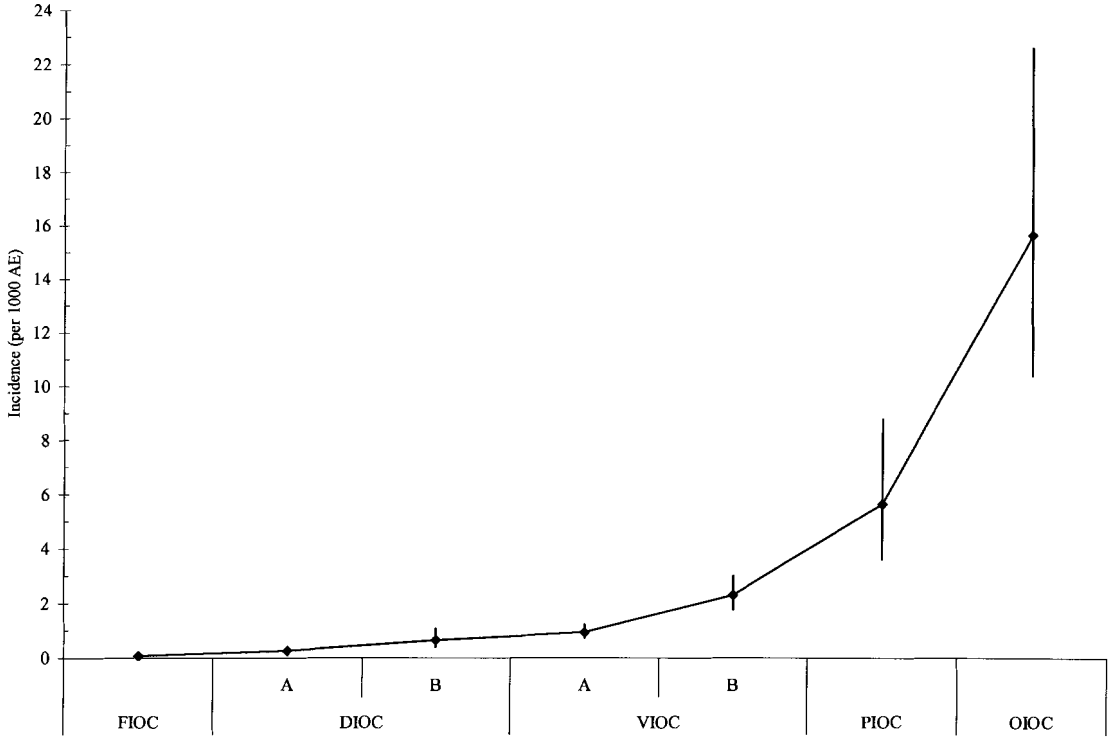


Table 1.2 compares incidence estimates per 1000 player game hours (PGH) from this study with those calculated using reported data from previous investigations of incidence in youth male ice hockey. With the exception of Gerberich *et al.* (1987), the cited studies used a prospective surveillance system requiring injury diagnosis by an athletic trainer or a physician.[15] Roberts *et al.* (1999) and Roberts *et al.* (1996) report rates similar to those estimated from reports by the athletes in our investigation, perhaps because these studies included all injuries evaluated by a team trainer, regardless of severity, and do not necessitate referral to a physician due to injury, 24 hours absence from participation due to injury, or loss of consciousness or post-traumatic amnesia.[15,20,26] However, our OIOC estimate is substantially greater than all other estimates reported in the literature. We suggest this is an indication that observers are not able to confirm an

IOC when monitoring play from the stands. Direct evaluation of the athlete may be required to ascertain reasonable estimates of the incidence of concussions in youth ice hockey.

Table 1.2 Concussion Incidence Estimates per 1000 PGH from This Study and Selected Studies

Study	Period	Setting	Age (years)	CX[a]	*N*	AE	PGH	Incidence
FIOC	2003-2004	CAN	*R*:11-17	43	22,491	645,492	180,738[b]	0.23
DIOC Approach B	2003-2004	CAN	*R*:11-17	15	16[c]	23,323	6,530[b]	2.30
VIOC Approach B	2003-2004	CAN	*R*:11-17	54	16[c]	23,323	6,530[b]	8.42
PIOC	2003-2004	CAN	*R*:15-16	19	148	3,380	946[b]	20.08
OIOC	2003-2004	CAN	*R*:11-17	28	16[c]	1,792	502[b]	55.78
Gerberich (1987)	1982-1983	USA	*M*:16.1	22	251		4,142[d]	5.31
			R:12-13	2	132		86.4	23.15
Roberts (1999)	1993-1994	USA	*R*:14-15	1	127		93.6	10.68
			R:12-15	2	163		108	18.52
Roberts (1996)	1994	USA		4	273		213.9	18.70
Smith (1997)	1994-1995	USA		1[e]	86		639[f]	1.56
Stuart (1995)	1993-1994	USA	*R*:16-21	0	66		4,707	0

[a]Number of concussions. [b]Assuming `6 athletes on ice/ 16-member team × 0.75 hours games = player exposure of 0.28 PGH/AE.` [c]Average number of players per team. [d]Calculated from `mean number of game hours per player × number of players.` [e]Calculated from `number of injuries × proportion of injuries that were concussions.` [f]Calculated from `number of injuries ÷ incidence of injury per player game hour.`

This study is subject to some important limitations. First, it was assumed that all FIOC were sustained during games. Because some FIOC may have occurred during practices, this may have resulted in an overestimation of the rate of concussion based on official injury reports. Second, it was assumed that team volunteers and players were capable of appropriately identifying the signs and symptoms consistent with a concussive injury. Though many coaches and all safety personnel have passed the Canadian Hockey

Safety Program, we did not confirm if our volunteers had completed the course. Third, a definitive diagnosis criterion for concussions remains elusive; but we were limited to using concussion symptomatology. Fourth, selection bias may been introduced if team volunteers who had prior experience in dealing with concussions or had an attitudinal bias were more willing to volunteer for the program or report incidents than the general population of volunteers. Fifth, the HHIHA may not have captured all possible concussions if surveyed players who had unwittingly sustained a previous concussion were unable to recognize the symptoms. It should also be noted that the use of this tool may have also introduced recall bias. Sixth, PIOC estimates were ascertained from elite youth ice hockey players and may underestimate the rate observed in recreational hockey based on findings from Williamson and Goodman (2006).[32] And lastly, the means by which we calculated time at risk for each study cohort were based on educated assumptions of the number of games played and players exposed, but this was necessary in order to compare estimates from several data sources using measures consistent with the literature.

1.5 Conclusions

The underreporting of concussions to hockey's governing bodies has important implications for decision makers and parents that look to make informed decisions about the risk of concussion in the game of hockey. Of particular concern to us is the underreporting of concussions by players to team staff. Players that do not report incidents indicative of concussions and return to play while still symptomatic may be placing themselves at risk of further and perhaps more serious injury.

Finch (2006) and van Mechelen (1992) identify injury surveillance and establishing the extent of the problem as the first steps in their respective models of injury prevention.[61,62] Considering the potentially debilitating effects of concussions and our evidence for concussion rates up to and exceeding 20 per 1000 PGH, we feel there is sufficient cause for concern and a need for control measures in youth ice hockey in BC. However, based on the converging evidence cited above, the underreporting of concussions, both by players and by bench staff, is a major problem that injury control policies and future investigations will need to carefully consider. Hockey Canada has indicated a desire to expand the use of injury reports to create an injury tracking system in minor hockey.[37] Unless appropriate steps are taken to address the underreporting of concussions, and possibly other injuries, results obtained from this data source may be inaccurate.

1.6 References

1. Cantu RC. Cerebral concussion in sport: management and prevention. *Sports Med* 1992;14(1):64-74.
2. Grindel SH. Epidemiology and pathophysiology of minor traumatic brain injury. *Curr Sports Med Rep* 2003;2(1):18-23.
3. Gronwall D, Wrightson P. Delayed recovery of intellectual function after minor head injury. *Lancet* 1974;2(7881):605-609.
4. Macciocchi SN, Barth JT, Alves W, Rimel RW, Jane JA. Neuropsychological functioning and recovery after mild head injury in collegiate athletes. *Neurosurgery* 1996;39(3):510-514.
5. Macciocchi SN, Barth JT, Littlefield LM. Outcome after mild head injury. *Clin Sports Med* 1998;17(1):27-36.
6. McCrea M, Kelly JP, Randolph C, Cisler R, Berger L. Immediate Neurocognitive Effects of Concussion. *Neurosurgery* 2002;50(5):1032-1042.
7. Gronwall D, Wrightson P. Cumulative effect of concussion. *Lancet* 1975;2(7943):995-997.
8. Cantu RC. Second-impact syndrome. *Clin Sports Med* 1998;17(1):37-44.
9. Collins MW, Lovell MR, Iverson GL, Cantu RC, Maroon JC, Field M. Cumulative effects of concussion in high school athletes. *Neurosurgery* 2002;51(5):1175-1179.
10. Gaetz M, Goodman D, Weinberg H. Electrophysiological evidence for the cumulative effects of concussion. *Brain Inj* 2000;14(12):1077-1088.
11. Gennarelli TA, Thibault, L.E., Graham, D.I. Diffuse axonal injury: an important form of traumatic brain damage. *Neuroscientist* 1998;4:202-15.
12. Iverson GL, Gaetz M, Lovell MR, Collins MW. Cumulative effects of concussion in amateur athletes. *Brain Inj* 2004;18(5):433-443.
13. Brust JD, Leonard BJ, Pheley A, Roberts WO. Children's ice hockey injuries. *American Journal of Diseases of Children* 1992;146(6):741-747.
14. Dryden DM, Francescutti LH, Rowe BH, Spence JC, Voaklander DC. Epidemiology of women's recreational ice hockey injuries. *Med Sci Sports Exerc* 2000;32(8):1378-1383.
15. Gerberich SG, Finke R, Madden M, Priest JD, Aamoth G, Murray K. An epidemiological study of high school ice hockey injuries. *Childs Nerv Syst* 1987;3(2):59-64.
16. Groger A. Ten years of ice hockey-related-injuries in the German Ice Hockey Federation - A ten year prospective study/523 international games. *Sportverletzung Sportschaden* 2001;15(4):82-86.

17. McFaull S. Contact injuries in minor hockey: a review of the CHIRPP database for the 1998/1999 hockey season. *CHIRPP News* 2001;19:1-9.

18. Pinto M, Kuhn JE, Greenfield ML, Hawkins RJ. Prospective analysis of ice hockey injuries at the Junior A level over the course of one season. *Clin J Sport Med* 1999;9(2):70-74.

19. Reid SR, Losek JD. Factors associated with significant injuries in youth ice hockey players. *Pediatr Emerg Care* 1999;15(5):310-313.

20. Roberts WO, Brust JD, Leonard B. Youth ice hockey tournament injuries: rates and patterns compared to season play. *Med Sci Sports Exerc* 1999;31(1):46-51.

21. Roy MA, Bernard D, Roy B, Marcotte G. Body checking in pee wee hockey. *The Physician and Sportsmedicine* 1989;17(3):119-126.

22. Smith AM, Stuart MJ, Wiese-Bjornstal DM, Gunnon C. Predictors of injury in ice hockey players: A multivariate, multidisciplinary approach. *Am J Sports Med* 1997;25(4):500-507.

23. Stuart MJ, Smith AM, Nieva JJ, Rock MG. Injuries in youth ice hockey: A pilot surveillance strategy. *Mayo Clin Proc* 1995;70(4):350-356.

24. Macpherson A, Rothman L, Howard A. Body-checking rules and childhood injuries in ice hockey. *Pediatrics* 2006;117(2):e143-e147.

25. Willer B, Kroetsch B, Darling S, Hutson A, Leddy J. Injury rates in house league, select, and representative youth ice hockey. *Med Sci Sports Exerc* 2005;37(10):1658-1663.

26. Roberts WO, Brust JD, Leonard B, Hebert BJ. Fair-play rules and injury reduction in ice hockey. *Arch Pediatr Adolesc Med* 1996;150(2):140-145.

27. Sutherland GW. Fire on ice. *Am J Sports Med* 1976;4(6):264-269.

28. Daffner RH. Injuries in Amateur Ice Hockey - 2-Year Analysis. *J Fam Pract* 1977;4(2):225-227.

29. Guskiewicz KM, Weaver NL, Padua DA, Garrett WE. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;28(5):643-650.

30. Goodman D, Gaetz M, Meichenbaum D. Concussions in hockey: there is cause for concern. *Med Sci Sports Exerc* 2001;33(12):2004-2009.

31. Tegner Y, Lorentzon R. Ice hockey injuries: incidence, nature and causes. *Br J Sports Med* 1991;25(2):87-89.

32. Williamson IJS, Goodman D. Converging evidence for the under-reporting of concussions in youth ice hockey. *Br J Sports Med* 2006;40(2):128-132.

33. Meeuwisse W, Love E. Athletic injury reporting: development of universal systems. *Sports Med* 1997;24:184-204.

34. Hockey Canada. *Hockey Canada Injury Report* (2005 September). Available: http://members.hockeycanada.ca/downloads/insurance/English%20Injury%20Reports/BC.pdf (accessed 2006 June 2).

35. Schulz MR, Marshall SW, Mueller FO, Yang J, Weaver NL, Kalsbeek WD, Bowling JM. Incidence and risk factors for concussion in high school athletes, north Carolina, 1996-1999. *Am J Epidemiol* 2004;160(10):937-44.

36. Montelpare WJ. Final report to the Ontario Hockey Federation and the Canadian Hockey Association: measuring the effects of initiating body-checking at the Atom age level (2001 June). Available: www.bcaha.org/mailouts/2002-07-28/2002-19-Iatt%20Bodychecking%20Report%202002-07-18.pdf (accessed 2005 January 4).

37. Jackson T. *Canadian Hockey Association Safety Net*. 1st ed. Available: http://www.hockeycanada.ca/multimedia/e/develop/insurance/downloads/safety_net_e.pdf (accessed 2006 June 2).

38. Aubrey JB, Dobbs AR, Rule BG. Laypersons knowledge about the sequelae of minor head injury and whiplash. *J Neurol Neurosurg Psychiatry* 1989;52(7):842-846.

39. Alves W, Macciocchi S, Barth J. Postconcussive symptoms after uncomplicated mild head injury. *J Head Trauma Rehabil* 1993;8(3):48-49.

40. Covassin T, Swanik B, Sachs M. Epidemiological considerations of concussions among intercollegiate athletes. *Appl Neuropsychol* 2003;10(1):12-22.

41. Ruff RM, Crouch JA, Troster AI, Marshall LF, Buchsbaum MS, Lottenberg S, Somers LM. Selected cases of poor outcome following a minor brain trauma: Comparing neuropsychological and positron emission tomography assessment. *Brain Inj* 1994;8(4):297-308.

42. Dikmen SS, Levin HS. Methodological issues in the study of mild head injury. *J Head Trauma Rehabil* 1993;8(3):30-37.

43. Schick DM, Meeuwisse WH. Injury rates and profiles in female ice hockey players. *Am J Sports Med* 2003;31(1):47-52.

44. Tegner Y, Lorentzon R. Concussion among Swedish elite ice hockey players. *Br J Sports Med* 1996;30(3):251-255.

45. Wennberg R. Collision frequency in elite hockey on North American versus International size rinks. *Can J Neurol Sci* 2004;31(3):373-377.

46. Wennberg R. Effect of ice surface size on collision rates and head impacts at the world junior hockey championships, 2002 to 2004. *Clin J Sport Med* 2005;15(2):67-72.

47. Agresti A, Coull BA. Approximate is better than "exact" for interval estimation of binomial proportions. *Amer Stat* 1998;52(2):119-126.

48. Brown LD, Cai TC, DasGupta A. Interval estimation for a binomial proportion. *Stat Sci* 2001;16(2):101-33.

49. Ulm K. A simple method to calculate the confidence interval of a standardized mortality ratio. *Am J Epidemiol* 1990;131(2):373-75.

50. Fleiss JL, Levin B, Myunghee CP. *Statistical Methods for Rates and Proportions.* Wiley Series in Probability and Statistics. 3rd ed. New Jersey: John Wiley & Sons, Inc, 2003.

51. Hockey Canada. *Safety Program: Concussion Awareness*. Available: http://www.hockeycanada.ca/7/6/9/9/index1.shtml (accessed June 2, 2006).

52. Aubry M, Cantu R, Dovrak J, Graf-Baumann T, Johnston K, Kelly J, Lovell M, McCrory P, Meeuwisse W, Schamasch P. Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001. *Br J Sports Med* 2002;36(2):6-10.

53. Hamm J. Estimating the Rate of Concussions in British Columbia Minor Hockey Using Community Volunteer Collected Data [M.Sc.]. Simon Fraser University, 2004.

54. van Mechelen W. The severity of sports injuries. *Sports Med* 1997;24:176-180.

55. Brooks JHM, Fuller CW. The influence of methodological issues on the results and conclussions from epidemiological studies of sports injuries. *Sports Med* 2006;36(6):459-72.

56. Pelletier RL, Montelpare WJ, Stark RM. Intercollegiate ice hockey injuries. A case for uniform definitions and reports. *Am J Sports Med* 1993;21(1):78-81.

57. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med.* 2005;39(6):324-329.

58. Finch C. An overview of some definitional issues for sports injury surveillance. *Sports Med* 1997;24(3):157-63.

59. van Mechelen W. To count or not to count sports injuries? *Br J Sports Med* 1998;32:297-8.

60. Chalmers D. Injury prevention in sport: not yet part of the game? *Inj Prev* 2002;8(Suppl 4):iv22-iv25.

61. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport* 2006;9:3-9.

62. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med* 1992;14:82-99.

Chapter 2:
An Investigation of the Risk Factors and Management of Probable Concussion in Youth Ice Hockey Using Multiple Surveillance Strategies

2.1 Introduction

There is an inherent risk of injury in all sport, but concussions pose a special problem. The effects of these mild traumatic brain injuries can be diverse, subtle, may linger for extended periods of time, and can seriously compromise quality of life for a minority of athletes.[1-4] Moreover, the apparent under-reporting of concussions in some sports may increase the risks of further concussions and their cumulative or even catastrophic effects.[1,5-13]

Given the nature of the game, which is played at high speeds in an unforgiving environment, it is perhaps unsurprising that hockey ranks among the highest of all contact sports for concussion rates per player exposure.[14,15] Even at the youth level, rates as high as 23.15 concussions per 1000 player-hours have been reported, indicating that concussions can occur nearly as frequently among youths as their NHL counterparts (29.59 per 1000 player-hours), yet most research has focused on professional and collegiate hockey.[16,17] At the youth level, concussion surveillance and management frequently lies with players, parents, and coaches, conditions that do not facilitate the surveillance strategies used in the majority of hockey injury studies, which require a doctor's or therapist's diagnosis for injury inclusion. However, with nearly 500,000 children registered with Hockey Canada and at risk of injury, there is sufficient justification for investigating concussions regardless of surveillance constraints.[6,7,16,18-24]

According to van Mechelen, Hlobil, and Kemper (1992), the first steps in controlling sport injuries include identifying an injury's aetiology.[25] Knowledge of athlete-related and environmental risk factors allows for the formulation of more precise rate estimates and strategies to reduce injury frequency.[26,27] With respect to hockey however, conservatism may be necessary when using past research in the development of control guidelines because few studies report exclusively on concussions; most report risk factors associated with all injuries.[22,23,25,28-32] This study takes important steps to rectify this issue.

Using three surveillance strategies, this study investigates concussion in samples of British Columbian youth ice hockey players. The purposes are: (a) to better elucidate the causes of hockey-related concussions, (b) to examine how concussions are reportedly managed in youth ice hockey, and (c) to speak to the value of the different surveillance strategies.

2.2 Methods

Concussions are ideally diagnosed following a medical professional's assessment, but the majority of potentially concussed hockey players do not seek medical advice.[6,7] Therefore, to maximize the capture of concussions we broadened injury inclusion criteria and observed samples of the same population with three surveillance strategies.[33] Head incidents of concern (IOC), or head injuries indicative of concussions, were considered proxies for concussions confirmed by health care professionals. Three sources of data were analyzed: (a) official injury reports, (b) reports from team personnel, and (c) reports from trained observers. This investigation is distinctive in the breadth and depth of its approach to studying a seldom researched population at risk of concussion.

All data were collected from youth teams and games in the British Columbia Amateur Hockey Association (BCAHA), a provincial governing branch of Hockey Canada, during the 2003-2004 season. The Office of Research Ethics at Simon Fraser University and the BCAHA Executive approved all aspects of each observation strategy. Participation was completely voluntary and all individual data were kept strictly confidential.

2.2.1 Observation Strategies

2.2.1.1 Official Injury Reports

The BCAHA provided all official reports of injuries sustained during the 2003-2004 season. According to Hockey Canada, official injury reports are to be completed "for each case where an injury is sustained by a player ... at a sanctioned hockey activity."[34] These reports are filed by team personnel and collected by the BCAHA on an ongoing basis for insurance purposes. Similar sources have been used for tracking injuries in other studies.[32,35-37]

Team personnel could use the Hockey Canada Injury Report or the BCAHA Mutual Aid Form to report injuries. (Copies of these forms are provided in Appendices A and B.) These official injury reports included descriptive information about the injured player, the details of the event, and the nature of the injury. A researcher reviewed forms for explicit reports of concussions sustained by hockey players during game play within the pee wee (11 and 12 years), bantam (13 and 14 years), and midget (15 through 17 years) age divisions. Official reports of concussions were categorized as Formal Incidents of Concern (FIOC).

2.2.1.2 Volunteer Reports

During the 2003-2004 season, minor hockey volunteers (coaches, managers, or safety personnel) in two districts of the BCAHA (Lower Mainland and Okanagan-Mainline) were asked to record and report the details of potential concussions sustained by their team's players during games. These Volunteer-identified Incidents of Concern (VIOC) were defined as injuries indicative of a concussion based on observed and reported signs and symptoms. It was assumed that team personnel were able to identify and report potential concussions. Most coaches and all safety personnel have passed the Canadian Hockey Safety Program, which includes information addressing concussion symptomatology and assessment, and lay people appear able to recognize the common symptoms associated with minor head injury.[38] Though the signs and symptoms of concussion may be linked to other conditions, when presented after an impulsive blow to the head, they are considered indicative of concussion and diagnosis with symptomatology has been an integral component of many past studies.[6,9,35,39-45]

One hundred twenty-seven team volunteers from the pee wee, bantam, and midget age divisions agreed to participate in response to e-mail and phone call soliciting by researchers. Volunteers were provided packages detailing their reporting responsibilities, the symptoms and risks associated with concussions, and the VIOC inclusion criteria: any incident that resulted in a player expressing the signs and symptoms usually demonstrated by concussed athletes. (A copy of this package is provided in Appendix C.) Researchers followed up (by phone or e-mail) with volunteers reporting VIOC to determine if the injured player had seen a doctor and if the doctor had confirmed the injury to be a concussion. Those VIOC that received a confirmatory diagnosis by a doctor were also labelled Doctor-confirmed Incidents of Concern (DIOC) and met the inclusion criteria of

other investigations: confirmation by a doctor or athletic therapist or athletic trainer.[16,18-22,24,30,46]

In order to track exposure, participants were asked to report the dates and outcomes (VIOC or no VIOC) of all games played for the first and second halves of each month for the duration of the season. However, to accommodate for anticipated discrepancies in bi-monthly game reporting official game schedules were also obtained, thereby allowing researchers to track each team's exposure independent of bi-monthly reports and providing the opportunity for two approaches to the analyses. Approach A assumed that all volunteers were active participants for the duration of the season and that a non-report indicated no VIOC occurred; all scheduled games were included in the analysis. Approach B assumed that only bi-monthly reports from study participants appropriately described player exposure.

VIOC reporting forms gathered the epidemiological details associated with each VIOC and the bi-monthly reporting forms ascertained each game's injury outcome. Both standardized forms could be submitted by mail, fax, or an online web page.

2.2.1.3 Observer Reports

During the 2003-2004 season, nine research assistants were trained to recognize events with a potential to generate concussions based on the impact mechanism, the player's response, and attention provided to the player by team personnel. Research assistants participated in a training session that included taped footage of incidents of concern and instruction in the use of a standardized reporting form. These researchers, called "observers", were randomly assigned to watch cluster samples of pee wee, bantam and midget hockey games in the Lower Mainland district of the BCAHA and reported

incidents were labelled Observer-identified Incidents of Concern (OIOC). Similar strategies have been used in previous studies.[47,48] (Copies of the observer package and the reporting form are provided in Appendix E.)

2.2.2 Statistical Methods

Each observation strategy utilized a different reporting form to capture the details associated with an IOC, as a result there are some differences in the amount and type of information collected across strategies. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 14.0.[49]

2.2.2.1 Descriptive Analyses

Players could participate in one of two skill levels in the pee wee, bantam, or midget age divisions: representative (A and B) or house (C); the former category arguably included the most skilled players in an age division. Similarly, player position (centre, wing, defence, or goalie), the location of the IOC (offensive or defensive corners, offensive or defensive slots, or the neutral zone), and the period in which the IOC occurred (first, second, third, or overtime) were all single response categories. The mechanisms that lead to the IOC (the cause), the resulting actions by or taken upon the player's head (the result), and the player and team personnel's responses were each multiple response categories. Analyses were conducted using SPSS Descriptives.[49]

2.2.2.2 Inferential Analyses

Binary logistic regressions were used to assess whether specific variables made a significant contribution to the probability of IOC for two observation strategies: official injury reports and volunteer reports (VIOC and DIOC). Poisson regression was used to

assess the influence of predictor variables to the probability of IOC for the observer reporting strategy.

Response variables.

Each observation strategy required a slightly different definition of an IOC, but all IOC represented probable concussions and were dichotomous variables (IOC or no IOC), except OIOC because observers reported games with zero, one, and two OIOC.

Predictor variables.

There was a need to be selective in the choice of variables to include in the logistic regressions because of the high number of observations and comparatively few IOC; incorporating too many predictor variables can lead to coefficient inflations or failures in achieving convergence.[50,51] Three variables of particular interest were age division, skill category, and time (first-part regular season, second-part regular season, and playoffs). Previous research suggests the absolute number of injuries increases with both age division and skill category, and concussions may occur with varying frequencies as the season progresses.[18,32,52,53]

To incorporate a temporal measure into the analysis, games were classified into categories according to the skill category of the participating teams and the month the games were played: (a) first-part regular season games were played between October and December in house hockey, and between November and December in representative hockey; (b) second part regular season games were played in January in both skill categories; and (c) playoff games were played from February through April in both skill categories. This game classification scheme was established based on reviews of samples of season schedules for each age division and skill category combination.

Missing values.

Patterns of missing data in each observation strategy were generated using SPSS Missing Value Analysis and variables missing in more than 20% of cases were removed from further analyses. The effects of missing cases were analyzed with exact Pearson's chi-square tests of the variables of interest (response versus missing) against a dichotomous dummy variable (e.g. form type). Non-significant chi-square statistics ($p > .05$) indicated missing cases did not differ significantly from cases that responded and these missing cases were assumed missing at random. (Appendix F presents a sample calculation.) Subsequent logistic regressions were conducted using only complete cases.[50,54,55]

Regressions.

Binary logistic regressions were performed on the predictor variables (age division, skill category, and time) with IOC as the response variable using the forced entry method. A Poisson regression was performed on the predictor variables with OIOC as the response variable. The contribution of each predictor variable was assessed using a likelihood ratio statistic and a deviance chi-square statistic for the logistic and Poisson regressions, respectively; significance was set *a priori* at .05. Analyses were reported as odds ratios (OR) with 95% confidence intervals (95% CI).

2.3 Results

2.3.1 Descriptive Statistics

Table 2.1 summarizes the general features of IOC reported by each observation strategy. Figures 2.1 and 2.2 show the causes and results of IOC from each observation strategy, respectively.

2.3.1.1 Official Reports

Among the 396 injuries sustained by hockey players and reported to the BCAHA during the 2003-2004 season, 66 (17%) explicitly reported a concussion. Broken bones (27%), sprains and strains (18%), and contusions and bruises (18%) occurred more frequently.

Table 2.1 shows that more players from the pee wee, bantam, and midget age divisions sustained FIOC than all other divisions combined and more FIOC occurred in the first part of the regular season than in playoffs than in the second part of the regular season. Also, more FIOC occurred during games (76%) than practices (6%).

Causes.

Figure 2.1 shows the causes of FIOC sustained by pee wee, bantam, and midget players as reported on the Hockey Canada Injury Reports or as categorized by a researcher who reviewed BCAHA Mutual Aid Form accident descriptions. Direct interaction with other players through body checks, hits from behind, and open and blindside hits were reported as a cause in nearly 41% of all FIOC. However, other collisions (collisions with the boards) were the overwhelming leading cause (42%); whether they were induced by interaction with other players is unknown.

2.3.1.2 Volunteer Reports

One hundred twenty-seven team volunteers from a pool of 619 teams (21%) were recruited to report significant hits to the head sustained by their team's players during games. Assuming all 127 volunteers were compliant for the duration of the season, 3,777 games were observed and 73 VIOC were reported. Nineteen of the VIOC (26.0%) were

diagnosed as concussions by doctors, qualifying them as DIOC, and a further four VIOC (6%) were referred to doctors but the outcomes of the evaluations were unknown.

Table 2.1 illustrates that the majority of VIOC (78%) and DIOC (79%) occurred during regular season or playoff games, most VIOC and DIOC occurred in the neutral zone and, as expected, the vast majority of VIOC and all DIOC occurred during competition that permitted body checking. Table 2.1 also shows that VIOC were sustained most frequently during representative games, but DIOC were sustained more often during house hockey. The wings sustained the highest number of VIOC, but the defence sustained the most DIOC.

Causes and results.

Figure 2.1 shows the reported causes of all VIOC and DIOC sustained during pee wee, bantam, and midget hockey. Thirty-seven VIOC (51%) were reportedly caused by an act (or a combination of actions) that are against the rules in youth ice hockey in BC: 23 (32%) hits from behind, 13 (8%) hits to the head, and 5 (7%) crosschecks.** Six DIOC (32%) were reportedly caused by penalizable acts (or actions): four (21%) hits to the head and two (11%) hits from behind. However, only 17 VIOC (23%) actually culminated with a penalty call: 8 (11%) hits from behind, 3 (4%) hits to the head, 1 (1%) crosscheck, 1 (1%) elbowing, 1 (1 %) interference, 1 (1%) boarding and 2 (3%) unspecified penalties. Similarly, only three DIOC (16%) were penalized: one boarding (5%) and two (11%) unspecified penalties. The 13 "other" causes of VIOC depicted in Figure 2.1 included 6 (8 %) players colliding with the boards, 2 (3%) players who were run into the net, 1 (1%) player who was hit in the head by a puck, and 4 (6%) unspecified causes. Other causes of

** Total number of causes exceeds total number of VIOC because some VIOC have multiple causes.

DIOC included two (11%) players colliding with the boards and one (5%) unspecified cause. No fights were reported as a cause of VIOC or DIOC.

Figure 2.2 describes the results of the causes that induced VIOC and DIOC. Collisions of the head with the boards or glass were the leading mechanism of VIOC (56%), and direct interactions with other players (via their body or elbow or glove) were the inducing mechanisms of most DIOC (53%).

Concussion management.

Figure 2.3 depicts the symptoms volunteers identified among players who sustained an IOC: headache, dizziness, confusion, and seeing stars were reported most frequently. A comparatively lower proportion of players who sustained a VIOC were reported to have suffered from a loss of consciousness or memory problems (post-traumatic amnesia) than those who sustained a DIOC (8% and 26%, respectively). The "other" symptoms included reports of sore necks or backs.

Thirty-four (47%) injured players were removed from play after sustaining a VIOC, but 25 (34%) finished the game. Thirty-three (45%) injured players returned for the next scheduled ice time, 25 (34%) missed at least one ice time, and 15 (20%) did not report the time missed due to injury. The mean numbers of ice times and days missed before returning to the ice were 1.88 and 4.29, respectively (*SD* = 3.79 and 7.52, respectively). Only one injured player (1%) was a call up from a lower age division or skill category, a pee wee-aged athlete playing bantam house hockey. Comparatively, a higher percentage of players who sustained a DIOC were removed from play and, on average, they were out of competition for a longer period. Sixteen players (84%) who sustained a DIOC were removed from play, 2 (11%) finished the game, and 1 (5%) did

not specify. Four (21%) injured players returned for the next scheduled ice time, 14 (74%) missed at least one ice time, and 1 (5%) did not specify. The mean numbers of ice times and days missed before returning to the ice after a DIOC were 4.67 and 9.83, respectively (*SD* = 5.51 and 10.30, respectively). No DIOC were reportedly sustained by players called up from a lower age division or skill category.

Twenty-eight (38%) players were reported to be wearing a mouth guard at the time of the VIOC and 36 (46%) were not, the mouth guard use of 2 (3%) players was unknown, and it was not reported in 7 (10%) cases. A lower proportion of players who sustained a DIOC were reported to be wearing a mouth guard: six (32%) players were using a mouth guard, 12 (63%) were not, and the mouth guard use of 1 (5%) player was not specified.

2.3.1.3 Observer Reports

A total of 28 OIOC were reported from monitoring 127 games: 22 games (17%) with one incident each and 3 games (2%) with two incidents each. Bantam-aged players, those playing house, and forwards sustained the highest numbers of OIOC. The majority were reported during the first part of the regular season and in the third period. Only one penalty was called following an OIOC: a 4-minute minor for charging.

Causes and results.

Figures 2.1 and 2.2 show the reported causes and results of OIOC. At least 16 (57%) were reportedly caused by an act (or combination of actions) that are against the rules in youth ice hockey in BC, and collisions with the boards were the overwhelming mechanism leading to OIOC (42%).

Concussion management.

According to observers, eight (29%) players were assessed by team personnel while on the ice and 12 (43%) were assessed when they arrived at the bench. Fifteen (54%) of the athletes left the ice immediately preceding the injury, six (21%) were assisted off the ice, and eight (29%) did not return to play in the same game.

Table 2.1 Features of IOC Reported In Each Observation Strategy

Features	FIOC		VIOC		DIOC		OIOC	
	N	% FIOC	*N*	% VIOC	*N*	% DIOC	*N*	% OIOC
Age Divisions								
Below pee wee	5	8						
Pee wee	16	24	34	47	7	37	6	21
Bantam	28	42	24	33	5	26	13	46
Midget	13	20	15	21	7	37	9	32
Juvenile	1	2						
Female	2	3						
Missing	1	2						
Total	66	100	73	100	19	100	28	100
Skill Category								
Representative	15	23	43	59	7	37	6	21
House	7	11	30	41	12	63	22	79
Missing	44	67		0	0	0		
Total	66	100	73	100	19	100	28	100
Time								
Preseason/ tiering	1	2	5	7	0	0		
Regular season, first part	28	45	33	45	6	32	18	64
Regular season, second part	8	13	14	19	6	32	8	29
Playoff	24	39	10	14	3	16	2	7
Tournament	0	0	9	12	3	16		
Exhibition	0	0	2	3	1	5		
Missing	1	2						
Total	62[a]	100	73	100	19	100	28	100
Body contact								
Body checking permitted			72	99	19	100		
No body checking			1	1	0	0		
Total			73	100	19	100		
Position								
Forward							19	68
Wing			30	41	7	37		
Center			23	32	3	16		
Defence			16	22	8	42	7	25
Goaltender			1	1	1	5	2	7
Missing			3	4	0	0		
Total			73	100	19	100	28	100
Location								
Neutral zone			24	33	6	32		
Offensive corner			22	30	5	26		
Defensive corner			13	18	4	21		
Offensive slot			5	7	3	16		
Defensive slot			4	6	1	5		
Missing			5	7	0	0		
Total			73	100	19	100		
Period								
First			13	18	3	16	6	21
Second			29	40	7	37	8	29
Third			23	32	8	42	14	50
Missing			8	11	1	5		
Total			73	100	19	100	28	100

Note. Percentages may not add to 100 due to rounding.

[a]Four FIOC were sustained during practices.

Figure 2.1 Reported causes of IOC across observation strategies.

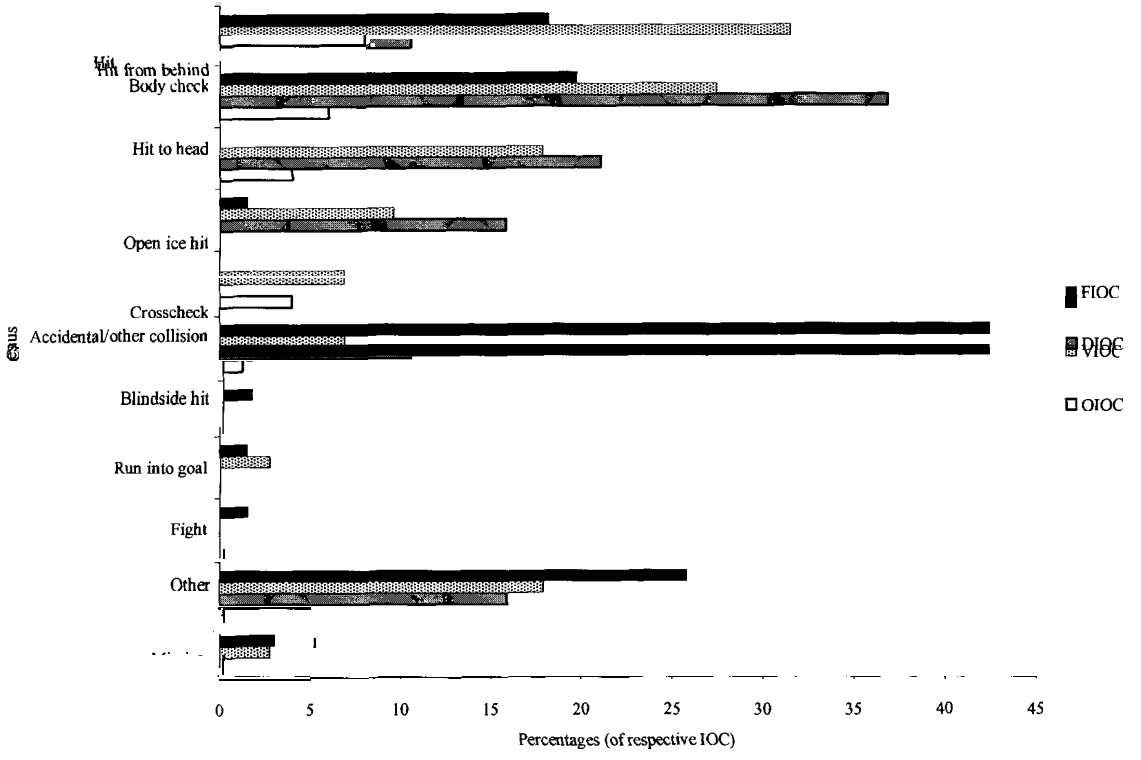


Figure 2.2 Reported results of causes that induced IOC across observation strategies.

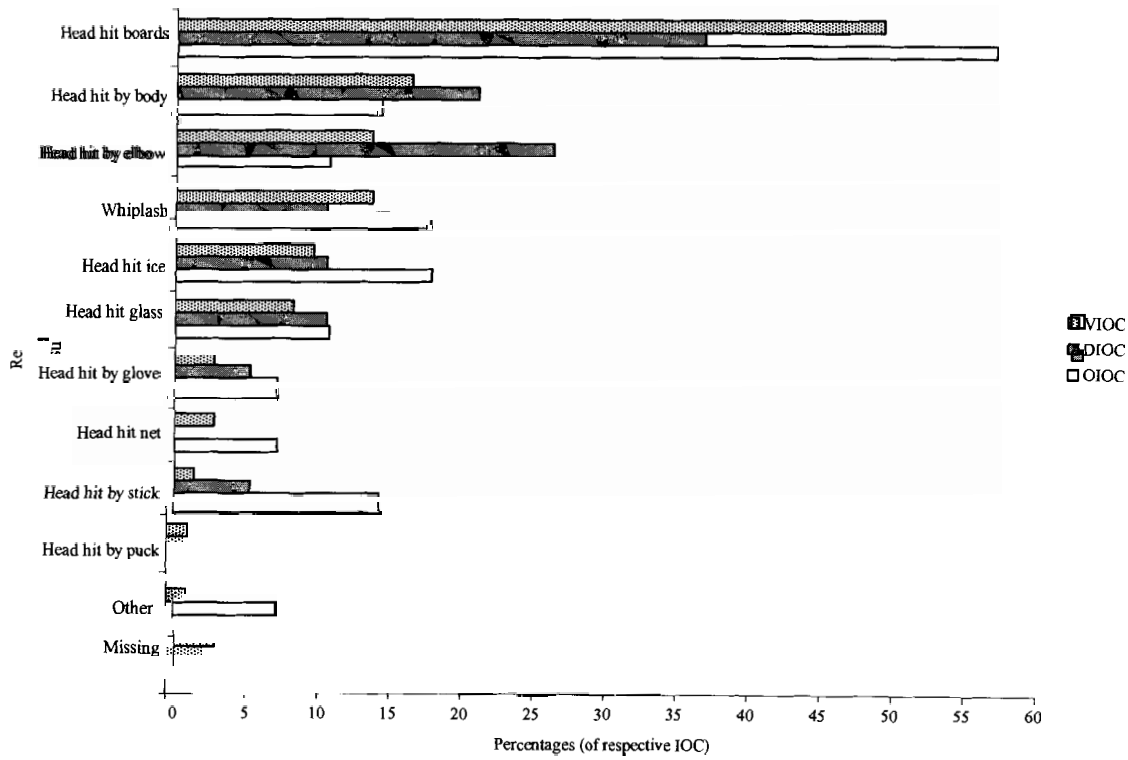
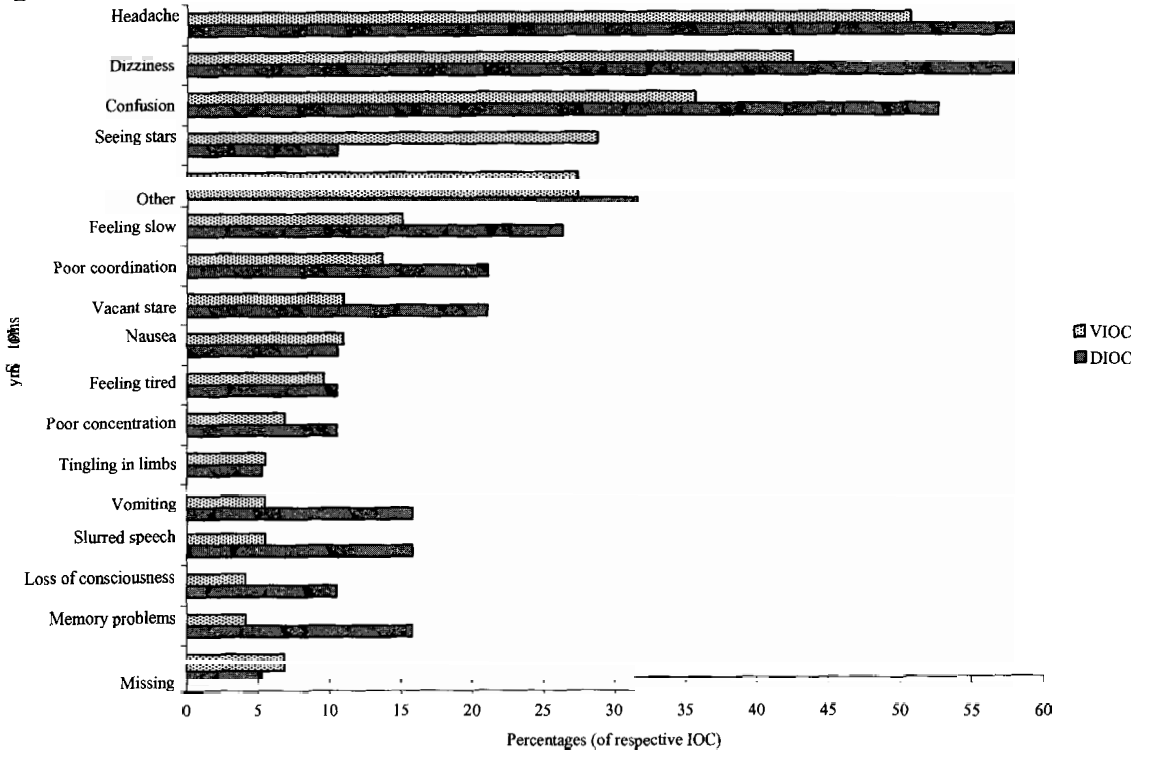


Figure 2.3 Reported symptoms presented by players who sustained VIOC and DIOC.



2.3.2 Inferential Statistics

Table 2.2 summarizes the results of the logistic regressions.

2.3.2.1 Official Reports

Among the 256 injury reports acquired from pee wee, bantam, and midget hockey in the regular season and playoffs, 35 (14%) did not report a specific injury type. However, an exact Pearson's chi-square test indicated missing cases were not significantly ($p > .05$) different from response cases on a dichotomous dummy variable (form type: Hockey Canada Injury Report; BCAHA Mutual Aid Form), thus these cases were excluded as missing at random. The variable skill category was excluded from further analyses because it was missing more than 20% of cases. Forty-three FIOC (65%) were included in the analysis after the exclusion of: eight FIOC from divisions other than pee wee, bantam, or midget and one from an unknown division; four sustained during practices; eight that did not report if they were sustained in games or practices; one sustained during preseason hockey; and one that did not report the timing of the injury.

A forced logistic regression was performed on FIOC as outcome for a set of two predictor variables: age and time. The model did not differ significantly from a constant-only model, model χ^2 (4, $N = 223$ injury reports) = 5.97, $p = .20$, and neither age or time were significantly ($p > .05$) associated with FIOC. However, as Table 2.2 illustrates, the odds of sustaining an FIOC were significantly ($p < .05$) lower in midget than pee wee hockey by nearly a factor of three.

2.3.2.2 Volunteer Reports

Approach A.

Fifty-four VIOC (74%) were included in the analysis after the exclusion of: five from preseason or tiering games, nine from tournament games, two from exhibition games, and three for which there was no exposure data available on the reporting teams. Of the 3777 games scheduled for our participating teams during the 2003-2004 season, 3642 (96.4%) were played during the regular season and playoffs.

A forced logistic regression was performed on VIOC as outcome for the set of three predictor variables: age division, skill category, and time. The model differed significantly from a constant-only model, model χ^2 (5, N = 3642 games) = 13.20, p = .02, but only age was significantly associated with VIOC, likelihood ratio χ^2 (2, N = 3642 games) = 9.70, p = .01. As shown in Table 2.2, the odds of sustaining a VIOC were reduced with increasing age division and were significantly ($p < .05$) lower in bantam and midget than in pee wee by nearly a factor of two and three, respectively.

Approach B.

Sixty-eight of the 127 volunteers (54%) reported directly on 1,679 games, of which 1,455 (87%) were played during the regular season and playoffs. The same 54 VIOC were included as in the Approach A analysis.

A forced logistic regression was performed on VIOC as outcome for the set of three predictor variables. The model was significantly different from a constant-only model, model χ^2 (5, N = 1,455 games) = 18.27, p = .003, but only age division was significantly associated with VIOC, likelihood ratio χ^2 (2, N = 1,424 games) = 15.54, $p <$ .001. As shown in Table 2.2, the odds of sustaining a VIOC were significantly ($p < .05$)

lower in bantam and midget than in pee wee by more than a factor of three and nearly a factor of three, respectively.

2.3.2.3 Doctor-confirmed Incidents of Concern

Approach A.

Fifteen DIOC remained after the exclusion of four DIOC (21%) sustained during exhibition and tournament games. A forced logistic regression was performed on DIOC as outcome for the set of three predictor variables. The model did not differ significantly from a constant-only model, model χ^2 (5, N = 3,603 games[††]) = 10.13, p = .07, and no variable was significantly ($p > .05$) associated with DIOC. However, as shown in Table 2.2, the odds of sustaining a DIOC in the second part of the regular season were significantly ($p < .05$) greater than the odds in the first part of the regular season; nearly a 3.5-factor difference.

Approach B.

A forced logistic regression was performed on the 15 DIOC as outcome for the set of three predictor variables. The model was not significantly different from a constant-only model, model χ^2 (2, N = 1,416[††]) = 7.56, p = .18 and, as shown in Table 2.2, no variable made a significant ($p > .05$) contribution to the prediction of DIOC.

2.3.2.4 Observer Reports

Over 11% (15/127) of cases were missing on OIOC, but an exact Pearson's chi-square test indicated missing cases were not significantly ($p > .05$) different from response cases on a dichotomous dummy variable (team one locality: home; away); therefore, missing cases were excluded as missing at random.

[††] The 39 VIOC that were not DIOC were excluded.

A direct Poisson regression was performed on OIOC as outcome for the set of predictor variables. The model was not significantly different from the saturated model, deviance χ^2 (106, N = 112 games) = 77.26, p = 0.98, but, as shown in Table 2.2, only skill category was significantly ($p < .05$) associated with OIOC; there were higher odds of OIOC in representative than house hockey by nearly a factor of three.

Table 2.2 Analysis of Risk Factors Across Observation Strategies

Observation Strategy	Risk Factors	Unadjusted OR	95% CI	*p*
FIOC	Age division			
	Pee wee	1.00		
	Bantam	0.67	0.30, 1.50	.33
	Midget	0.34	0.13, 0.91	.03
	Time			
	Regular season, first part	1.00		
	Regular season, second part	1.02	0.42, 2.45	.97
	Playoffs	1.08	0.41, 2.79	.88
VIOC	Age division			
Approach A	Pee wee	1.00		
	Bantam	0.51	0.27, 0.95	.03
	Midget	0.35	0.16, 0.73	.01
	Skill category			
	House	1.00		
	Representative	0.99	0.56, 1.76	.98
	Time			
	Regular season, first part	1.00		
	Regular season, second part	1.54	0.80, 2.96	.20
	Playoffs	0.71	0.35, 1.46	.35
VIOC	Age Division			
Approach B	Pee wee	1.00		
	Bantam	0.28	0.15, 0.53	.00
	Midget	0.38	0.19, 0.79	.01
	Skill category			
	House	1.00		
	Representative	0.74	0.41, 1.34	.32
	Time			
	Regular season, first part	1.00		
	Regular season, second part	1.14	0.59, 2.18	.70
	Playoffs	0.69	0.33, 1.42	.31
DIOC	Age division			
Approach A	Pee wee	1.00		
	Bantam	0.34	0.09, 1.26	.11
	Midget	0.37	0.10, 1.36	.13
	Skill category			
	House	1.00		
	Representative	1.86	0.65, 5.29	.24
	Time			
	Regular season, first part	1.00		
	Regular season, second part	3.63	1.07, 12.30	.04
	Playoffs	1.74	0.47, 6.52	.41
DIOC	Age division			
Approach B	Pee wee	1.00		
	Bantam	0.37	0.10, 1.35	.13
	Midget	0.98	0.29, 3.34	.98
	Skill category			
	House	1.00		
	Representative	2.08	0.73, 5.89	.17
	Time			
	Regular season, first part	1.00		
	Regular season, second part	2.30	0.73, 7.22	.16
	Playoffs	1.03	0.26, 4.16	.97

Observation Strategy	Risk Factors	Unadjusted OR	95% CI	*p*
OIOC	Age division			
	Pee wee	1.00		
	Bantam	0.86	0.25, 2.70	.98
	Midget	1.32	0.51, 3.57	.68
	Skill category			
	House	1.00		
	Representative	2.89	1.11. 8.88	.03
	Time			
	Regular season, first part	1.00		
	Regular season, second part	1.81	0.42, 16.52	.66
	Playoffs	1.74	0.33, 17.35	.76

2.4 Discussion

Few studies have examined the issue of concussion in youth ice hockey. This study takes important steps to better elucidate the causes of this mild traumatic brain injury and its reported management in youth hockey. Descriptive analyses identified possible risk factors based on differences in the proportions of IOC and inferential analyses facilitated the exploration of the associations between a selection of external risk factors and IOC.

2.4.1 Findings from Descriptive Analyses

With the exception of Pettersson and Lorentzon (1993), who reported stick contact as the primary mechanism causing injury on an elite Swedish team, studies commonly report contact between players (e.g. checks into the boards, collisions with other player, etc.) as the most frequent cause of injuries or concussions in hockey.[6,22,29-31,56-58] This study reiterates these findings by showing IOC occurred most frequently when players interacted through checks from behind, body checks, hits to the head, and other collisions. Moreover, the outcome of these interactions was commonly further contact through hits to the head by the body or elbow. Though body checks are allowed

through out most of the BCAHA from the pee wee age division upward, dangerous actions like checking from behind and hitting the head are most certainly illegal (all checks from behind include a game misconduct and even minor hits to the head include a 10-minute misconduct). However, despite reports that over 50% of VIOC and 31% of DIOC were caused by acts (or combinations of actions) that are against the rules of youth ice hockey, only 23% of VIOC and 16% of DIOC resulted in penalties.

Though this finding supports the assertions of Smith, Stuart and Wiese-Bjornstal (1997) and Stuart *et al.* (1995), who reported that the majority of concussions result from unpenalized actions, it also indicates the absence of a penalty call does not necessarily indicate that the action causing the concussion was legal. Macpherson, Rothman, and Howard (2006) recently demonstrated that the introduction of body checking was associated with a significantly ($p < .05$) higher risk of concussion among players aged 10 to 13 years, and Roberts *et al.* (1996) and Marcotte and Simard (1994) showed that a reduction in concussions could be achieved with the introduction of fair-play rules that reward safer play and fewer penalties.[59-61] Therefore, efforts to reduce the number of body checks and illegal plays may result in a lower occurrence of concussions, but we suggest the latter intervention, which reinforces the current rules of the game, may be easier to introduce and more readily accepted.[62-64]

Based on official injury reports, FIOC occur dramatically more often in games than practices (76% versus 6%). This observation has been reported through out the literature and indicates elements of game play elevate the likelihood of concussion beyond what can be expected simply by participating in plays and drills.[6,9,23,57,65-68]

2.4.2 Findings from Inferential Analyses

This investigation found evidence for a significant ($p < .05$) relationship between VIOC and age division, but the results contrast previously reported trends of an increase in the number of concussions with increasing age.[18,32,53] The higher risk of sustaining a concussion in pee wee hockey may be attributable to the introduction of body checking in this age division, which may generate an initial spike in concussions followed by a decrease in risk with prolonged exposure; however, a *post hoc* Pearson's chi-square test found no evidence of a significant ($p > .05$) association between body checking and VIOC. The increasing size and speeds of older players have long been alleged to cause an increase in the risk of injury, but few studies have examined how improvements in skill and awareness may contribute to a reduction in the risk of injury with time.[18,46,69] We suggest more research, which accounts for player skill and experience, is needed to better elucidate the effects of both age and body checking (especially its initial introduction) on the occurrence of concussions.

The absence of a detectable relationship between age division and IOC in the DIOC and OIOC observation strategies may be the result of a lack of statistical power due to the comparatively few IOC that were captured: 19 and 28, respectively. [Bahr and Holme (2003) recommend 20 to 50 injury cases in order to detect moderate to strong associations by way of multivariate analysis.[27]] That a relationship was not observed when using the more stringent injury inclusion criteria for DIOC may also highlight the limitations of observation strategies that do not account for the under-reporting of concussions to detect relationships.

There was evidence for a significantly ($p < .05$) higher odds of OIOC in representative hockey than house hockey, which is consistent with reports of an increase in the absolute numbers of injuries with increasing skill category.[32,52] This may indicate that representative players sustain significantly more concussions, or it shows that aspects of representative (more skilled) hockey contribute to an increased perception of the risk of concussion. Future studies considering this observation strategy will need to determine how many OIOC can be confirmed as concussions before these findings can be extrapolated and used in developing injury control policies.

2.4.3 Limitations

Our study is subject to some important limitations. First, it was assumed that explicit reports of concussions among formal injury reports were confirmatory when some may have been speculative. Second, we assumed bench personnel were capable of appropriately identifying the signs and symptoms of concussion but did not take steps to assess their awareness of concussion symptomatology. Third, caution is needed when using symptoms as the inclusion criteria because these symptoms can be associated with other conditions.[44] In addition, some concussions may not have been reported or may have gone unrecognized and the variable commitment of some volunteers may have led to under-reporting. Fourth, nearly half of all volunteers recruited for this project never submitted an IOC reporting form or a bi-monthly report. This begs the question of whether we can assume a non-report is indicative of a non-event. Fifth, with respect to OIOC, because observers did not assess the potentially injured players the observers were limited in their capacity to identify incidents that resulted in concussions. Lastly, because this study used reporting forms, it is also subject to the limitations of many surveys: (a)

there may have been a selection bias, (b) there may have been recall bias, (c) there may have been an interpretation bias, and (d) there was no assessment of internal validity.

2.5 Conclusions

To the best of our knowledge, this study is the broadest investigation of concussion in youth ice hockey to date. There were approximately 22,400 BC players registered in the pee wee, bantam, and midget age divisions during the 2003-2004 season and, by way of our multi-faceted approach to surveillance, we observed all of them to varying degrees. Our use of multiple surveillance strategies and broad injury inclusion criteria was an attempt to maximize the capture of incidents of concern and, whenever possible, we employed the multivariate analyses recommended for modern sport injury research.[26,33,70,71]

Inconsistencies in the findings across observation strategies may provide further evidence for the influence of methodological issues on the results and conclusions from epidemiological studies of sports injuries.[25,72-74] Future studies of hockey injuries should focus on incorporating more risk factors into their inferential analyses and hockey injury researchers should follow the lead of their counterparts in other sports by devising a consensus statement for injury definitions and collections procedures.[75]

2.6 References

1. Iverson GL, Gaetz M, Lovell MR, Collins MW. Cumulative effects of concussion in amateur athletes. *Brain Inj* 2004;18(5):433-443.

2. Matser EJ, Kessels AG, Lezak MD, Jordan BD, Troost J. Neuropsychological impairment in amateur soccer players. *JAMA* 1999;282(10):971-973.

3. Ruff RM, Camenzuli L, Mueller J. Miserable minority: Emotional risk factors that influence the outcome of a mild traumatic brain injury. *Brain Inj* 1996;10(8):551-565.

4. Wood RL. Understanding the 'miserable minority': a diasthesis-stress paradigm for post-concussional syndrome. *Brain Inj* 2004;18(11):1135-1153.

5. McCrea M, Hammeke T, Olsen G, Leo P, Guskiewicz KM. Unreported concussion in high school football players - implications for prevention. *Clin J Sport Med* 2004;14(1):13-17.

6. Goodman D, Gaetz M, Meichenbaum D. Concussions in hockey: there is cause for concern. *Med Sci Sports Exerc* 2001;33(12):2004-2009.

7. Williamson IJS, Goodman D. Converging evidence for the under-reporting of concussions in youth ice hockey. *Br J Sports Med.* 2006;40(2):128-132.

8. Gaetz M, Goodman D, Weinberg H. Electrophysiological evidence for the cumulative effects of concussion. *Brain Inj* 2000;14(12):1077-1088.

9. Gerberich SG, Finke R, Madden M, Priest JD, Aamoth G, Murray K. An epidemiological study of high school ice hockey injuries. *Childs Nerv Syst* 1987;3(2):59-64.

10. Zemper ED. Two-year prospective study of relative risk of a second cerebral concussion. *Am J Phys Med Rehabil* 2003;82(9):653-659.

11. Kelly JP, Nichols JS, Filley CM, Lillehei KO, Rubinstein D, Kleinschmidt-DeMasters BK. Concussion in sports. Guidelines for the prevention of catastrophic outcome. *JAMA* 1991;266(20):2867-2869.

12. Cantu RC. Second-impact syndrome. *Clin Sports Med* 1998;17(1):37-44.

13. Saunders RL, Harbaugh RE. The second impact in catastrophic contact-sports head trauma. *JAMA* 1984;252(4):538-9.

14. Cantu RC. Head injuries in sport. *Br J Sports Med* 1996;30(4):289-296.

15. Mueller FO. Sports related head and brain trauma. *N C Med J* 2001;62(6):368-372.

16. Roberts WO, Brust JD, Leonard B. Youth ice hockey tournament injuries: rates and patterns compared to season play. *Med Sci Sports Exerc* 1999;31(1):46-51.

17. Wennberg RA, Tator CH. National Hockey League reported concussions, 1986-87 to 2001-02. *Can J Neurol Sci* 2003;30(3):206-209.

18. Brust JD, Leonard BJ, Pheley A, Roberts WO. Children's ice hockey injuries. *American Journal of Diseases of Children* 1992;146(6):741-747.

19. Dryden DM, Francescutti LH, Rowe BH, Spence JC, Voaklander DC. Epidemiology of women's recreational ice hockey injuries. *Med Sci Sports Exerc* 2000;32(8):1378-1383.

20. Groger A. Ten years of ice hockey-related-injuries in the German Ice Hockey Federation - A ten year prospective study/523 international games. *Sportverletzung Sportschaden* 2001;15(4):82-86.

21. Pinto M, Kuhn JE, Greenfield ML, Hawkins RJ. Prospective analysis of ice hockey injuries at the Junior A level over the course of one season. *Clin J Sport Med* 1999;9(2):70-74.

22. Smith AM, Stuart MJ, Wiese-Bjornstal DM, Gunnon C. Predictors of injury in ice hockey players: A multivariate, multidisciplinary approach. *Am J Sports Med* 1997;25(4):500-507.

23. Stuart MJ, Smith AM, Nieva JJ, Rock MG. Injuries in youth ice hockey: A pilot surveillance strategy. *Mayo Clin Proc* 1995;70(4):350-356.

24. Sutherland GW. Fire on ice. *Am J Sports Med* 1976;4(6):264-269.

25. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med* 1992;14:82-99.

26. Meeuwisse WH. Assessing causation in sport injury: a multifactorial model. *Clin J Sport Med* 1994;4:166-70.

27. Bahr R, Holme I. Risk factor for sports injuries - a methodological approach. *Br J Sports Med* 2003;37:384-392.

28. Benson BW, Rose MS, Meeuwisse WH. The impact of face shield use on concussions in ice hockey: a multivariate analysis. *Br J Sports Med* 2002;36(1):27-32.

29. Biasca N, Simmen HP, Bartolozzi AR, Trentz O. Review of typical ice hockey injuries. Survey of the North American NHL and Hockey Canada versus European leagues. *Unfallchirurg* 1995;98(5):283-238.

30. McFaull S. Contact injuries in minor hockey: a review of the CHIRPP database for the 1998/1999 hockey season. *CHIRPP News* 2001;19:1-9.

31. Reid SR, Losek JD. Factors associated with significant injuries in youth ice hockey players. *Pediatr Emerg Care* 1999;15(5):310-313.

32. Willer B, Kroetsch B, Darling S, Hutson A, Leddy J. Injury rates in house league, select, and representative youth ice hockey. *Med Sci Sports Exerc.* 2005;37(10):1658-1663.

33. Meeuwisse W, Love E. Athletic injury reporting: development of universal systems. *Sports Med* 1997;24:184-204.

34. Hockey Canada. *Hockey Canada Injury Report* (2005 September). Available: http://members.hockeycanada.ca/downloads/insurance/English%20Injury%20Reports/BC.pdf (accessed 2006 June 2).

35. Schulz MR, Marshall SW, Mueller FO, Yang J, Weaver NL, Kalsbeek WD, Bowling JM. Incidence and risk factors for concussion in high school athletes, north Carolina, 1996-1999. *Am J Epidemiol* 2004;160(10):937-44.

36. Hockey Canada. *Hockey Canada Injury Report* (2005 September). Available: http://members.hockeycanada.ca/downloads/insurance/English%20Injury%20Reports/BC.pdf (accessed 2006 June 2).

37. Jackson T. *Canadian Hockey Association Safety Net.* 1st ed. Available: http://www.hockeycanada.ca/multimedia/e/develop/insurance/downloads/safety_net_e.pdf (accessed 2006 June 2).

38. Aubrey JB, Dobbs AR, Rule BG. Laypersons knowledge about the sequelae of minor head injury and whiplash. *J Neurol Neurosurg Psychiatry* 1989;52(7):842-846.

39. Alves W, Macciocchi S, Barth J. Postconcussive symptoms after uncomplicated mild head injury. *J Head Trauma Rehabil* 1993;8(3):48-49.

40. Covassin T, Swanik B, Sachs M. Epidemiological considerations of concussions among intercollegiate athletes. *Appl Neuropsychol* 2003;10(1):12-22.

41. Guskiewicz KM, Weaver NL, Padua DA, Garrett WE. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;28(5):643-650.

42. Macciocchi SN, Barth JT, Alves W, Rimel RW, Jane JA. Neuropsychological functioning and recovery after mild head injury in collegiate athletes. *Neurosurgery* 1996;39(3):510-514.

43. Ruff RM, Crouch JA, Troster AI, Marshall LF, Buchsbaum MS, Lottenberg S, Somers LM. Selected cases of poor outcome following a minor brain trauma: Comparing neuropsychological and positron emission tomography assessment. *Brain Inj* 1994;8(4):297-308.

44. Dikmen SS, Levin HS. Methodological issues in the study of mild head injury. *J Head Trauma Rehabil* 1993;8(3):30-37.

45. Schick DM, Meeuwisse WH. Injury rates and profiles in female ice hockey players. *Am J Sports Med* 2003;31(1):47-52.

46. Daffner RH. Injuries in Amateur Ice Hockey - 2-Year Analysis. *J Fam Pract* 1977;4(2):225-227.

47. Wennberg R. Collision frequency in elite hockey on North American versus International size rinks. *Can J Neurol Sci* 2004;31(3):373-377.

48. Wennberg R. Effect of ice surface size on collision rates and head impacts at the world junior hockey championships, 2002 to 2004. *Clin J Sport Med* 2005;15(2):67-72.

49. SPSS. *SPSS Base 14.0 User's Guide.* Chicago: SPSS Inc., 2005.

50. Tabachnik BG, Fidell LS. *Using multivariate statistics*. 4th ed. Needham Heights: Allyn & Bacon, 2001.

51. Field A. *Discovering Statistics: using SPSS for Windows. Introducing Statistical Methods*. Thousand Oaks: Sage Publications Ltd, 2000.

52. Sim FH, Simonet WT, Melton LJ, Lehn TA. Ice hockey injuries. *Am J Sports Med* 1987;15(1):30-40.

53. Hostetler SG, Xiang H, Smith GA. Characteristics of ice hockey-related injuries treated in US emergency departments, 2001-2002. *Pediatrics* 2004;114(6):e661-6.

54. Rubin DB. Inference and missing data. *Biometrika* 1976;63(3):582-92.

55. Madow WG, Nisselson H, Olkin I. *Incomplete Data In Sample Surveys*. Vol. 1. New York: Academic Press, 1983.

56. Tegner Y, Lorentzon R. Ice hockey injuries: incidence, nature and causes. *Br J Sports Med* 1991;25(2):87-89.

57. Pettersson M, Lorentzon R. Ice hockey injuries: A 4-year prospective study of a Swedish elite ice hockey team. *Br J Sports Med* 1993;27(4):251-254.

58. Delaney JS, Puni V, Rouah F. Mechanisms of injury for concussions in University football, ice hockey, and soccer: a pilot study. *Clin J Sport Med* 2006;16(2):162-65.

59. Macpherson A, Rothman L, Howard A. Body-checking rules and childhood injuries in ice hockey. *Pediatrics* 2006;117(2):e143-e147.

60. Marcotte G, Simard D. *Fair-Play: An Approach to Hockey for the 1990s.* Safety in Ice Hockey: Second Volume 1993:103-108.

61. Roberts WO, Brust JD, Leonard B, Hebert BJ. Fair-play rules and injury reduction in ice hockey. *Arch Pediatr Adolesc Med* 1996;150(2):140-145.

62. Cantu RC. Cerebral concussion in sport: management and prevention. *Sports Med* 1992;14(1):64-74.

63. Canadian Academy of Sports Medicine Concussion Committee. Guidelines for assessment and management of sport-related concussion. *Clin J Sport Med* 2000;10(3):209-211.

64. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport* 2006;9:3-9.

65. Roberts WO. Factors that predict intercollegiate ice hockey injuries. *Clin J Sport Med* 1999;9(4):248.

66. Tegner Y, Lorentzon R. Concussion among Swedish elite ice hockey players. *Br J Sports Med* 1996;30(3):251-255.

67. Jorgensen U, Schmidt-Olsen S. The epidemiology of ice hockey injuries. *Br J Sports Med* 1986;20(1):7-9.

68. Benson BW, Mohtadi NG, Rose MS, Meeuwisse WH. Head and neck injuries among ice hockey players wearing full face shields vs half face shields. *JAMA* 1999;282(24):2328-2332.

69. Roy MA, Bernard D, Roy B, Marcotte G. Body checking in pee wee hockey. *The Physician and Sportsmedicine* 1989;17(3):119-126.

70. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med.* 2005;39(6):324-329.

71. Meeuwisse WH, Fowler PJ. Frequency and predictability of sports injuries in intercollegiate athletes. *Canadian Journal of Sport Sciences* 1988;13(1):35-42.

72. Brooks JHM, Fuller CW. The influence of methodological issues on the results and conclussions from epidemiological studies of sports injuries. *Sports Med* 2006;36(6):459-72.

73. Langley J. Challenges for surveillance for injury prevention. *Inj Control Saf Promot* 2004;11(1):3-8.

74. Pelletier RL, Montelpare WJ, Stark RM. Intercollegiate ice hockey injuries. A case for uniform definitions and reports. *Am J Sports Med* 1993;21(1):78-81.

75. Fuller CW, Ekstrand J, Junge A, Andersen TE, Bahr R, Dvorak J, Hagglund M, McCrory P, Meeuwisse WH. Consensus statement on injury definitions and data collections procedures in studies of football (soccer) injuries. *Br J Sports Med* 2006;40:193-201.

Chapter 3:
The Occurrence and Management of Probable Concussions as Reported by Elite Youth Ice Hockey Players over a 4-Year Period

3.1 Introduction

Concussions are brain injuries resulting from impulsive blows to the head and can cause neuropsychological deficits and the expression of symptoms consistent with post concussion syndrome.[1-5] Perceptible consequences typically subside within weeks, but symptoms have been reported to linger for periods of a year or longer and there is growing evidence for the cumulative effects of multiple concussions and an increased risk of recurrent injury following an initial concussion .[3,6-14] In rare cases, multiple concussions have even led to the catastrophic autonomic dysfunction that characterizes Second Impact Syndrome.[15-18]

Increased awareness of these harmful consequences, as well as reports of high-profile athletes sidelined by sport-related concussions, have led to the development of concussion management programs throughout sports, including ice hockey. The National Hockey League and the Ontario Hockey League concussion programs and studies within Canadian Interuniversity Sport have provided concussion surveillance and guidance at the professional, semi-professional, and collegiate levels, respectively. However, a formal concussion management program does not yet exist for youth ice hockey in Canada, despite overwhelming evidence that these children are at risk.[6,19-30] Hockey Canada has developed concussion guidelines for their Safety Program but there are no steadfast or enforceable rules. Consequently, concussion recognition and management typically lies

with players, parents and team personnel rather than the prescribed medical professionals.[31]

Concussions in North American youth ice hockey have been reported to occur at rates comparable to the NHL (23.15 and 29.59 concussions per 1000 player-hours, respectively) and elite youth hockey players, who are competing for positions on junior or major-junior clubs, may be particularly at risk.[32,33] These athletes play with intensity comparable to their professional counterparts, yet their histories of traumatic brain injures are often unknown or obscured.[34] In this study, we sought to better understand the occurrence and management of concussions in elite youth ice hockey by surveying players competing in two annual tournaments over four consecutive years. This approach also allowed us to investigate possible changes in the epidemiology and management of these injuries with time. Understanding the prevalence of concussions at this level may provide insight into the number of athletes entering collegiate or semi-professional hockey with a history of head injuries, and identifying the risk factors may help prevent future concussions. This information could be of value to youth hockey organizations working toward reducing the occurrence of concussions, to sports medicine practitioners and athletic therapists who may need to manage future concussions, as well as to the young athletes whose head injury history may affect them for the rest of their lives.

3.2 Methods

The Hockey Head Injury History Assessment (HHIHA) was developed in-house to survey players about their history of hockey-related head injury. The HHIHA ascertains whether an athlete has ever sustained "a significant hit to the head while playing hockey" and when applicable: (a) the details associated with their most recent

significant hit to the head, (b) the symptoms they experienced, (c) how the head injury was managed, (d) decisions regarding return to play, and (e) attitudes about head injuries. (A copy of the HHIHA is provided in Appendix D.) Retrospective injury surveys have been used in numerous studies to estimate concussion or head injury incidence and to assess the risk factors associated with these injuries.[6,26,35-37]

Male hockey players attending the British Columbia Amateur Hockey Association's (BCAHA) Best Ever tournaments from 2001 through 2004 were invited to participate. There are two annual male tournaments categorized according to age: Under-16 and Under-17 years. Each year, players compete at assessment camps across BC for the opportunity to represent their region in the tournaments. Arguably the best players in each region are selected by BCAHA-appointed personnel. Every region in BC is represented at each tournament through district teams, with eight and six teams competing in the Under-16 and Under-17 tournaments, respectively. This survey summarizes the results of HHIHA completed by samples of players competing in eight separate tournaments over the four years. HHIHA were completed under the supervision of a researcher and a member of each district team's personnel. Participation was completely voluntary, all reports were anonymous, and all individual data were kept strictly confidential. The Office of Research Ethics at Simon Fraser University and the BCAHA Executive approved the study.

Reports of significant hits to the head that resulted in the presentation of concussion symptoms were classified as significant symptomatic head hits (SSHH); a

SSHH was considered indicative of a concussion.[‡‡] In some cases participants from the Under-16 tournament competed in the Under-17 tournament the following year. Therefore, HHIHA were carefully screened for reports of the same SSHH in two consecutive years. When SSHH details from both tournaments matched the second report was excluded. Players competing in both tournaments who did not report a SSHH were considered exposed in both years.

Analyses of factors related to each SSHH were performed using descriptive statistics expressed as percentages or, when applicable, exact Pearson's chi-square tests. The lifetime prevalence of SSHH per 100 players was calculated as the `(number of SSHH/ total number of athletes at risk) × 100`. Exact binomial confidence intervals were calculated as recommended by Clopper and Pearson (1934).[38,39] A direct binary logistic regression was performed on SSHH status (SSHH versus no significant head hit) as response variable against four predictor variables: year, tournament (Under-16 or Under-17), district, and position. Four districts from the Under-16 tournament (Fraser Valley and Fraser River, and North East and North West) were collapsed into two categories similar to those represented at Under-17 tournaments (Fraser and North, respectively) to facilitate comparison across tournaments. All statistical analyses were carried out using the Statistical Package for the Social Sciences, version 14.0.[40]

[‡‡] Though caution is needed when using symptoms as a qualifying criteria for concussions, there remains a heavy reliance on post concussion symptoms in diagnosing concussions and lay people appear able to recognize the common symptoms associated with minor head injury.

3.3 Results

3.3.1 Demographics

Between 2001 and 2004, 591 HHIHA were completed by elite male hockey players; approximately 50% of all tournament participants completed a questionnaire. The mean ages of participants in the Under-16 and Under-17 tournaments were 14.84 and 15.89 years (SD = 0.84 and 0.85), respectively. A total of 195 players (33%) reported that they had sustained a hockey-induced significant hit to the head in their lifetime, 169 of whom reported suffering from at least one concussion symptom following the incident. Fifty-five players (9%) were missing data on one or more variables: 21 players (4%) did not report if they had sustained a hockey-induced significant hit to the head, 26 (4%) did not report if they had presented symptoms following a significant hit to the head, and 8 (1%) did not report their position, including 1 player who had sustained a SSHH. There was no significant ($p > .05$) differences between missing and complete cases when analyzed with an exact Pearson's chi-square tests of SSHH (response versus missing) against a dichotomous dummy variable; therefore, these cases were excluded as missing at random.[41] Table 3.1 summarizes the occurrence of SSHH by four predictor variables: year, tournament, district, and position. A test of the model with all four predictor variables was not significantly different from a constant-only model, χ^2 (10, N = 536 players) = 7.15, p = .71, indicating that there is no evidence the predictor variables, as a set, reliably predict SSHH. Likelihood ratio chi-square statistics for each predictor variable were also not significant ($p > .05$), indicating there is no evidence that year, tournament, district, or position are independently associated with the occurrence of

SSHH. This allowed the collapsing of SSHH across years, tournaments, districts, and positions.

Table 3.1 SSHH Occurrence Across Years, Tournaments, Districts, and Positions

Predictor Variables	Players Who Sustained a SSHH	Players At Risk	Percentage of Players
Year			
2001	37	98	38
2002	52	197	27
2003	35	113	31
2004	45	136	33
Total	169	544	31
Tournament			
Under-16 Years	65	190	34
Under-17 Years	104	354	29
Total	169	544	31
District			
Fraser	50	142	35
Greater Vancouver	18	54	33
Kootenay	24	88	27
North	16	63	25
Okanagan	47	150	31
Vancouver Island	14	47	30
Total	169	544	31
Position			
Forward	91	303	30
Defence	60	170	35
Utilitya	4	9	44
Goalie	13	54	24
Total	168[b]	536[c]	31

[a]Utility players reported playing both forward and defence. [b]One player who sustained a SSHH did not report their position. [c]Eight players did not report their positions.

One hundred fifty-five SSHH (92%) were sustained during games and seven (4%) during practices; seven (4%) other players did not report the setting. The prevalence estimates of SSHH per 100 players (with 95% CI in parentheses) for games and practices were 28.9 (25.1, 32.9) and 1.3 (0.5, 2.7), respectively. Clearly, and as expected, the prevalence of SSHH in games was significantly ($p < .05$) higher than in practices.

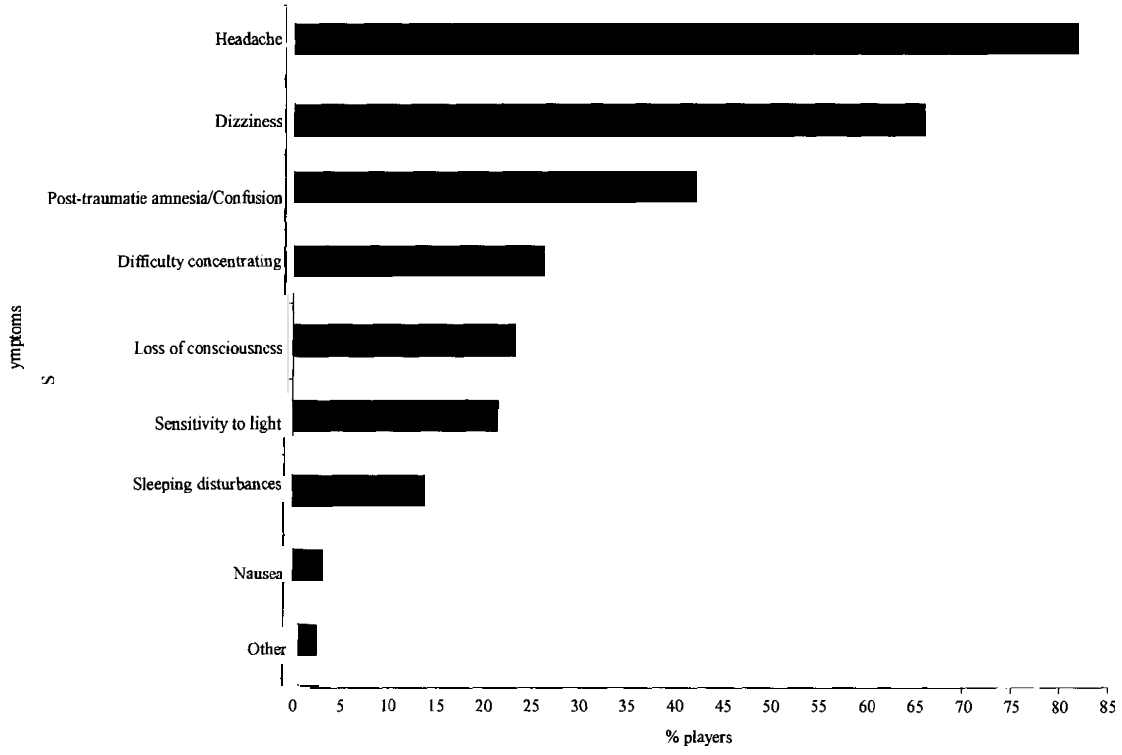
Among the athletes reporting a SSHH, 154 (91%) reported their age when injured. Ages ranged between 8 and 16 years and the mean was 13.64 (SD = 1.42). Seventy-three players (55%) were playing full contact hockey (body checking permitted) when they sustained the SSHH, 29 (22%) were playing hockey that did not permit full contact, and 30 (23%) did not specify. Thirty-five players (21%) reported at least one other hockey-related SSHH during their lifetimes, and 27 (16%) reported at least one SSHH outside of hockey. Twelve players (7%) who reported additional hockey-induced SSHH also reported sustaining at least one SSHH outside of hockey. Table 3.2 summarizes the numbers and percentages of players who sustained other SSHH in their lifetimes. Nearly 30% of players who reported a SSHH also reported previous symptomatic hits to head.

Table 3.2 Numbers of Players Who Have Sustained Previous SSHH

Previous SSHH	*N*	Percentage Who Sustained a SSHH
1 or more	50	30
2 or more	35	21
3 or more	14	8
4 or more	6	4

Figure 3.1 shows the percentage of players reporting different symptoms following their most recent SSHH. (Athletes were able to report multiple symptoms.) Headache and dizziness are clearly the most frequently cited symptoms with 138 and 111 players experiencing these effects, respectively. Post-traumatic amnesia and loss of consciousness, two symptoms used to qualify severity in early grading schemes, were reported by 71 and 39 players, respectively.[42,43]

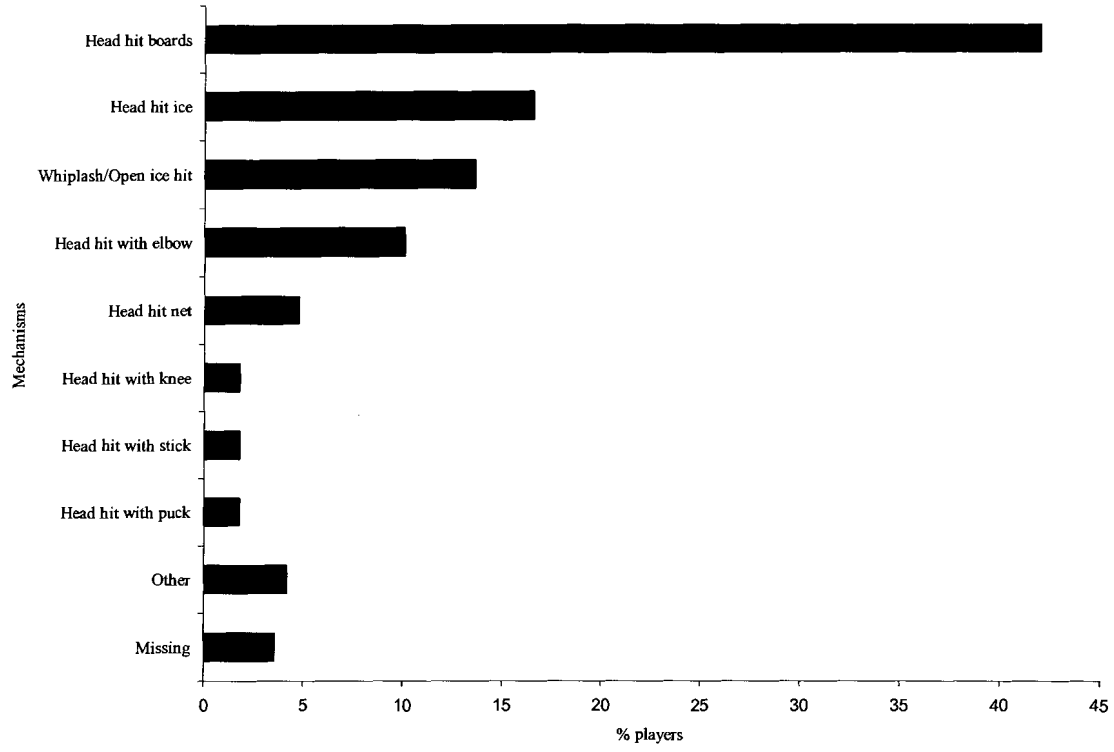
Figure 3.1 Frequencies of symptoms experienced by players reporting SSHH.



3.3.2 Causes

Figure 3.2 shows the causes of SSHH reported by players. By far, the most frequently reported mechanism was the head striking the boards, followed by the head hitting the ice, whiplash or open ice hits, and hits to the head with the elbow. "Other" causes included: being crushed by a falling opponent (2%), a cross-check (1%), a skate to the head (1%), and unspecified (1%). No athlete reported sustaining a SSHH as a result of a fight or punch.

Figure 3.2 Frequencies of mechanisms players reported caused SSHH.



Eighty respondents (47%) indicated they felt another player caused the SSHH and nine (5%) did not specify. Among the respondents reporting their SSHH was caused by another athlete: 29 incidents (36%) resulted in a major penalty and 24 (30%) resulted in a minor penalty.

3.3.3 Treatment

Nearly half (47%) of all players who reported sustaining a SSHH did not specify who examined them after the incident, but among those who did respond: 30 (34%) were examined by a doctor, 24 (27%) by a safety person or trainer, 18 (20%) were not examined, 9 (10%) were examined by a coach, 4 (5%) by a parent, and 4 (5%) by some one else. Seventy players (41%) were taken to hospital following their SSHH and five players (3%) did not specify.

Players surveyed from 2002 onward were asked if they were still experiencing symptoms when they returned to play: 25 players (19%) were symptomatic, 98 (74%) were not, and 9 (7%) did not specify. An exact Pearson's chi-square test was not significant ($p > .05$), indicating that there was no evidence of significant differences in the proportions of players returning to competition when symptomatic across tournament years. Figure 3.3 shows the time span before athletes who sustained SSHH returned to play. The majority of players (61%) did not play for at least two days, but over one third (34%) returned the same day or the next day.

Figure 3.3 Frequencies of time span before players reported returning to play after SSHH.

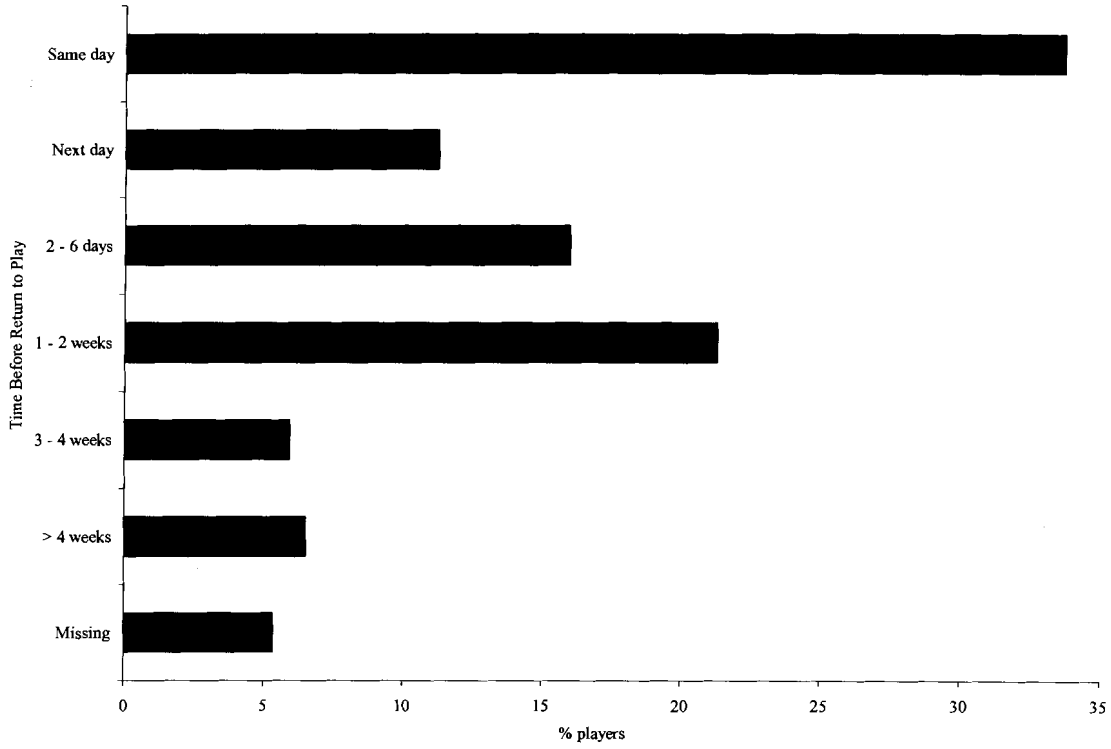
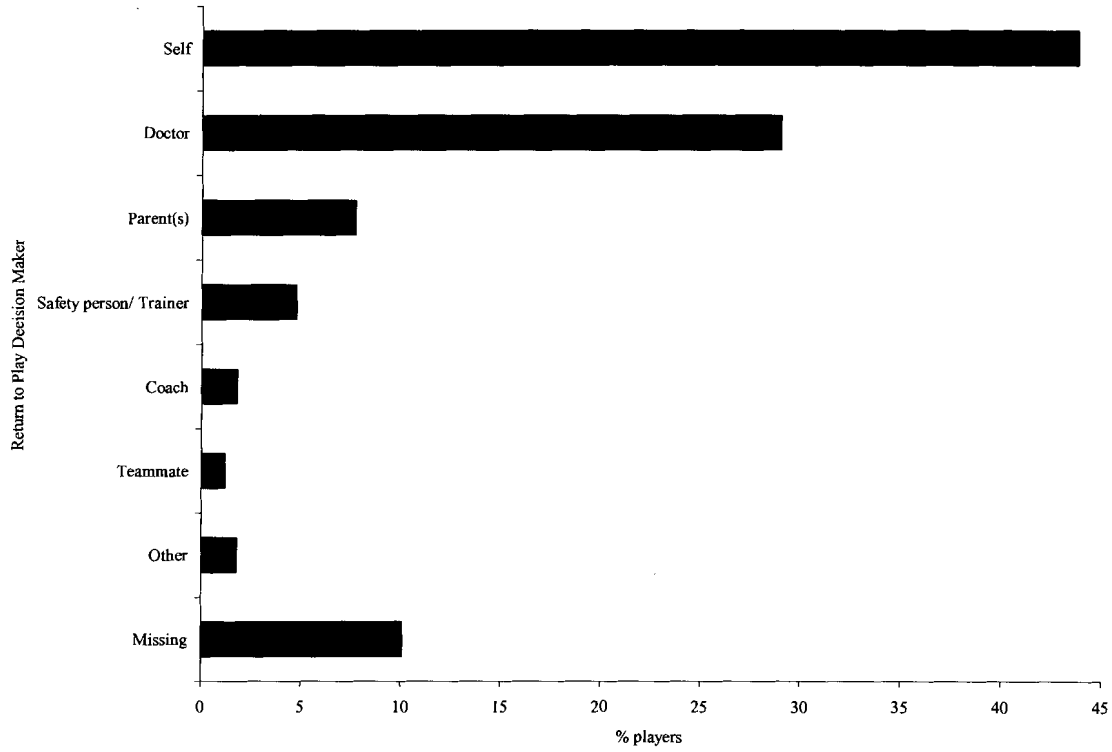


Figure 3.4 shows who players indicated made the decision about when they should return to play. Although over a third of players (34%) sought guidance from doctors and safety people or trainers, individuals with some training in recognizing and

managing concussions, the majority (44%) made their own decision about when to return to competition. Sixty-one players (36%) reported that they were tested at exercise before they returned to play, 103 (61%) reported they were not, and 5 (3%) players did not specify.

Figure 3.4 Frequencies of people who players reported made the decision about return to play.



3.3.4 Prevention

Almost all players (99%) reported wearing a helmet when they sustained a SSHH. Among the three players (2%) not wearing a helmet, one (1%) was injured during a practice, one (1%) during a warm-up, and the other (1%) did not specify the setting. Nearly all players (95%) also reported wearing a face shield when they sustained a SSHH. Among the four players (2%) not wearing a face shield, one (1%) was injured during a warm-up and the remainder (2%) during games; five players (3%) did not

specify. Players surveyed from 2002 onward also reported on their use of mouth guards: 226 (51%) and 58 (11%) reported wearing a mouth guard during games and practices, respectively, and 13 (3%) did not respond to these questions. An exact Pearson's chi-square test of the independence of SSHH outcomes and mouth guard use in games was not significant, χ^2 (1, N = 213 players) = .06, p = .89; therefore, there was no evidence to indicate wearing a mouth guard during games reduced the likelihood of sustaining a SSHH during games.[§§]

3.3.5 Attitudes

The majority of surveyed players, 463 (78%), reported that they were not concerned about sustaining a concussion, 96 (16%) were concerned, and 32 (5%) did not specify. An exact Pearson's chi-square test of SSHH outcomes and concern about concussions was not significant, χ^2 (1, N = 513 players) = 1.62, p = .25; therefore, there was no evidence to indicate players who have sustained a SSHH are more concerned about this injury than those with no history of a SSHH. Players surveyed in 2001 reported on their use of "special" equipment to prevent concussions. Seventeen players (16%) reported they did not use special equipment, but 70 players (65%) reported they used a mouth guard, a "concussion" helmet, or both, to help prevent concussions; 21 players (19%) did not specify.

3.4 Discussion

This study sought to better understand the occurrence of concussion in elite youth ice hockey with the intent of informing decision makers and medical professionals and, in

[§§] The low numbers of SSHH sustained during practices did not allow for a similar chi-square test on mouth guard use and SSHH occurrence in practices.

turn, reducing its frequency. The prevalence of SSHH sustained during games, 28.9 per 100 players, was considerably higher than head injury estimates previously reported within male youth hockey, which range between 0 and 7.2 per 100 players. Our estimate was greater than those from professional, semi-professional and recreational adult hockey, which range between 3.9 and 20 per 100 players.[6,24,25,28,35,36,44,45] The prevalence of SSHH sustained during practices however, 1.3 per 100 players, is comparable to past studies, which range between 0.45 and 11.21 per 100 players.[6,7,26,35,38,44,45] Differences in the methods used and populations examined make comparisons between studies difficult, but our prevalence estimates serve as overwhelming evidence that concussions are occurring in elite youth ice hockey and that these players are at a higher risk than may have been anticipated given their young age.

The prevalence estimates reported in this study lend considerable support to an observation reported consistently across investigations of hockey injuries: the higher occurrence of concussions in games than practices.[23,24,27,35,36,46-49] We observed over a 20-factor difference between game and practice prevalence in elite youth hockey, indicating a possible increase in the number and influence of concussion risk factors during game play.[50] Previous studies have also consistently reported goalies to sustain fewer concussions than forwards and defence. Though this may be the story told by absolute numbers, our analysis indicates all positions have similar odds of sustaining a SSHH in elite youth ice hockey; therefore, strategies to reduce the occurrence of these injuries should focus on all positions.[19,21,35,47,51,52]

Like other investigation, this study found the most commonly reported symptoms of concussion were headache, dizziness, and post-traumatic amnesia.[13,35] It also found the

majority of players reporting a SSHH did not report a loss of consciousness, indicating that youth hockey players recognize a loss of consciousness is not the only qualifying symptom of concussion. The causes of SSHH observed in this study are also consistent with the literature. Head contact with the boards and ice, whether or not the result of a collision with another player, are consistently reported as the most common mechanism of injuries, including concussions.[22,24,27,28,33,48,49] Therefore, strategies to reduce the number and intensity of these impacts may lead to a reduction in the prevalence of traumatic brain injuries. This study also found that over 34.3% of all SSHH were reported to have been caused by an action that was penalized. This level of penalization is higher than previously reported but reiterates that the majority of concussions are sustained during plays that do not result in penalties.[24,35,48,49]

There has been speculation that the reporting of concussions is improving with increasing education and prevention efforts, as well as in response to recent reports of high-profile athletes sidelined by the consequences of concussions.[53,54] However, this study found no evidence of a significant ($p > .05$) difference in the reporting of SSHH among years. To the contrary, with over 20% of athletes who reported a SSHH choosing not to seek guidance for their injury assessment and management, this study lends further support to findings of a drastic under-reporting of concussions in youth ice hockey.[34,35]

Among athletes reporting a hockey-related SSHH: (a) nearly half made their own decision about when to return to play, (b) over a fifth reported they were symptomatic when they returned, (c) nearly a third reported they were tested at exercise before returning, and (d) more than one third reported they returned to the same game. In total, 135 athletes reporting a SSHH (79.9%) did not follow the concussion guidelines of the

Hockey Canada Safety Program and those outlined by the Concussion in Sport Group.[1,55] Moreover, there was no significant ($p > .05$) reduction, over the years, in the number of players who returned to play when symptomatic. This may perhaps indicate that warnings about the risks of concussions and the key strategies for their management are not reaching players or are not being heard.

There have been numerous proposals that mouth guards may reduce the risk of concussions and they have been marketed accordingly (our findings indicate over 50% of surveyed players use mouth guards with the intent of preventing concussions).[56-58] Yet, despite their clear value in the prevention of dental and facial injuries, there has been little substantive evidence that mouth guards prevent concussions and this study found no evidence of a protective effect.[59] It is imperative that players are reminded no equipment can completely prevent concussions and that genuine concussion control is more likely to be achieved through safe and respectful hockey. We also need to help players understand that concussions can be a genuine threat in youth ice hockey, one that can change the direction of their hockey careers or eliminate them entirely. With over 75% of players reporting that they are not concerned about sustaining a concussion while playing hockey, there is clearly more work to be done.

This study is subject to limitations consistent with many retrospective surveys: (a) there may have been a selection bias, (b) there may have been recall bias, (c) there may have been an interpretation bias, and (d) there was no assessment of internal validity.

3.5 Conclusions

We suggest the high prevalence of SSHH in elite youth ice hockey is a cause for concern and warrant for further investigation of a group of athletes likely to continue

playing highly competitive hockey for many years. We suggest steps can be taken to reduce their occurrence, including stricter rule enforcement, increasing understanding of the consequences of this injury, and improved adherence to Hockey Canada concussion management guidelines.

3.6 References

1. Aubry M, Cantu R, Dovrak J, Graf-Baumann T, Johnston K, Kelly J, Lovell M, McCrory P, Meeuwisse W, Schamasch P. Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001. *Br J Sports Med* 2002;36(2):6-10.
2. Grindel SH. Epidemiology and pathophysiology of minor traumatic brain injury. *Curr Sports Med Rep* 2003;2(1):18-23.
3. Gronwall D, Wrightson P. Delayed recovery of intellectual function after minor head injury. *Lancet* 1974;2(7881):605-609.
4. Cantu RC. Cerebral concussion in sport: management and prevention. *Sports Med* 1992;14(1):64-74.
5. Macciocchi SN, Barth JT, Alves W, Rimel RW, Jane JA. Neuropsychological functioning and recovery after mild head injury in collegiate athletes. *Neurosurgery* 1996;39(3):510-514.
6. Gerberich SG, Finke R, Madden M, Priest JD, Aamoth G, Murray K. An epidemiological study of high school ice hockey injuries. *Childs Nerv Syst* 1987;3(2):59-64.
7. Zemper ED. Two-year prospective study of relative risk of a second cerebral concussion. *Am J Phys Med Rehabil* 2003;82(9):653-659.
8. Iverson GL, Gaetz M, Lovell MR, Collins MW. Cumulative effects of concussion in amateur athletes. *Brain Inj* 2004;18(5):433-443.
9. Gaetz M, Goodman D, Weinberg H. Electrophysiological evidence for the cumulative effects of concussion. *Brain Inj* 2000;14(12):1077-1088.
10. Naunheim RS, Standeven J, Richter C, Lewis LM. Comparison of impact data in hockey, football, and soccer. *J Trauma* 2000;48(5):938-941.
11. Gennarelli TA, Thibault, L.E., Graham, D.I. Diffuse axonal injury: an important form of traumatic brain damage. *Neuroscientist* 1998;4:202-15.
12. Collins MW, Lovell MR, Iverson GL, Cantu RC, Maroon JC, Field M. Cumulative effects of concussion in high school athletes. *Neurosurgery* 2002;51(5):1175-1179.
13. Guskiewicz KM, Weaver NL, Padua DA, Garrett WE. Epidemiology of concussion in collegiate and high school football players. *Am J Sports Med* 2000;28(5):643-650.
14. Alves W, Macciocchi S, Barth J. Postconcussive symptoms after uncomplicated mild head injury. *J Head Trauma Rehabil* 1993;8(3):48-49.

15. Kelly JP, Nichols JS, Filley CM, Lillehei KO, Rubinstein D, Kleinschmidt-DeMasters BK. Concussion in sports. Guidelines for the prevention of catastrophic outcome. *JAMA* 1991;266(20):2867-2869.

16. Cantu RC. Second-impact syndrome. *Clin Sports Med* 1998;17(1):37-44.

17. Saunders RL, Harbaugh RE. The second impact in catastrophic contact-sports head trauma. *JAMA* 1984;252(4):538-9.

18. McQuillen JB, McQuillen EN, P. M. Trauma, sport, and malignant cerebral edema. *Am J Forensic Med Pathol* 1988;9(1):12-15.

19. Brust JD, Leonard BJ, Pheley A, Roberts WO. Children's ice hockey injuries. *American Journal of Diseases of Children* 1992;146(6):741-747.

20. Dryden DM, Francescutti LH, Rowe BH, Spence JC, Voaklander DC. Epidemiology of women's recreational ice hockey injuries. *Med Sci Sports Exerc* 2000;32(8):1378-1383.

21. Groger A. Ten years of ice hockey-related-injuries in the German Ice Hockey Federation - A ten year prospective study/523 international games. *Sportverletzung Sportschaden* 2001;15(4):82-86.

22. McFaull S. Contact injuries in minor hockey: a review of the CHIRPP database for the 1998/1999 hockey season. *CHIRPP News* 2001;19:1-9.

23. Pinto M, Kuhn JE, Greenfield ML, Hawkins RJ. Prospective analysis of ice hockey injuries at the Junior A level over the course of one season. *Clin J Sport Med* 1999;9(2):70-74.

24. Reid SR, Losek JD. Factors associated with significant injuries in youth ice hockey players. *Pediatr Emerg Care* 1999;15(5):310-313.

25. Roberts WO, Brust JD, Leonard B. Youth ice hockey tournament injuries: rates and patterns compared to season play. *Med Sci Sports Exerc* 1999;31(1):46-51.

26. Roy MA, Bernard D, Roy B, Marcotte G. Body checking in pee wee hockey. *The Physician and Sportsmedicine* 1989;17(3):119-126.

27. Smith AM, Stuart MJ, Wiese-Bjornstal DM, Gunnon C. Predictors of injury in ice hockey players: A multivariate, multidisciplinary approach. *Am J Sports Med* 1997;25(4):500-507.

28. Stuart MJ, Smith AM, Nieva JJ, Rock MG. Injuries in youth ice hockey: A pilot surveillance strategy. *Mayo Clin Proc* 1995;70(4):350-356.

29. Sutherland GW. Fire on ice. *Am J Sports Med* 1976;4(6):264-269.

30. Macpherson A, Rothman L, Howard A. Body-checking rules and childhood injuries in ice hockey. *Pediatrics* 2006;117(2):e143-e147.

31. Hockey Canada. *Safety Program: Concussion Awareness*. Available: http://www.hockeycanada.ca/7/6/9/9/index1.shtml (accessed June 2, 2006).

32. Wennberg RA, Tator CH. National Hockey League reported concussions, 1986-87 to 2001-02. *Can J Neurol Sci* 2003;30(3):206-209.

33. Roberts WO. Factors that predict intercollegiate ice hockey injuries. *Clin J Sport Med* 1999;9(4):248.

34. Williamson IJS, Goodman D. Converging evidence for the under-reporting of concussions in youth ice hockey. *Br J Sports Med.* 2006;40(2):128-132.

35. Goodman D, Gaetz M, Meichenbaum D. Concussions in hockey: there is cause for concern. *Med Sci Sports Exerc* 2001;33(12):2004-2009.

36. Tegner Y, Lorentzon R. Concussion among Swedish elite ice hockey players. *Br J Sports Med* 1996;30(3):251-255.

37. Hockey Canada. *Hockey Canada Injury Report* (2005 September). Available: http://members.hockeycanada.ca/downloads/insurance/English%20Injury%20Reports/BC.pdf (accessed 2006 June 2).

38. Clopper CJ, Pearson ES. The use of confidence or fiducial limits illustrated in the case of the binomial. *Biometrika* 1934;26:404-13.

39. Fleiss JL, Levin B, Myunghee CP. *Statistical Methods for Rates and Proportions. Wiley Series in Probability and Statistics*. 3rd ed. New Jersey: John Wiley & Sons, Inc., 2003.

40. SPSS. *SPSS Base 14.0 User's Guide*. Chicago: SPSS Inc., 2005.

41. Tabachnik BG, Fidell LS. *Using multivariate statistics*. 4th ed. Needham Heights: Allyn & Bacon, 2001.

42. Cantu RC. Return to play guidelines after a head injury. *Clin Sports Med* 1998;17(1):45-60.

43. Colorado Medical Society. *Report of the Sports Medicine Committee: Guidelines for the Management of Concussion in Sports*. Denver: Colorado Medical Society, 1991.

44. Jorgensen U, Schmidt-Olsen S. The epidemiology of ice hockey injuries. *Br J Sports Med* 1986;20(1):7-9.

45. Benson BW, Mohtadi NG, Rose MS, Meeuwisse WH. Head and neck injuries among ice hockey players wearing full face shields vs half face shields. *JAMA* 1999;282(24):2328-2332.

46. Covassin T, Swanik B, Sachs M. Epidemiological considerations of concussions among intercollegiate athletes. *Appl Neuropsychol* 2003;10(1):12-22.

47. Pettersson M, Lorentzon R. Ice hockey injuries: A 4-year prospective study of a Swedish elite ice hockey team. *Br J Sports Med* 1993;27(4):251-254.

48. Tegner Y, Lorentzon R. Ice hockey injuries: incidence, nature and causes. *Br J Sports Med* 1991;25(2):87-89.

49. Molsa J, Kujala U, Nasman O, Lehtipuu T-P, Airaksinen O. Injury profile in Ice Hockey from the 1970s through the 1990s in Finland. *Am J Sports Med* 2000;28(3):322-327.

50. Bahr R, Holme I. Risk factor for sports injuries - a methodological approach. *Br J Sports Med* 2003;37:384-392.

51. Hostetler SG, Xiang H, Smith GA. Characteristics of ice hockey-related injuries treated in US emergency departments, 2001-2002. *Pediatrics* 2004;114(6):e661-6.

52. Sim FH, Simonet WT, Melton LJ, Lehn TA. Ice hockey injuries. *Am J Sports Med* 1987;15(1):30-40.

53. Goodman D, Gaetz M. Return-to-play guidelines after concussion: the message is getting through. *Clin J Sport Med* 2002;12(5):265.

54. Johnston KM. Hockey concussion reporting improved. *Can J Neurol Sci* 2003;30(3):183.

55. McCrory P, Johnston K, Meeuwisse W, Aubry M, Cantu R, Dvorak J, Graf-Baumann T, Kelly J, Lovell M, Schamasch P. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. *Br J Sports Med* 2005;39(4):196-204.

56. Benson BW, Rose MS, Meeuwisse WH. The impact of face shield use on concussions in ice hockey: a multivariate analysis. *Br J Sports Med* 2002;36(1):27-32.

57. Labella CR, Smith BW, Sigurdsson A. Effect of mouthguards on dental injuries and concussions in college basketball. *Med Sci Sports Exerc* 2002;34(1):41-44.

58. Delaney JS, Lacroix VJ, Gagne C, Antoniou J. Concussions among university football and soccer players: A pilot study. *Clin J Sport Med* 2001;11(4):234-240.

59. McCrory P. Do mouthguards prevent concussion? *Br J Sports Med* 2001;35(2):81-82.

Chapter 4:
Overview and Future Directions

4.1 Overview of Findings

The preceding chapters report the results of a multi-faceted investigation of concussion in youth ice hockey in British Columbia. The incidences of probable concussions were estimated, risk factors were identified, and the management of these injuries were described. To the best of our knowledge, this study represents the most comprehensive investigation of concussion in youth ice hockey to date.

Chapter One described the incidence of incidents of concern, or probable concussions, among pee wee, bantam, and midget-aged youth ice hockey players. By utilizing several observation strategies, we were able to illustrate the apparent under-reporting of concussions by youth hockey players to team personnel and by team personnel to the BCAHA. This finding has important implications for: (a) Association executives, who require accurate estimates to make informed decisions about the need for injury control strategies; (b) team personnel, who need to understand that players may not report when they have sustained a possible concussion; and (c) parents and players, who need to be informed about the risk of concussion in youth ice hockey.

The variability in incidence estimates may also reflect the ability (or inability) of each observation strategy to capture incidents of concern. Though the reliance on trained observers, who do not have direct contact with players, resulted in what may be an over estimation of the incidence of concussion in youth ice hockey, the use of a medical professional's diagnosis as the inclusion criteria resulted in what is possibly an under

estimation of the true rate. These findings support Meeuwisse and Love's (1997) recommendation that studies investigating athletic injuries use broad injury inclusion criteria to maximize the capture of events; possible cases can be scrutinized with more conservative criteria *post hoc*.[1] However, it is also important that investigators carefully convey the observation methods used and their associated limitations, as differences in incidence estimates (and risk factors) devised for a common population but calculated from different observation strategies, are not just possible, they are likely.[2]

Chapter Two reported the risk factors of incidents of concern. Age division was a consistent risk factor among incidents of concern identified by volunteers, but the direction of the relationship was opposite that previously reported in the literature: there were significantly ($p < .05$) higher odds of sustaining an incident of concern in pee wee than both bantam and midget. However, the cause of this observation remains unclear.

The majority of incidents of concern resulted from direct interaction between players and were most often caused by checks from behind, body checks, hits to the head, and other collisions. Though player interaction is an inherent aspect of ice hockey, over 50% of the causes reported by volunteers were penalizable. This may indicate that the number of concussions can be reduced if stricter rule enforcement leads to a reduction in the occurrence of penalizable actions.[3,4]

Chapter Three summarized the details associated with self-reported incidents of concern and the experiences of the injured athletes. As expected, considerably more concussions occurred during games than practices but, contrary to past reports, there was no evidence of significant ($p > .05$) differences in the occurrence of concussions among forwards, defence, and goalies. This finding was supported by the incidence estimates

formulated in Chapter One and indicates that it is important to develop injury control strategies for all participants in ice hockey, not just skaters.

We expected an increase in the number of player-identified incidents of concern with time in response to recent educational interventions and reports of high profile athletes having to retire due to multiple concussions.[5,6] We found no evidence of such a change in reporting of incidents of concern across four years and, perhaps even more disconcerting, we found no evidence of an improvement in adherence to Hockey Canada's concussion guidelines across years (e.g. evaluation by a physician, removed from play when symptomatic, etc.). It appears that youth players are not changing their behavior or heeding the warnings; moreover, their concussions continue to be under-reported. We suggest these athletes are not getting the message that concussions are an injury of concern and should be treated seriously.

4.2 General Limitations

The findings derived from this investigation are based on data collected over one to four years in a defined geographic area. It is not clear if they can be generalized to other hockey populations. They are best viewed as an additional step in the investigation of the incidence of concussions, their risk factors, and the management of concussed players.

4.3 Future Directions

Additional research into the incidence of concussions, their causes, and the management of injured players are still warranted. Future studies should consider a multi-faceted approach to surveillance and should specifically address the issue of body

checking and its influence (including the timing of its introduction) on the occurrence of concussions. Also, strategies to improve the reporting and managing of concussions are clearly necessary. We suggest that changes in policy guidelines and enforcement may have the farthest reaching effects.

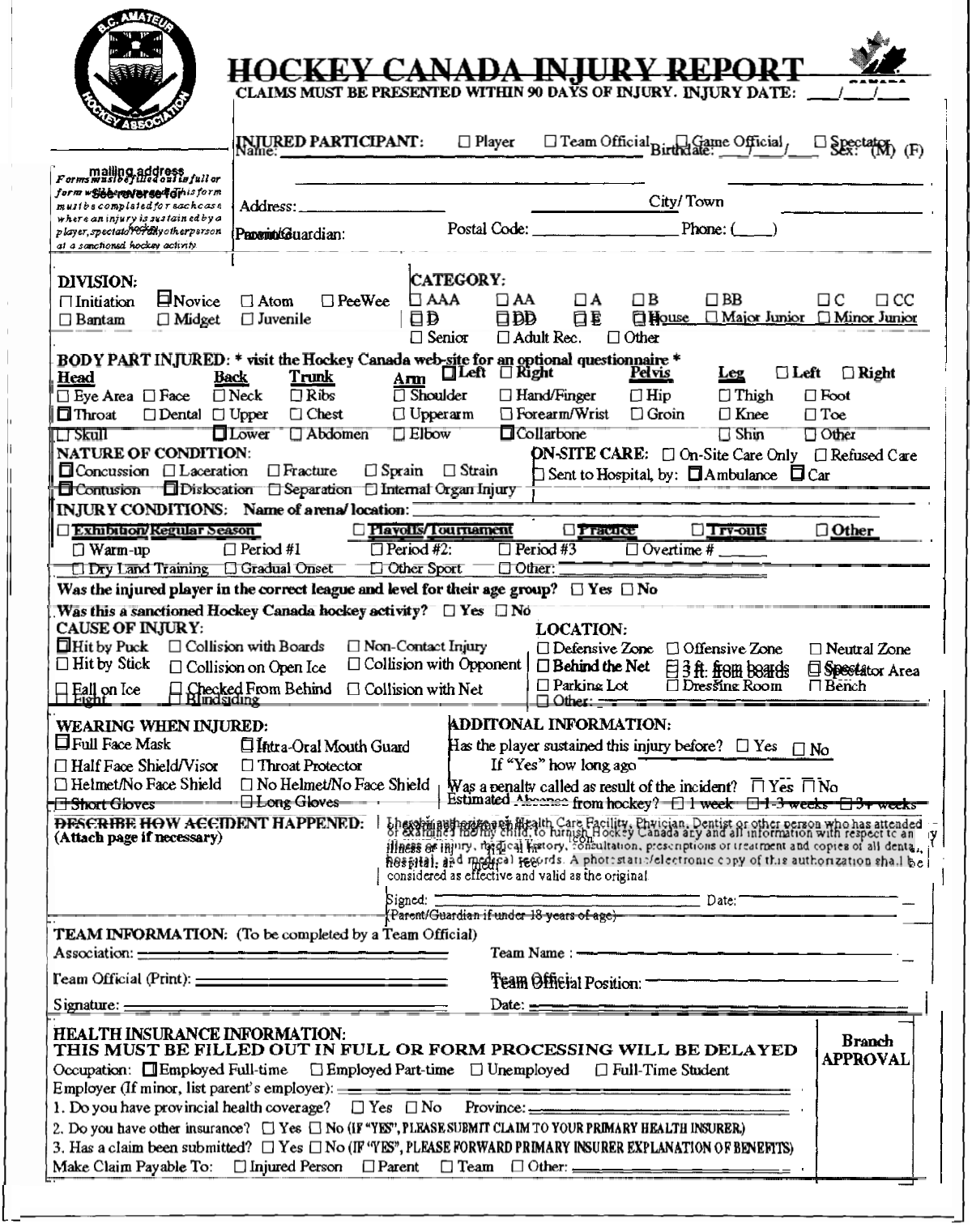
This research took important steps in addressing Stages 1 and 2 of the injury prevention strategies developed by Finch (2006) and van Mechelen (1992): establishing the extent of the problem (injury surveillance), and establishing the aetiology and mechanism of injury.[7,8] We have also used the findings from this investigation to suggest potential preventive measures, thereby contributing the Stage 3. However, true injury prevention and control will only be knowingly achieved when our findings, and others within the extant literature, are used to develop, test, and introduce "real-world" solutions.

4.4 References

1. Meeuwisse W, Love E. Athletic injury reporting: development of universal systems. *Sports Med* 1997;24:184-204.
2. Brooks JHM, Fuller CW. The influence of methodological issues on the results and conclussions from epidemiological studies of sports injuries. *Sports Med* 2006;36(6):459-72.
3. Marcotte G, Simard D. *Fair-Play: An Approach to Hockey for the 1990s*. Safety in Ice Hockey: Second Volume 1993:103-108.
4. Roberts WO, Brust JD, Leonard B, Hebert BJ. Fair-play rules and injury reduction in ice hockey. *Arch Pediatr Adolesc Med* 1996;150(2):140-145.
5. Cook DJ, Cusimano MD, Tator CH, Chipman ML. Evaluation of the ThinkFirst Canada, Smart Hockey, brain and spinal cord injury prevention video. *Inj Prev* 2003;9(4):361-366.
6. Hockey Canada. *Safety Program: Concussion Awareness*. Available: http://www.hockeycanada.ca/7/6/9/9/index1.shtml (accessed June 2, 2006).
7. Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport* 2006;9:3-9.
8. van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Med.* 1992;14:82-99.

Appendices

Appendix A



HOCKEY CANADA INJURY REPORT

CLAIMS MUST BE PRESENTED WITHIN 90 DAYS OF INJURY. INJURY DATE: ___/___/___

INJURED PARTICIPANT: ☐ Player ☐ Team Official ☐ Game Official ☐ Spectator
Name: _____ Birthdate: ___/___/___ Sex: (M) (F)

Forms must be filled out in full or form will be returned. This form must be completed for each case where an injury is sustained by a player, spectator or any other person at a sanctioned hockey activity

mailing address
See reverse for

Address: _____ City/ Town _____

Parent/Guardian: _____ Postal Code: _____ Phone: (___)

DIVISION:
☐ Initiation ☐ Novice ☐ Atom ☐ PeeWee
☐ Bantam ☐ Midget ☐ Juvenile

CATEGORY:
☐ AAA ☐ AA ☐ A ☐ B ☐ BB ☐ C ☐ CC
☐ D ☐ DD ☐ E ☐ House ☐ Major Junior ☐ Minor Junior
☐ Senior ☐ Adult Rec. ☐ Other

BODY PART INJURED: * visit the Hockey Canada web-site for an optional questionnaire *

Head	Back	Trunk	Arm ☐ Left ☐ Right	Pelvis	Leg ☐ Left ☐ Right
☐ Eye Area ☐ Face	☐ Neck	☐ Ribs	☐ Shoulder ☐ Hand/Finger	☐ Hip	☐ Thigh ☐ Foot
☐ Throat ☐ Dental	☐ Upper	☐ Chest	☐ Upperarm ☐ Forearm/Wrist	☐ Groin	☐ Knee ☐ Toe
☐ Skull	☐ Lower	☐ Abdomen	☐ Elbow ☐ Collarbone		☐ Shin ☐ Other

NATURE OF CONDITION:
☐ Concussion ☐ Laceration ☐ Fracture ☐ Sprain ☐ Strain
☐ Contusion ☐ Dislocation ☐ Separation ☐ Internal Organ Injury

ON-SITE CARE: ☐ On-Site Care Only ☐ Refused Care
☐ Sent to Hospital, by: ☐ Ambulance ☐ Car

INJURY CONDITIONS: Name of arena/ location: _____
☐ Exhibition/Regular Season ☐ Playoffs/Tournament ☐ Practice ☐ Try-outs ☐ Other
☐ Warm-up ☐ Period #1 ☐ Period #2: ☐ Period #3 ☐ Overtime # ___
☐ Dry Land Training ☐ Gradual Onset ☐ Other Sport ☐ Other: _____

Was the injured player in the correct league and level for their age group? ☐ Yes ☐ No

Was this a sanctioned Hockey Canada hockey activity? ☐ Yes ☐ No

CAUSE OF INJURY:
☐ Hit by Puck ☐ Collision with Boards ☐ Non-Contact Injury
☐ Hit by Stick ☐ Collision on Open Ice ☐ Collision with Opponent
☐ Fall on Ice ☐ Checked From Behind ☐ Collision with Net
☐ Fight ☐ Blindsiding

LOCATION:
☐ Defensive Zone ☐ Offensive Zone ☐ Neutral Zone
☐ Behind the Net ☐ 3 ft. from boards ☐ Spectator Area
☐ Parking Lot ☐ Dressing Room ☐ Bench
☐ Other: _____

WEARING WHEN INJURED:
☐ Full Face Mask ☐ Intra-Oral Mouth Guard
☐ Half Face Shield/Visor ☐ Throat Protector
☐ Helmet/No Face Shield ☐ No Helmet/No Face Shield
☐ Short Gloves ☐ Long Gloves

ADDITONAL INFORMATION:
Has the player sustained this injury before? ☐ Yes ☐ No
If "Yes" how long ago _____
Was a penalty called as result of the incident? ☐ Yes ☐ No
Estimated Absence from hockey? ☐ 1 week ☐ 1-3 weeks ☐ 3+ weeks

DESCRIBE HOW ACCIDENT HAPPENED: (Attach page if necessary)

I hereby authorize any Health Care Facility, Physician, Dentist or other person who has attended or examined me/my child, to furnish Hockey Canada any and all information with respect to an illness or injury, medical history, consultation, prescriptions or treatment and copies of all dental, hospital, and medical records. A photostatic/electronic copy of this authorization shall be considered as effective and valid as the original

Signed: _____ Date: _____
(Parent/Guardian if under 18 years of age)

TEAM INFORMATION: (To be completed by a Team Official)
Association: _____ Team Name : _____
Team Official (Print): _____ Team Official Position: _____
Signature: _____ Date: _____

HEALTH INSURANCE INFORMATION:
THIS MUST BE FILLED OUT IN FULL OR FORM PROCESSING WILL BE DELAYED

Branch APPROVAL

Occupation: ☐ Employed Full-time ☐ Employed Part-time ☐ Unemployed ☐ Full-Time Student
Employer (If minor, list parent's employer): _____
1. Do you have provincial health coverage? ☐ Yes ☐ No Province: _____
2. Do you have other insurance? ☐ Yes ☐ No (IF "YES", PLEASE SUBMIT CLAIM TO YOUR PRIMARY HEALTH INSURER.)
3. Has a claim been submitted? ☐ Yes ☐ No (IF "YES", PLEASE FORWARD PRIMARY INSURER EXPLANATION OF BENEFITS)
Make Claim Payable To: ☐ Injured Person ☐ Parent ☐ Team ☐ Other: _____

Appendix B

BRITISH COLUMBIA AMATEUR HOCKEY ASSOCIATION

INJURY REPORT/CLAIM STATEMENT FOR ASSISTANCE

NAME OF INJURED: _____ ACCIDENT DATE: _____

HOME ADDRESS: _____ CITY: _____

PROVINCE: _____ POSTAL CODE: _____ PHONE: ( ) _____

MUTUAL AID NUMBER FOR IDENTIFICATION: _____

NAME OF ASSOCIATION/FEMALE TEAM: _____

PLEASE CHECK TYPE OF INJURY: ☐ MEDICAL ☐ DENTAL

DIVISION: (Check one)

☐ BELOW PEE WEE	☐ MIDGET	☐ TEAM OFFICIAL
☐ PEE WEE	☐ JUVENILE	☐ MINOR OFFICIAL
☐ BANTAM	☐ FEMALE	☐ REFEREE

CHEQUE PAYABLE TO: ☐ Claimant ☐ Doctor ☐ Other _____ (Please specify name)

Type of Expense i.e. Drugs, Podiatrist	Date Expenses Incurred Day	Month	Year	Total Amount Charged
			TOTAL:	

ACCIDENT DESCRIPTION: _____

Signed: _____ Date: _____
Witness (Association Official)

NOTES:
1. The Mutual Aid Committee reserves the right to refuse payment of any claim that does not comply with the Mutual Aid By-Laws.
2. Claims must be submitted to the BCAHA within 90 days of injury. Please mail to 6671 Oldfield Road, Saanichton BC V8M 2A1 or fax to 250-652-4536.
3. All receipts and/or invoices can follow original claim.
4. Do not wait for bills if this will put the claim past 90 days.
5. This is a mutual aid fund, not an insurance plan. The assistance provided shall be for expenses not provided by a medical or dental plan of the member or his/her parents.

I, the undersigned, agree that I am financially responsible for any charges for services described on this claim form that are not covered as per BCAHA By-Law 7.

Signed _____ Date: _____
(Parent/Guardian if under 18)

June 2003 J:\Forms\Insurance\Mutual Aid Injury Report - Claim Statement.doc

Appendix C

Dear Dedicated Volunteer,

Thank-you for agreeing to participate in the Simon Fraser University (SFU) research project entitled "Concussion in Hockey: There Really is a Cause for Concern." Our project, part of a Canada-wide community health initiative, is entering its third year of operation and we hope you will play an integral role in addressing the issue of mild traumatic brain injury (concussion) in minor (youth) hockey.

To date, we have received the kind support of Mr. Ed Mayert, President of the B.C.A.H.A., Mrs. Shannon Bell, P.C.A.H.A District Director, Mrs. Donna Henderson, O.M.A.H.A. District Director and, of course, your own association president. It is your contribution, however, that will be key to the success of this project.

Head injuries to professional hockey players have received considerable media attention recently but concussions are an equally important concern among minor hockey players. The objective of this research project will be to **quantify the occurrence of concussions among youth hockey participants.**

By agreeing to participate, you will act as a field researcher and observe all (or most) of your team's hockey games as you normally would. Should an incident occur during game play with the potential to generate a concussion, we ask that you complete and submit an ***Incident of Concern Reporting Form***. By submitting this form, you will have indicated a player on your team is exhibiting signs or symptoms of a concussion. *Please note: We are not asking you to definitively diagnose a concussion and all information you provide will be kept strictly confidential.*

We also request that you submit ***Game Confirmation Calendars*** every two weeks. This information allows researchers to track the number of games played and whether or not there was an incident.

For your convenience, there are three methods available to submit the forms:

- **on-line** at www.sfu.ca/concussion ; or,
- **fax** at (604) 291-4286; or,
- **mail**, using the SFU self-addressed envelopes provided.

While participating in this project may sound like a lot of extra work, the actual time commitment (outside attending games as you normally would) is about **20 minutes a month**.

The ***Community Reporter Package*** you have been provided includes a brief concussion awareness section, a list of community reporter tasks, and the necessary forms. Please make special note of the ***Reporter Endorsement Form***, which we ask that you return in the near future to confirm your participation.

We encourage you to maintain your participation for the duration of the season, so feel free to notify us at any time should you have a comment, concern or question. This is a community-based research endeavor, and your feedback is always encouraged and appreciated.

We wish you and your team the very best this hockey season!

Gratefully yours,

Ian Williamson – Community Coordinator

Reporter Endorsement Form

I, _____ (please print) am willing to assist the SFU Concussion Research Project, and I agree not to reveal any details regarding the study and its data.

_____ _____

Signature Date

Association Name: _____ (e.g. Coquitlam Minor)

Division of Play: ☐ Midget ☐ Bantam ☐ Pee Wee

Category of Play: ☐ A ☐ B ☐ C

If 'Rep', indicate Tier: _____ (e.g. AAA or BB)

Team Number: _____ (e.g. B2 or C8)

Affiliation with Team: _____ (e.g. Manager, Safety Person, etc.)

Preferred Method of Contact:

☐ Phone ☐ Fax ☐ Email ☐ Mail

Preferred Method of Reporting:

☐ Phone ☐ Fax ☐ Email ☐ Mail

(If you indicate 'mail', we will send you additional postage-paid envelopes.)

Address: (For the purposes of FOLLOW-UP ONLY. No information will be released.)

_____

_____

_____

_____

PLEASE SUBMIT THIS FORM AS SOON AS POSSIBLE!

Submission Methods

Fax: (604) 291-4286

Mail (See postage-paid envelopes provided)

Concussion Awareness

WHAT IS A CONCUSSION?

A concussion is any **direct** or **indirect** hit to the head that can cause a change in behavior, awareness, and/or physical feeling.

DIRECT BLOW: an elbow, stick, or puck hitting the head, or the head being forced into the boards. It can also occur when a player falls and hits his/her head on the ice, goalpost, boards, etc.

INDIRECT BLOW: a moving player hitting an immovable object like boards, goal post or another player, in a whiplash manner. This forces the players to stop or change direction suddenly, which can cause their brain to contact their skull.

YOU DON'T NEED TO BE KNOCKED OUT TO HAVE A CONCUSSION!

A **direct** or **indirect** blow to the head may produce a rapid back and forth movement of the head and neck, which causes extra force between the brain and its surrounding attachments.

Forces which are not absorbed are transmitted to the brain. From this concussion injury, brain cells become abnormal and don't function properly. Sometimes the player may get knocked out, but **most of the time** the main problems are headaches, dizziness, fatigue and memory problems. These are called concussion symptoms, and the more common signs and symptoms are listed on the next page.

WHY SHOULD WE BE AWARE OF CONCUSSIONS?

Concussions have received a lot of attention lately, and rightly so. While bone and soft tissue injuries (sprains and strains) may cause aches and soreness later in life, having repeated concussions, or *even **one** which is not treated properly*, may lead to permanent **cognitive problems** later in life. This can include chronic headaches, difficulty concentrating or remembering, and changes in personality.

Hockey players are a tough bunch, and their determination and love of the game often drives them to play through injuries. Unfortunately, playing with a headache is not like playing with a sore knee or shoulder. In addition to potential long term effects, athletes that return to competition too soon run the risk of another concussion at the very least, and Second Impact Syndrome at the worst.

Second Impact Syndrome occurs when a brain that is still symptomatic receives another trauma. This second impact can cause a change in blood flow and swelling in the brain, which can lead to coma and death. Fortunately, Second Impact Syndrome is rare – however, the risk for repeat injury, long term cognitive deficits, and loss of playing time make it very important that concussions be identified and managed in accordance with the current guidelines.

WHAT ARE THE SIGNS AND SYMPTOMS OF CONCUSSION?

- Headache
- Dizziness
- Nausea and/or vomiting
- Feeling "dinged" or "having my bell rung"
- Loss of field of vision or double vision
- Decreased playing ability
- Slow to answer questions or perform tasks
- Feeling "slow"
- Poor coordination or balance
- Poor concentration
- Confusion/lack of awareness of events
- Sleepiness
- Vacant stare/glassy eyed
- Displaying unusual or inappropriate emotions

This list highlights the more common signs and symptoms of concussion, but other symptoms may be present as well. Every concussion is different, so be suspicious of anything that seems inconsistent with the usual personality of the player.

WHEN SHOULD A PLAYER BE REMOVED FROM PLAY?

If you detect any of the above symptoms following a direct or indirect blow to the head, the athlete should be removed from competition, examined and observed. *Repeated assessment* is very important, as some symptoms may not show up immediately. The athlete should never be left alone or given medication. Any player with concussion symptoms needs a medical evaluation. Return to play must follow a gradual process, monitored by a medical doctor.

WHEN IS IT OK TO RETURN TO PLAY?

A player begins the return to play process ONLY after receiving clearance from a medical physician to return to activity. ***The time required to progress will vary with the severity of the concussion!*** If an athlete plays or practices too soon, he/she may have to sit out even longer.

STEP 1: No activity, complete rest.
Once **ASYMPTOMATIC** proceed to step 2, with clearance from a physician. CONTINUE TO PROCEED through the steps **IF ASYMPTOMATIC**. If symptoms occur, drop back to where there are no symptoms, and try to progress again.

STEP 2: Light exercise off of the ice (riding a stationary bike, walking...)

STEP 3: Hockey specific activity **without** body contact
(skating, shooting - **no drills**)

STEP 4: On ice practice **without** body contact (dressed and drills)

STEP 5: On ice practice **with** body contact, **after** clearance from a physician.

STEP 6: Return to competition!

A PLAYER SHOULD NEVER RETURN TO PLAY WHILE SYMPTOMATIC!

WHEN IN DOUBT, SIT THEM OUT!

Frequently Asked Questions

When should I report an incident to my trainer or to SFU researchers?

Anytime a player has his "bell-rung," or exhibits any concussion signs and symptoms due to direct or indirect head impact, please submit an *Incident of Concern Reporting Form*. We will classify the incident based on information received from submitted forms and the follow-up.

How long will the player be out for?

Once a player enters the Concussion Management Program, we ask that they follow their clinical team's directions before returning to play. The health care team will work hard to ensure every player follows a safe, graded return-to-play protocol. We ask that team personnel respect the guidance of the health care team and encourage their athletes to adhere to the team's recommendations.

Will I have access to the findings?

In order to protect player confidentiality and to ensure that the final decisions about return-to-play are made by the clinicians who know the athlete best (e.g. trainer, family physician), we will not be releasing test results to individual players or their teams. When there are findings that require more considerable clinical investigation, family physicians will be notified.

We plan on providing a synopsis of study findings to the BCAHA at the end of each season.

When I submit a form, who sees the information?

Our research team is ethically bound to keep all information strictly confidential. No other agency or hockey body has access to specific information. Any information we request, regarding you or a player involved in an incident of concern, is for tracking, follow-up, and assessing trends in different levels of hockey. No identifying details will be released in reports or publications.

I have already filed an injury report to BCAHA – do I still have to file this form to the SFU Concussion Research Project?

While our research team works closely with BCAHA, their injury report forms are not disclosed to us, nor do we disclose specific information from our forms to them (this would violate our confidentiality agreement). At the end of the season, we compile a summary of our findings, which is available to BCAHA, and to you!

Volunteer Incident of Concern Reporting Form

RECORDER INFORMATION

Name: _____ **Phone / Email:** _____

Today's Date: (dd/mm/yy) _____

TEAM INFORMATION

Association: _____ (e.g. Coquitlam Minor)

Division of Play: ▫ Midget ▫ Bantam ▫ Pee Wee **Category of Play:** ▫ A ▫ B ▫ C

Team Number: _____ (eg. B2 or C8) **If 'Rep'**, indicate Tier: _____ (eg. AAA or BB)

Where were you playing? ▫ Home ▫ Away **Who were your opponents?** _____ (e.g. Port Moody C2)

PLAYER INFORMATION

Player Year of Birth: _____ **Player Position:** ▫ Center ▫ Left Wing ▫ Right Wing ▫ Defense ▫ Goalie

Was the player wearing a mouth guard? ▫ Yes ▫ No ▫ Unknown

Is the player a call-up from another category/division of play? ▫ Yes ▫ No ▫ Unknown

INJURY DATA

Injury Date: (dd/mm/yy) _____

Cause of Incident: ▫ Accidental Collision ▫ Body Check ▫ Cross Check ▫ Hit to Head ▫ Run into Goal ▫ Hit from Behind ▫ Open Ice Hit ▫ Other _____

Result of Incident:

Hit Head on: ▫ Boards ▫ Glass ▫ Goalpost ▫ Ice
or, Head Hit by: ▫ Elbow ▫ Glove ▫ Fist ▫ Body ▫ Stick ▫ Puck
or, Hit Caused: ▫ Whiplash ▫ Other _____

Location of Incident With Respect to Injured Player:

▫ Offensive Left Corner ▫ Offensive Right Corner ▫ Offensive Slot ▫ Neutral Zone
▫ Defensive Left Corner ▫ Defensive Right Corner ▫ Defensive Slot

What type of game?

▫ preseason/tiering ▫ regular season
▫ playoff ▫ tournament

In what period did the injury occur?

▫ 1st ▫ 2nd ▫ 3rd ▫ Overtime

Was there a penalty called on the play? ▫ Yes ▫ No ▫ Unknown
If 'Yes', what was the penalty? _____

Did you observe the incident? ▫ Yes ▫ No
If 'No', who reported the incident to you? _____

SYMPTOM CHECKLIST (Please check all symptoms demonstrated by the player)

▫ confusion ▫ dizziness ▫ slurred speech ▫ feeling tired ▫ nausea
▫ vomiting ▫ memory problems ▫ slow to answer ▫ tingling in limbs ▫ vacant stare
▫ seeing stars ▫ headaches ▫ poor concentration ▫ poor coordination
▫ other _____

REMARKS (Please use back of this document if more space is required)

If found, please contact the SFU Concussion Research Project
email: concuss@sfu.ca *tel: 604-291-5793 *fax: 604-291-4286

SFU Concussion Research Project

Game Confirmation Calendar
October 1st – 15th

Recorder Information

Name: _____ **Phone / Email:** _____

Today's Date:(dd/mm/yy) _____

Team Information

Association: _____(e.g. Coquitlam Minor)

Division of Play: ☐ Midget ☐ Bantam ☐ Pee Wee **Category of Play:** ☐ A ☐ B ☐ C

Team Number: _____ (e.g. B2 or C8) **If 'Rep', indicate Tier:** _____(e.g. AAA or BB)

On dates when your team played:

1. If you **DID** attend the game, circle **'Y'**
   If you **DID NOT** attend the game, circle **'N'**
   **missed the game? See the* Reporter Tasks *section for info*
2. If the game **DID** have an Incident of Concern, write **'✓'**
   If the game **DID NOT** have an Incident of Concern, write **'X'**

If you indicate a game with an Incident of Concern, please submit an ***Incident of Concern Reporting Form.***

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1 Y / N	2 Y / N	3 Y / N	4 Y / N
5 Y / N	6 Y / N	7 Y / N	8 Y / N	9 Y / N	10 Y / N	11 Y / N
12 Y / N	13 Y / N	14 Y / N	15 Y / N			

Forms can be submitted online at www.sfu.ca/concussion , by fax (604) 291-4286 or by mail.

Thank you for your continued support

Appendix D

Best Ever 2004 HOCKEY HEAD INJURY ASSESSMENT

Researchers at Simon Fraser University in cooperation with the BCAHA and CHA are carrying out this study in order to further understand the nature of concussions in hockey. All Best Ever 2004 players have been asked to participate. We appreciate your cooperation in providing your careful recollection of any head injury you may have suffered. In the case of suffering more than one head injury, please report the most RECENT incident. Please note that ALL personal information will be kept STRICTLY CONFIDENTIAL. Only group data will be reported.

Players, Please answer the following questions to the best of your ability by checking the correct box or writing your answer in the space provided. If you do not know the answer to a question, or do not wish to answer it, leave it blank.

SECTION A: GENERAL INFORMATION:

1. Name: _____ [optional]
2. Team (District): _____ Player number _____

3. Birth date: Day____ Month____ Year_____ Height_____ Weight_____
4. Handedness (your writing hand):
   Right handed ____ Left handed ____ both ____
5. Do you currently attend school?
   - ☐ Yes → what grade? _____
   - ☐ No → what is the highest grade you finished? _____

6. How many years have you been playing hockey? _____

SECTION B: CONCUSSION INFORMATION:

Have you ever received a significant hit to the head while playing hockey?

- ☐ No
- ☐ Yes

If **YES**, did the hit:

- ☐ cause you to lose consciousness or be "knocked out"
- ☐ cause confusion and/or loss of memory without being "knocked out"
- ☐ cause no specific symptoms, but yet was of concern

If NO, please proceed to Section C on Page 4.

Most Recent Hockey Concussion:

(If you have never received a significant hit to the head, please proceed to Section C on Page 4.)

1. How old were you when this injury (concussion) happened? _____
2. In what setting did this concussion occur?
   - ☐ a practice
   - ☐ a game
   - ☐ other, explain _____

Best Ever 2004 HOCKEY CONCUSSION ASSESSMENT

3. Were you wearing a helmet when this incident occurred?
   - ☐ No
   - ☐ Yes

4. Were you wearing a face shield when this incident occurred?
   - ☐ No
   - ☐ Yes
     - ☐ Full visor: plastic __ or metal __
     - ☐ Half visor: plastic __ or metal __

5. Were you wearing a mouth guard when the incident occurred?
   - ☐ No
   - ☐ Yes

6. What was the ***main*** cause of the concussion? (**check one only**)
   - ☐ struck head into the boards
   - ☐ struck head on the ice
   - ☐ collision or open ice hit (whiplash)
   - ☐ hit with a stick
   - ☐ hit with a puck
   - ☐ a fight or punch
   - ☐ elbow to jaw or head
   - ☐ other, explain _____

7. Did another player cause the concussion?
   - ☐ No
   - ☐ Yes. Did the player receive a penalty?
     - ☐ Major penalty
     - ☐ Minor penalty
     - ☐ No penalty

8. Did you lose consciousness?
   - ☐ No
   - ☐ Yes

   If **YES**,

   i) I was reported to be unconscious by my (may check more than one)
      - ☐ coach
      - ☐ trainer / safety person
      - ☐ parent
      - ☐ doctor
      - ☐ other, specify: _____

   ii) How long were you unconscious for?
      - ☐ less than 1 min
      - ☐ 1 - 5 mins
      - ☐ 6 - 30 mins
      - ☐ 31 mins to 1 day
      - ☐ more than 1 day

9. What do you remember as the last thing that happened before the hit?

   _____

   _____

10. What do you remember as the first thing after the hit?

    _____

    _____

Best Ever 2004 HOCKEY CONCUSSION ASSESSMENT

11. Please check any symptoms resulting from the concussion:

☐ Dizziness	How long symptom lasted _____
☐ Headaches	How long symptom lasted _____
☐ Sensitivity to light and/or noise	How long symptom lasted _____
☐ Nausea	How long symptom lasted _____
☐ Difficulty concentrating	How long symptom lasted _____
☐ Fatigue or sleeping more than usual	How long symptom lasted _____
☐ Other _____	How long symptom lasted _____

12. Who examined you following the incident? (**may check more than one**)
    - ☐ no one
    - ☐ teammate(s)
    - ☐ trainer / safety person
    - ☐ coach
    - ☐ doctor
    - ☐ parent(s)
    - ☐ other, specify: _____

13. Were you taken to the hospital?
    - ☐ No
    - ☐ Yes

14. Did you return to play during the same game or practice?
    - ☐ No
    - ☐ Yes

15. If you did ***not*** return to the same game or practice, when did you return to regular play? (**check one only**)
    - ☐ later the same day
    - ☐ the next day
    - ☐ 2 - 6 days later
    - ☐ 1 - 2 weeks later
    - ☐ 3 - 4 weeks later (explain why): _____
    - ☐ more than 4 weeks later (explain why): _____

16. Did you still have post concussion symptoms when you returned to play? No___ Yes ____

    If **YES**, please describe the symptoms and how long they lasted

    _____

17. Before you returned to play, were you tested to see if any concussion symptoms returned during exercise? (e.g. running, sit-ups, push-ups, light skating, etc.)
    - ☐ No
    - ☐ Yes

18. Who was the ***main*** person who made the decision for you to return to play? (**check one only**)
    - ☐ yourself
    - ☐ teammate(s)
    - ☐ trainer / team safety person
    - ☐ coach
    - ☐ doctor
    - ☐ parent(s)
    - ☐ other, specify: _____

19. Have you had more than one hockey related concussion?
    - ☐ No
    - ☐ Yes: How many? _____

SECTION C: HOCKEY RELEVANT INFORMATION:

1. Have you ever had a concussion outside of hockey?
   - ☐ No
   - ☐ Yes: How many? _____

2. In the last three seasons of playing hockey, for what team, level and league did you play?

	TEAM	LEVEL	LEAGUE	FULL CONTACT?
Example:	*Coquitlam Titans*	*Bantam AA*	*Fraser Valley North*	*Yes*
This Season				
Last Season				
Two Seasons ago				

3. What position do you play? Now_____ Last season_____ Two seasons ago_____
4. Are you concerned about getting a concussion while playing? No _____ Yes ___
5. Do you wear a mouth guard? During games? No ____ Yes ____
   During practices? No____ Yes____
   If "Yes" what type of mouth guard do you wear? Stock (already made)____ Mouth formed (boil and bite)____
   Custom formed (dentist made)____ Pressure laminated custom made____
   Brand name of mouth guard (eg Shock Doc, Itech)_____
5. What type of helmet do you wear? Brand_____ Model_____
6. In the past 2 years have you changed any of your equipment ***due to an injury***? No__ Yes__
   If **YES**, please explain_____
   _____

This survey is now complete. Thank you.

Thank you for your cooperation in completing this survey, and all the best for your hockey future.

Appendix E

Concussion Awareness

WHAT IS A CONCUSSION?

A concussion is any **direct** or **indirect** hit to the head that can cause a change in behavior, awareness, and/or physical feeling.

DIRECT BLOW: an elbow, stick, or puck hitting the head, or the head being forced into the boards. It can also occur when a player falls and hits his/her head on the ice, goalpost, boards, etc.

INDIRECT BLOW: a moving player hitting an immovable object like boards, goal post or another player, in a whiplash manner. This forces the players to stop or change direction suddenly, which can cause their brain to contact their skull.

YOU DON'T NEED TO BE KNOCKED OUT TO HAVE A CONCUSSION!

A **direct** or **indirect** blow to the head may produce a rapid back and forth movement of the head and neck, which causes extra force between the brain and its surrounding attachments.

Forces which are not absorbed are transmitted to the brain. From this concussion injury, brain cells become abnormal and don't function properly. Sometimes the player may get knocked out, but **most of the time** the main problems are headaches, dizziness, fatigue and memory problems. These are called concussion symptoms, and the more common signs and symptoms are listed on the next page.

WHY SHOULD WE BE AWARE OF CONCUSSIONS?

Concussions have received a lot of attention lately, and rightly so. While bone and soft tissue injuries (sprains and strains) may cause aches and soreness later in life, having repeated concussions, or *even **one** which is not treated properly*, may lead to permanent **cognitive problems** later in life. This can include chronic headaches, difficulty concentrating or remembering, and changes in personality.

Hockey players are a tough bunch, and their determination and love of the game often drives them to play through injuries. Unfortunately, playing with a headache is not like playing with a sore knee or shoulder. In addition to potential long term effects, athletes that return to competition too soon run the risk of another concussion at the very least, and Second Impact Syndrome at the worst.

Second Impact Syndrome occurs when a brain that is still symptomatic receives another trauma. This second impact can cause a change in blood flow and swelling in the brain, which can lead to coma and death. Fortunately, Second Impact Syndrome is rare – however, the risk for repeat injury, long term cognitive deficits, and loss of playing time make it very important that concussions be identified and managed in accordance with the current guidelines.

WHAT ARE THE SIGNS AND SYMPTOMS OF CONCUSSION?

- Headache
- Dizziness
- Nausea and/or vomiting
- Feeling "dinged" or "having my bell rung"
- Loss of field of vision or double vision
- Decreased playing ability
- Slow to answer questions or perform tasks
- Feeling "slow"
- Poor coordination or balance
- Poor concentration
- Confusion/lack of awareness of events
- Sleepiness
- Vacant stare/glassy eyed
- Displaying unusual or inappropriate emotions

This list highlights the more common signs and symptoms of concussion, but other symptoms may be present as well. Every concussion is different, so be suspicious of anything that seems inconsistent with the usual personality of the player.

WHEN SHOULD A PLAYER BE REMOVED FROM PLAY?

If you detect any of the above symptoms following a direct or indirect blow to the head, the athlete should be removed from competition, examined and observed. *Repeated assessment* is very important, as some symptoms may not show up immediately. The athlete should never be left alone or given medication. Any player with concussion symptoms needs a medical evaluation. Return to play must follow a gradual process, monitored by a medical doctor.

WHEN IS IT OK TO RETURN TO PLAY?

A player begins the return to play process ONLY after receiving clearance from a medical physician to return to activity. ***The time required to progress will vary with the severity of the concussion!*** If an athlete plays or practices too soon, he/she may have to sit out even longer.

STEP 1: No activity, complete rest.
Once **ASYMPTOMATIC** proceed to step 2, with clearance from a physician. CONTINUE TO PROCEED through the steps **IF ASYMPTOMATIC**. If symptoms occur, drop back to where there are no symptoms, and try to progress again.

STEP 2: Light exercise off of the ice (riding a stationary bike, walking...)

STEP 3: Hockey specific activity **without** body contact
(skating, shooting - **no drills**)

STEP 4: On ice practice **without** body contact (dressed and drills)

STEP 5: On ice practice **with** body contact, **after** clearance from a physician.

STEP 6: Return to competition!

A PLAYER SHOULD NEVER RETURN TO PLAY WHILE SYMPTOMATIC!

WHEN IN DOUBT, SIT THEM OUT!

INCIDENT RECORDING SHEET TRAINING

Purpose

To provide researchers with a documented record of incidents that resulted in concussion OR had the potential to generate a concussion. The latter will be observed the majority of the time.

"We want to have documented evidence of these incidents so we can determine how often potentially dangerous incidents are occurring at the amateur level."

What is required?

Anytime an incident occurs within a game that resulted in a concussion or, in your subjective assessment, had the potential to generate a concussion, record the details of this incident an SFU Incident Recording Sheet.

"A concussion does not have to occur to have a reason to use the sheet. Any incident that appears as though, under different circumstances it could have resulted in concussion, is to be recorded."

Recordable Incidents

An incident in which a player's head moves in a manner suggestive of brain acceleration, deceleration, or impact. This includes direct hits and whiplash style injuries.

"We want you to record incidents in which a player's head is rotated or stopped quickly, strikes the ice or boards, or is struck by another player. Essentially, WATCH THE HEAD!"

In order to maximize the number of incidents you see, please follow the play. While incidents will occur behind the play and away from the puck, it is unreasonable to expect you to catch everything. By focusing primarily on the play and the puck, you can observe the game more consistently.

Observer Protocol - 1

1. Look and act respectable – suit and tie are definitely not required, but clothes with tears or food stains are no-go. Use your common work-sense!

2. Arrive at arena **15 minutes** before game start time.

3. Find a location in the stands that provides good visibility of both the ice and the team benches, but does NOT put you right in the middle of all the fans.

4. While observing the game, you must:
    a. remain in the stands WHENEVER THE CLOCK IS RUNNING for game play. It's a 1 ½ hour timeslot – snack and bathrooms breaks are before and/or after the game.
    b. be as DISCREET as possible. If you are questioned, politely answer that you are involved with a research project at SFU and are testing a tool that has been developed to gather information about game play. If they really want to talk, politely say that you have to focus on the game, but if they would like more information, you can give them contact information. Offer either Nori's or Ian's business card.
    c. remember that you are representing SFU, this lab, and this research project. We are lucky to have the level of community cooperation that we have, so keep comments about the game, the players, the refs, the association etc. to yourself - you never know who is listening.

5. After the game, you must:
    a. Talk to the designated representative from either one or both of the teams at THEIR convenience. YOU WILL BE NOTIFIED BEFOREHAND IF YOU NEED TO TALK TO BOTH TEAM REPS.
        i. Ask ONLY if there were any "incidents of concern" during the course of the game.
            1. No - Thanks, and good luck in your next game.
            2. Yes – Ok, please fill in and Incident of Concern Reporting Form soon, but at your convenience. Submit the form as you normally would. Remind of options: fax, online, self-addressed stamped envelopes.
        ii. If the team played a game that was not covered by one of our observers: Oh, I understand your team played on _____. Was there an incident of concern in that game?
            1. No – same as above
            2. Yes – same as above
        iii. DO NOT ask leading questions OR offer/share information from "your" perspective.
        iv. DO NOT ask about specific incidences which you observed.
        v. DO NOT ACCEPT ANY FORMS FROM THE VOLUNTEER. The volunteer must submit forms directly to the lab. If they ask why you cannot accept forms, just apologize that you are not able to do that, and answer briefly that we must keep the submission methods standardized and avoid the perception of introducing bias into the study.

Observer Protocol - 2

6. Fill in your Follow-up Form
    a. Do not let information from the Volunteer alter your information.

7. Submit your Hit Sheets and Follow-up form promptly.
    a. Within a couple of days of the game:
        i. staple the all Hit Sheets from one game together
        ii. put them into mailbox 84 in the Kinesiology department

How to use the Incident Sheet - 1

1) **Record details identifying game**:
    1) *Date:* Current date
    2) *Home Team:* Identify the Home Association and team level (ex. Coquitlam C2)
    3) *Away Team:* Identify the visiting Association and team level (ex. Port Moody C2)
    4) *Game #*: Identify the scheduled game number, according to your assigned schedule.
    5) *League*: Identify level of competition, ex. Midget B1, Bantam AA, PeeWee C6.
    6) *Type of Game:* Identify whether
        i. exhibition
        ii. league
        iii. tournament
        iv. play-offs
    7) *Played at:* Identify the city AND the arena in which the game is played (ex. Maple Ridge Planet Ice)

2) ***Incident #:*** Number the first incident you observe in the game as #1, the second incident as 2, and continue numbering consecutively.

Type

1) *Accidental Collision:* Impact between two players without intent to check.
2) *Body Check:* Impact between two player with the intent to hit, using the hip or shoulder.
3) *Cross Check:* To hit an opponent with both hands on the stick and no part of the stick on the ice. If a cross check to the head occurs, record as Hit to Head - hit head by stick. If a cross check from behind occurs, record as Hit from Behind result.
4) *Hit to Head:* Strike to an opponent's head using the stick, elbow, glove, fist, puck.
5) *Fight:* Strike to an opponent's head during a fight, or as the result of a fight (e.g. player is knocked down and strikes head on ice).
6) *Run into Goal:* Skating or being shoved into the net or goal post.
7) *Hit from Behind:* Shoving, striking or checking **a player who has their back turned** to the opponent. This includes cross checking from behind, and can occur anywhere on the ice.
8) *Hands-High Check:* A check given with the hands/forearms.
9) *Other:* Please specify the type of incident.

How to use the Incident Sheet - 2

3) ***Players Involved*** (complete 1 large grey box for each player involved in the incident)
   1) *Jersey #:* Number of each player involved.
   2) *Initiator?*: Did this player initiate the course of action – *Y* or *N*.
   3) *At risk?:* Was this player subjected to the course of action – *Y* or *N*.
   4) *Team*: Was this player from the *H* = Home or *V* = Visitor team.
   5) *Ctrl of puck?:*
      i. *Y* – yes – this player has possession of the puck, or was hit because he/she had been in possession of the puck.
      ii. *N* – no – this player was neither in possession of the puck, nor trying to gain possession of the puck.
      iii. *Loose* – this player was trying to gain control of the puck.

4) ***Time on Clock***: Time on clock when incident occurred.
   1) *Score*: Score of the game when incident occurred.
   2) *Period*: Period during which the incident occurred.

5) ***Result*** – How was the player's head affected during the incident? Circle the result. If more than one result, number the order of events chronologically. (ex. A player is bodychecked and hits head on glass, then falls and hits head on ice:
   Record as: (glass) [1] and (ice) [2]
   1) *Hit head on Boards/Glass/Goalpost/Ice*
      i. Please note that BOARDS AND GLASS ARE SEPARATE!
   2) *Hit head by Stick/Puck*
   3) *Hit head by Elbow/Glove/Fist/Body*
      i. Please only use Fist if the head is hit by a BARE HAND (e.g. in a fight)
   4) *Whiplash*
      i. No direct contact to the head, but rapid acceleration or deceleration was evident.

6) ***Penalty called on play?***
   1) If *Y*:
      i. *Jersey #*: Number of the player who received the penalty
      ii. *Time*: Duration of the penalty
      iii. *Type*: Indicate penalty call based on referee arm signals, or announcement.

7) ***Did either player leave the ice DUE TO incident?***
   1) *Y* – The player left the ice immediately, or soon after, the incident due to an apparent injury. If *Y:*
      i. Record player *jersey number*
      ii. Circle *Assisted or Unassisted*
   2) *N* – The player continued to be a part of the play or did not leave the ice due to an apparent injury.

How to use the Incident Sheet - 3

8) ***Safety Person/ Coach/ Trainer Assess Player?***
   1) *Y* – A person other than a teammate talked to/examined the player for at least 30 seconds. If *Y*, circle:
      i. *Ice:* The player was assessed before leaving the ice.
      ii. *Bench:* The player was assessed upon return to the bench.
      iii. *Other:* The player was assessed in the hallway, accompanied to the dressing room or first aid room, etc.
   2) *N* – The player was not talked to/examined by anyone other than a teammate for 30 seconds. If *N*, circle:
      i. Not at all: The player was not acknowledged by anyone (excluding teammates) upon return to the bench.
      ii. No exam: The player was acknowledged by someone (excluding teammates), but not examined. (e.g. "Are you ok?" "I'm fine" end of conversation.)
   3) *Unk* – Unable to confirm if player was talked to/examined.

9) ***Injured Player Outcome***
   1) *Loss of consciousness* – Player is visibly unconscious; does not move or respond for a period of time (> 5 seconds?).
   2) *Woozy / Shaken Up* – Player is visibly unsteady/uneasy on their feet.
   3) *Did player return to game* – After leaving the ice from the shift in which the incident occurred, did the player return to the game. If the incident happens at the end of a game, or at a point where the player cannot return to the game, please check unknown.
   4) *Other Injury* – Player sustains an injury not related to the head (e.g. broken leg, sprained ankle, etc.).
   5) *Equipment worn properly* – Helmet straps undone/broken, chinstrap too loose, tie-down not attached, etc. (Only indicate as available)

10) ***Arena picture***

Please indicate:

1) Your Location in the stands: Please indicate with an X.*
2) Location of players' bench: Please indicate with an arrow.*
3) Location of incident: Please indicate with an X.
4) Whose end the incident occurred in: Circle H or V

*Mark 1 (your location) and 2 (bench location) on the FIRST incident sheet, and fill these in on the other sheets during a stop in play or after the game.

SFU HOCKEY INCIDENT RECORDING SHEET

V3.1

* Unless space provided, please CIRCLE all appropriate information

Date: _____
Game #: _____
Home Team: _____
Visiting Team: _____
League: _____
Type of Game: _____
Played At: _____
Recorder: _____
Final Score: _____

INCIDENT # : Type

1. Accidental Collis'n
2. Body Check
3. Cross Check
4. High Check
6. Run into Goal
7. Hit from Behind
8. Hands

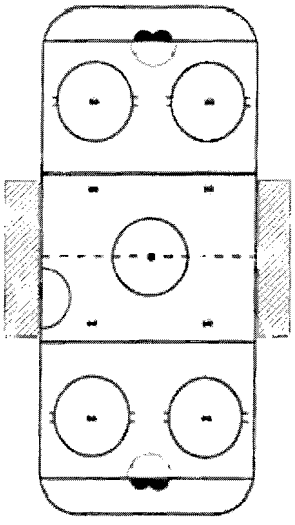
PLAYERS INVOLVED

JERSEY #				
	INITIATOR?:	Y	N	
	AT RISK?:	Y	N	
	Team:	H	V	
	Ctrl of puck?:	Y	N	Loose
	Position:	F	D	G

JERSEY #				
	INITIATOR?:	Y	N	
	AT RISK?:	Y	N	
	Team:	H	V	
	Ctrl of puck?:	Y	N	Loose
	Position:	F	D	G

* Please indicate: 1) Your Location (X)
2) Location of player's bench (Arrow)
3) Location of incident (X)
4) Whose end incident occurred in (Circle H or V)

H V



H V

TIME ON CLOCK:

SCORE H V

PERIOD 1 2 3 O/T

RESULT

- Hit Head on Boards / Glass / Goalpost / Ice
- Head Hit by Stick / Puck
- Head Hit by Elbow / Glove / Fist / Body
- Whiplash _____

PENALTY CALLED ON PLAY?

Jersey #	Time	Type
	2 / 4 / 5 / 10 / Match	

Jersey #	Time	Type
	2 / 4 / 5 / 10 / Match	

DID EITHER PLAYER LEAVE ICE DUE TO INCIDENT ?

Y JERSEY # _____
N
Assisted / Unassisted
JERSEY # _____

SAFETY PERSON/COACH/TRAINER ASSESS PLAYER?

Y	N	Unknown
Ice / Bench / Other	Not at all	No Exam

INJURED PLAYER OUT-

Jersey	LOSS OF CONSCIOUSNESS?	WOOZY/SHAKEN UP?	DID PLAYER RETURN TO GAME?	OTHER INJURY
_____	Y N Un-	Y N Un-	Y N Unknown	_____
_____				_____

Other Relevant Information:

Jersey	PLAYER WEARING MOUTHGUARD?	EQUIPMENT WORN PROPERLY?	SIZE DIFFERENCE IN PLAYERS?	COMMENTS:
_____	Y N Un-	Y N Un-	Y N Unknown	Please see other side of sheet
_____	known	known	# H / V Bigger	
	Y N Un-	Y N Un-	_____	

Appendix F

Pearson's exact chi-square tests were used to test for differences among cases missing data and complete cases. The proportions of complete cases and cases missing data on a dichotomous dummy variable would be identical under the null hypothesis: there are no significant differences between missing and complete cases. A non-significant ($p > .05$) chi-square statistic provides no evidence for rejection of the null hypothesis and indicates there may not be systematic differences between missing and complete cases.

For example, to test for differences in missing and complete cases on the nature of the injury reported by official injury reports, an exact Pearson's chi-square test of concussion (response cases; cases missing data) and form type (Hockey Canada Injury Report; BCAHA Mutual Aid Form) was non-significant ($p > .05$). Table F.1 summarizes the numbers (and proportions of cases on the dummy variable in parentheses). The non-significant chi-square statistic indicates there are no significant differences in the proportions of response and missing cases on either form type. This indicates there may be no systematic differences between response and missing cases and, as a result, missing cases are assumed missing at random.

Table F.1 Numbers (and Proportions) of Response and Missing Cases from Official Injury Reports

Concussion	Form Type		Totals
	Hockey Canada	BCAHA	
Response	33 (12)	235 (88)	268
Missing	3 (8)	35 (92)	38
Totals	36	270	306