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

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SIMON FRASER UNIVERSITY

Summer 2006

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## Approval

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<thead>
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<th>Name:</th>
<th>Ian James Sinclair Williamson</th>
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<tr>
<td>Degree:</td>
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<td>An Epidemiological Investigation of Concussion in Youth Ice Hockey</td>
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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.

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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.

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<th>Description</th>
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<tbody>
<tr>
<td>AE</td>
<td>Athlete Exposures</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>DIOC</td>
<td>Doctor-confirmed Incidents of Concern</td>
</tr>
<tr>
<td>FIOC</td>
<td>Formal Incidents of Concern</td>
</tr>
<tr>
<td>HHIHA</td>
<td>Hockey Head Injury History Assessment</td>
</tr>
<tr>
<td>Inc</td>
<td>Incidence</td>
</tr>
<tr>
<td>IOC</td>
<td>Incidents of Concern</td>
</tr>
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<td>PIOC</td>
<td>Player-identified Incidents of Concern</td>
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<tr>
<td>PGH</td>
<td>Player Game Hours</td>
</tr>
<tr>
<td>SSHH</td>
<td>Significant Symptomatic Head Hit</td>
</tr>
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<td>OIOC</td>
<td>Observer-identified Incidents of Concern</td>
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<td>VIOC</td>
<td>Volunteer-identified Incidents of Concern</td>
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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.\textsuperscript{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).\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{13-23,27}

Among those investigations that are able to report incidence, estimates are often
taken 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.\textsuperscript{13,14,16-}
\textsuperscript{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.\textsuperscript{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.\textsuperscript{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. 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. 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.” 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.

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. 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.

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.

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: \( \frac{\text{number of IOC}}{\text{estimated cumulative AE}} \times 1000. \)

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,\(^ \dagger\) 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.

\(^\dagger\) 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,\(^1\) 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.\(^6\) 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,\(^1\) 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

---

\(^1\) Average number of players obtained from a sample of BCAHA team rosters.

\(^6\) 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

<table>
<thead>
<tr>
<th></th>
<th>FIOC</th>
<th>DIOC</th>
<th>VIOC</th>
<th>PIOC</th>
<th>OIOC</th>
</tr>
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<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IOC</td>
<td>43</td>
<td>15</td>
<td>15</td>
<td>54</td>
<td>54</td>
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<tr>
<td>AE</td>
<td>645,492</td>
<td>58,381</td>
<td>23,323</td>
<td>58,381</td>
<td>23,323</td>
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<tr>
<td>Inc(^a)</td>
<td>0.07</td>
<td>0.26</td>
<td>0.64</td>
<td>0.93</td>
<td>2.31</td>
</tr>
<tr>
<td>CI(^b)</td>
<td>0.05, 0.09</td>
<td>0.16, 0.42</td>
<td>0.39, 1.06</td>
<td>0.71, 1.21</td>
<td>1.78, 3.02</td>
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Player

<table>
<thead>
<tr>
<th></th>
<th>IOC</th>
<th>AE</th>
<th>Inc(^a)</th>
<th>CI(^b)</th>
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<tbody>
<tr>
<td>IOC</td>
<td>14</td>
<td>53,865</td>
<td>0.26</td>
<td>0.15, 0.44</td>
</tr>
<tr>
<td>AE</td>
<td>14</td>
<td>21,19</td>
<td>0.65</td>
<td>0.39, 1.09</td>
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<tr>
<td>Inc(^a)</td>
<td>0.26</td>
<td>0.98</td>
<td>2.46</td>
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<td>CI(^b)</td>
<td>0.05</td>
<td>2.32</td>
<td>3.47, 8.88</td>
<td>10.26, 23.01</td>
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Goalie

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<tr>
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<th>AE</th>
<th>Inc(^a)</th>
<th>CI(^b)</th>
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<td>4,516</td>
<td>0.22</td>
<td>0.04, 1.25</td>
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<tr>
<td>AE</td>
<td>1</td>
<td>1,804</td>
<td>0.55</td>
<td>0.10, 3.13</td>
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<td>Inc(^a)</td>
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<td>0.55</td>
<td>0.04, 1.25</td>
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<tr>
<td>CI(^b)</td>
<td>0.04</td>
<td>2.12</td>
<td>1.72, 22.52</td>
<td>1.74, 51.98</td>
</tr>
</tbody>
</table>

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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{54,55} The apparent variability observed in this study reiterates calls to standardize epidemiological surveillance measures and methods in ice hockey.\textsuperscript{55-60}
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

<table>
<thead>
<tr>
<th>Study</th>
<th>Period</th>
<th>Setting</th>
<th>Age (years)</th>
<th>CX&lt;sup&gt;a&lt;/sup&gt;</th>
<th>N</th>
<th>AE</th>
<th>PGH</th>
<th>Incidence</th>
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<tbody>
<tr>
<td>FIOC</td>
<td>2003-2004</td>
<td>CAN</td>
<td>R:11-17</td>
<td>43</td>
<td>22,491</td>
<td>645,492</td>
<td>180,738&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.23</td>
</tr>
<tr>
<td>DIOC Approach B</td>
<td>2003-2004</td>
<td>CAN</td>
<td>R:11-17</td>
<td>15</td>
<td>16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>23,323</td>
<td>6,530&lt;sup&gt;b&lt;/sup&gt;</td>
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</tr>
<tr>
<td>VIOC Approach B</td>
<td>2003-2004</td>
<td>CAN</td>
<td>R:11-17</td>
<td>54</td>
<td>16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>23,323</td>
<td>6,530&lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.42</td>
</tr>
<tr>
<td>PIOC</td>
<td>2003-2004</td>
<td>CAN</td>
<td>R:15-16</td>
<td>19</td>
<td>148</td>
<td>3,380</td>
<td>946&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>OIOC</td>
<td>2003-2004</td>
<td>CAN</td>
<td>R:11-17</td>
<td>28</td>
<td>16&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1,792</td>
<td>502&lt;sup&gt;b&lt;/sup&gt;</td>
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</tr>
<tr>
<td>Gerberich (1987)</td>
<td>1982-1983</td>
<td>USA</td>
<td>M:16.1</td>
<td>22</td>
<td>251</td>
<td></td>
<td>4,142&lt;sup&gt;d&lt;/sup&gt;</td>
<td>5.31</td>
</tr>
<tr>
<td>Smith (1997)</td>
<td>1994-1995</td>
<td>USA</td>
<td>1&lt;sup&gt;g&lt;/sup&gt;</td>
<td>86</td>
<td></td>
<td></td>
<td>639&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1.56</td>
</tr>
</tbody>
</table>

<sup>a</sup>Number of concussions.  
<sup>b</sup>Assuming 6 athletes on ice/ 16-member team \(\times\) 0.75 hours games = player exposure of 0.28 PGH/AE.  
<sup>c</sup>Average number of players per team.  
<sup>d</sup>Calculated from mean number of game hours per player \(\times\) number of players.  
<sup>e</sup>Calculated from number of injuries \(\times\) proportion of injuries that were concussions.  
<sup>f</sup>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 have 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). 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.\textsuperscript{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.\textsuperscript{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


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. Moreover, the apparent under-reporting of concussions in some sports may increase the risks of further concussions and their cumulative or even catastrophic effects.

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. 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. 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.
According to van Mechelen, Hlobil, and Kemper (1992), the first steps in controlling sport injuries include identifying an injury's aetiology. Knowledge of athlete-related and environmental risk factors allows for the formulation of more precise rate estimates and strategies to reduce injury frequency. 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. 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. Therefore, to maximize the capture of concussions we broadened injury inclusion criteria and observed samples of the same population with three surveillance strategies. 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." 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.

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. 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.

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
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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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. 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.

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.  

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

<table>
<thead>
<tr>
<th>Features</th>
<th>FIOC</th>
<th>VIOC</th>
<th>DIOC</th>
<th>OIOC</th>
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<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
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*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.

- Headache
- Dizziness
- Confusion
- Seeing stars
- Other
- Feeling slow
- Poor coordination
- Vasal stare
- Nausea
- Feeling tired
- Poor concentration
- Tingling in limbs
- Vomiting
- Starred speech
- Loss of consciousness
- Memory problems
- Missing
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 \( \chi^2 (4, N = 223 \text{ injury reports}) = 5.97, p = .20 \), 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 $\chi^2 (5, N = 3642 \text{ games}) = 13.20, p = .02$, but only age was significantly associated with VIOC, likelihood ratio $\chi^2 (2, N = 3642 \text{ games}) = 9.70, p = .01$. 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 $\chi^2 (5, N = 1,455 \text{ games}) = 18.27, p = .003$, but only age division was significantly associated with VIOC, likelihood ratio $\chi^2 (2, N = 1,424 \text{ games}) = 15.54, p < .001$. 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 $\chi^2 (5, N = 3,603 \text{ games}^{\text{††}}) = 10.13, p = .07$, 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 $\chi^2 (2, N = 1,416^{\text{††}}) = 7.56, p = .18$ 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 $\chi^2 (106, N = 112 \text{ games}) = 77.26, p = 0.98$, 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.
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#### 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. 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...
throughout 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 throughout 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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


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.


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.\textsuperscript{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.\textsuperscript{3,6-14} In rare cases, multiple concussions have even led to the catastrophic autonomic dysfunction that characterizes Second Impact Syndrome.\textsuperscript{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.\textsuperscript{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 injuries 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.\textsuperscript{11} 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 \( \frac{\text{number of SSHH}}{\text{total number of athletes at risk}} \times 100. \) Exact binomial confidence intervals were calculated as recommended by Clopper and Pearson (1934).\textsuperscript{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.\textsuperscript{40}

\textsuperscript{11} 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, $\chi^2 (10, N = 536 \text{ players}) = 7.15, p = .71$, 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>
<thead>
<tr>
<th>Table 3.1 SSHH Occurrence Across Years, Tournaments, Districts, and Positions</th>
<th>Players Who Sustained a SSHH</th>
<th>Players At Risk</th>
<th>Percentage of Players</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>37</td>
<td>98</td>
<td>38</td>
</tr>
<tr>
<td>2002</td>
<td>52</td>
<td>197</td>
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</tr>
<tr>
<td>2003</td>
<td>35</td>
<td>113</td>
<td>31</td>
</tr>
<tr>
<td>2004</td>
<td>45</td>
<td>136</td>
<td>33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>169</td>
<td>544</td>
<td>31</td>
</tr>
<tr>
<td><strong>Tournament</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under-16 Years</td>
<td>65</td>
<td>190</td>
<td>34</td>
</tr>
<tr>
<td>Under-17 Years</td>
<td>104</td>
<td>354</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>169</td>
<td>544</td>
<td>31</td>
</tr>
<tr>
<td><strong>District</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fraser</td>
<td>50</td>
<td>142</td>
<td>35</td>
</tr>
<tr>
<td>Greater Vancouver</td>
<td>18</td>
<td>54</td>
<td>33</td>
</tr>
<tr>
<td>Kootenay</td>
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<td>88</td>
<td>27</td>
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<tr>
<td>North</td>
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<td>63</td>
<td>25</td>
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<tr>
<td>Okanagan</td>
<td>47</td>
<td>150</td>
<td>31</td>
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<tr>
<td>Vancouver Island</td>
<td>14</td>
<td>47</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>169</td>
<td>544</td>
<td>31</td>
</tr>
<tr>
<td><strong>Position</strong></td>
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</tr>
<tr>
<td>Forward</td>
<td>91</td>
<td>303</td>
<td>30</td>
</tr>
<tr>
<td>Defence</td>
<td>60</td>
<td>170</td>
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<tr>
<td>Utility</td>
<td>4</td>
<td>9</td>
<td>44</td>
</tr>
<tr>
<td>Goalie</td>
<td>13</td>
<td>54</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>168$^b$</td>
<td>536$^c$</td>
<td>31</td>
</tr>
</tbody>
</table>

$^a$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>
<thead>
<tr>
<th>Previous SSHH</th>
<th>N</th>
<th>Percentage Who Sustained a SSHH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 or more</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>2 or more</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>3 or more</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>4 or more</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

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.\textsuperscript{42,43}
Figure 3.1  Frequencies of symptoms experienced by players reporting SSHH.

1.3.2 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.
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.

![Bar chart showing time before return to play]

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, $\chi^2 (1, N = 213 \text{ players}) = .06, p = .89$; therefore, there was no evidence to indicate wearing a mouth guard during games reduced the likelihood of sustaining a SSHH during games.$^{\S\S}$

### 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, $\chi^2 (1, N = 513 \text{ players}) = 1.62, p = .25$; 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

$^{\S\S}$ 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. 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. 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. 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. 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.

Like other investigation, this study found the most commonly reported symptoms of concussion were headache, dizziness, and post-traumatic amnesia. 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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).\textsuperscript{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.\textsuperscript{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


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 overestimation 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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


Appendices
Appendix A

<table>
<thead>
<tr>
<th>HOKEY CANADA INJURY REPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLAIMS MUST BE PRESENTED WITHIN 30 DAYS OF INJURY. INJURY DATE:</td>
</tr>
</tbody>
</table>

### INJURED PARTICIPANT:
- Player [ ] Team Official [ ]
- Date of Birth: [ ]
- Sex: [M], [F]
- Address: [ ]
- City/Town [ ]
- Postal Code: [ ]
- Phone: [ ]

### NAME: [ ]

### PHONE: [ ]

### MAILING ADDRESS:

**Form must be signed and submitted within 30 days of injury**

**Please forward all claims to your Primary Health Insurance Provider**

### Division:
- AA [ ]
- AAA [ ]
- A [ ]
- B [ ]
- BB [ ]
- C [ ]
- CC [ ]
- D [ ]
- DD [ ]
- E [ ]
- F [ ]
- G [ ]
- J [ ]
- K [ ]
- L [ ]
- M [ ]
- N [ ]
- O [ ]
- P [ ]
- Q [ ]
- R [ ]
- S [ ]
- T [ ]
- U [ ]
- V [ ]
- W [ ]
- X [ ]
- Y [ ]
- Z [ ]

### BODY PART INJURED:
- Visit the Hockey Canada website for an optional questionnaire

### NATURE OF INJURY:
- Concussion [ ]
- Traumatic Fracture [ ]
- Sprain [ ]
- Strain [ ]
- Other [ ]

### INJURY CONDITIONS:
- Name of area/location: [ ]

### WEARING WHEN INJURED:
- Headgear [ ]
- Skating Guard [ ]
- Mouth Guard [ ]
- Skates [ ]
- Gloves [ ]
- Jockstrap [ ]
- Other [ ]

### WEARING AFTER INJURY:
- Headgear [ ]
- Skating Guard [ ]
- Mouth Guard [ ]
- Skates [ ]
- Gloves [ ]
- Jockstrap [ ]
- Other [ ]

### CAUSE OF INJURY:
- Hit by Puck [ ]
- Collision with Board [ ]
- Blocked Shot [ ]
- Other [ ]

### LOCATION:
- Behind the Net [ ]
- On Ice [ ]
- In the D [ ]
- Other [ ]

### INJURY RECORDED:
- Date: [ ]

### TEAM INFORMATION:
- Team Official (Print): [ ]
- Team Name: [ ]
- Team Official Position: [ ]

### HEALTH INSURANCE INFORMATION:
- Occupation: [ ]
- Employer: [ ]
- Insurance: [ ]
- Province: [ ]

### APPROVAL:
- Branch: [ ]
- Date: [ ]

---

**THIS MUST BE FILLED OUT IN FULL OR FORM PROCESSING WILL BE DELAYED**

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 INSURANCE PROVIDER**
3. Has a claim been submitted? [ ] Yes [ ] No If "YES", PLEASE FORWARD PRIMARY INSURANCE 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)

<table>
<thead>
<tr>
<th>Type of Expense</th>
<th>Date Expenses Incurred</th>
<th>Total Amount Charged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Month</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 Ollefield Road, Saanichton BC V8M 2A1 or fax to 250-492-4536.
3. All receipts and/or invoices are to 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.A. Formuser, Finance Committee, BCAHA

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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
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**

<table>
<thead>
<tr>
<th><strong>When should I report an incident to my trainer or to SFU researchers?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Anytime a player has his “bell-rung,” or exhibits any concussion signs and symptoms due to direct or indirect head impact, please submit an <em>Incident of Concern Reporting Form</em>. We will classify the incident based on information received from submitted forms and the follow-up.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>How long will the player be out for?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Will I have access to the findings?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th><strong>When I submit a form, who sees the information?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>I have already filed an injury report to BCAHA – do I still have to file this form to the SFU Concussion Research Project?</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>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!</td>
</tr>
</tbody>
</table>
**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: __________ (e.g. B2 or C8)  □ If 'Rep', indicate Tier: __________ (e.g. 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  □ 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  □ Other __________________________

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 CB)

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

**On dates when your team played:**

1. If you DID attend the game, circle "Y"  
2. If the game DID have an Incident of Concern, write '✓'

   If you DID NOT attend the game, circle "N"  
   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.

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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<td>7 Y/N</td>
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<td>10 Y/N</td>
<td>11 Y/N</td>
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<td>12 Y/N</td>
<td>13 Y/N</td>
<td>14 Y/N</td>
<td>15 Y/N</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Foms 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
   - Headaches
   - Sensitivity to light and/or noise
   - Nausea
   - Difficulty concentrating
   - Fatigue or sleeping more than usual
   - 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?
   - 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?

<table>
<thead>
<tr>
<th>TEAM</th>
<th>LEVEL</th>
<th>LEAGUE</th>
<th>FULL CONTACT?</th>
</tr>
</thead>
<tbody>
<tr>
<td>This Season</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Last Season</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Seasons ago</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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) ________________________________

6. 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.

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

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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.

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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.

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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
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- 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.
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.
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
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**. If a cross check from behind occurs, record as **Hit from Behind**
   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.
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: glass¹ and ice²
   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.
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

Date: ________________________________

Game # 1: ____________________________

Home Team: __________________________

Visiting Team: _________________________

League: ______________________________

Type of Game: _________________________

Played At: ____________________________

Recorder: _____________________________

Final Score: __________________________

**Incident #:**

**Type:**

**Players Involved:**

**Initiator?**

**AT RISK?**

**Team:**

**Control of Puck?**

**Position:**

**Jersey #**

**Score**

**Period**

**Time on Clock:**

**Result**

**Penalty Called On Play?**

**DID Either Player Leave Ice Due to Incident?**

**Jersey #**

**Safeguard Person/Coach/Trainer Assess Player?**

**Injured Player Out:**

**Loss of Consciousness?**

**Woozy/Shaken Up?**

**DID Player Return to Game?**

**Other Injury**

**Player Wearing Mouthguard?**

**Equipment Worn Properly?**

**Size Difference in Players?**

**Comments:**

*Unless space provided, please circle all appropriate information.*
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

<table>
<thead>
<tr>
<th>Concussion</th>
<th>Form Type</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hockey Canada</td>
<td>BCAHA</td>
</tr>
<tr>
<td>Response</td>
<td>33 (12)</td>
<td>235 (88)</td>
</tr>
<tr>
<td>Missing</td>
<td>3 (8)</td>
<td>35 (92)</td>
</tr>
<tr>
<td>Totals</td>
<td>36</td>
<td>270</td>
</tr>
</tbody>
</table>