UNITED STATES DISTRICT COURT

DISTRICT OF MINNESOTA

In re NATIONAL HOCKEY LEAGUE PLAYERS' CONCUSSION INJURY LITIGATION This Document Relates To: ALL ACTIONS.	MDL No. 14-2551 (SRN/JSM) DECLARATION OF R. DAWN COMSTOCK, PH.D

TABLE OF CONTENTS

		Page
I.	QUALIFICATIONS	1
II.	SCOPE OF OPINIONS	6
III.	SUMMARY OF OPINIONS	6
IV.	A NOTE ON RESEARCH METHODOLOGY	7
V.	ANALYSIS OF NHL HOCKEY EPIDEMIOLOGY	8
	A. The Epidemiology of Sports-Related Concussion	8
	1. Concussion Rates Across Sports	8
	2. Concussion Rates by Type of Activity	12
	B. Trends Over Time	13
	C. Concussion Symptomology	14
	D. Epidemiology of Concussion Across Age Groups and Level of Competitiveness	19
	E. Mechanisms Of and Risk Factors for Concussion	21
	1. Mechanisms of Concussion	21
	2. Risk Factors for concussions and repeated subconcussive impacts in Ice Hockey	22
	F. Association Between Playing Contact Sports and Long-term Negative Cognitive or Psychological Health Effects	27
	1. Chronic Traumatic Encephalopathy	28
	2. Dementia	29
	3. Violence	32
	4. Depression	32
	5. Suicide	33

G. Number of Former NHL Players Who May be Affected by Long-Term Negative Cognitive or Psychological Health Effects 34

H. Comparison of Full Contact Athletes To the General Public 38

I. Historical Review of Advances in Knowledge 38

1. Consensus Statements 38

2. Position Statements/Workgroups 41

3. Peer-review Publications 42

4. Timeline 44

J. Summary of NHL Hockey Epidemiologic Data 51

VI. PROPOSED EPIDEMIOLOGIC STUDY OF RETIRED NHL PLAYERS 52

1. Retrospective Study 55

2. Prospective Study 57

VII. CONCLUSION 59

I. QUALIFICATIONS

1. My name is Dr. R. Dawn Comstock. I am a Professor in the Department of Epidemiology in the Colorado School of Public Health and the Colorado School of Medicine Department of Pediatrics at the University of Colorado Anschutz Health Sciences Campus in Aurora Colorado. I am also the founding Director of the National High School Sports-Related Injury Surveillance Study ("High School RIO"). High School RIO, implemented in the 2005/06 academic year and maintained each academic year since then, prospectively captures data on sports injuries from a large national sample of US high schools.

2. I have a BS in microbiology from Colorado State University, an MS in Epidemiology from the University of Iowa, and a PhD in Epidemiology and Public Health from the joint doctoral program at the University of California San Diego and San Diego State University. My doctoral dissertation work was a study of injuries among female rugby players. Following my doctoral work, I served as an officer in the US Public Health Service as a CDC (Center for Disease Control and Prevention) EIS (Epidemic Intelligence Service) Officer. CDC's EIS program provides intensive post-doctorate training in applied public health practice.

3. I have worked as an injury epidemiologist for the past 15 years with a specific focus on sports-related injuries. In the academic setting I teach, conduct research, and interact with a number of sports governing bodies and community groups to help translate research to action by providing the data necessary to drive evidence-based decision making. Over the past decade, I have become recognized as a national expert in sports-related concussion due to my extensive work and large number of scientific publications on concussions among high school athletes.

4. Prior to my current position at the Colorado School of Public Health and the University of Colorado School of Medicine I was a faculty member at the Ohio State University's College of Medicine, Department of Pediatrics and College of Public Health, Department of Epidemiology with a position as a principal investigator (PI) at the Center for Injury Research and Policy (CIRP) at Nationwide Children's Hospital. During my tenure in

Columbus' CIRP it was one of fewer than 15 CDC funded ICRCs (Injury Control Research Centers). Although my primary research focus has been sports injury surveillance, epidemiology, and prevention, during my time in Colorado and Ohio I have collaborated on a variety of research projects in the role of injury epidemiologist covering a range of topics including carbon monoxide poisoning, evaluation of the effectiveness of state level public health legislation, injuries among children with diabetes, playground injuries, injury patterns around holidays, etc.

5. Before joining OSU I served two years as a CDC EIS Officer assigned to the Injury Prevention Service at the Oklahoma Department of Health. Although my activities centered on injury issues including tornado-related injuries, homicide-suicide clusters, comparing medical examiner and coroner coding of cause of death, etc., my duties also included bioterrorism preparedness and an investigation of a large nosocomial outbreak of hepatitis B and C.

6. As I pursued my education I held multiple positions focused across an array of public health issues. Prior to joining EIS I worked as an Associated Schools of Public Health Fellow at the Environmental Health Services Branch, National Center for Environmental Health at CDC where I was involved with environmental epidemiology investigations of negative health issues associated with mold and of recurrent waterborne illness outbreaks on a cruise ship. While completing my doctoral work in San Diego, I worked as a Research Assistant at the Naval Health Research Center's Clinical Epidemiology Division where I was involved with behavioral epidemiology investigations of the health of DOD (Department of Defense) personnel including projects on alcohol use and stress among Marines and the military's suicide prevention program. While completing my MS work in Iowa City, I worked in the Iowa Department of Public Health, Center for Acute Disease Epidemiology on a variety of projects including foodborne outbreaks, waterborne outbreaks and bioterrorism preparedness.

7. My experience across a range of public health topics during my work with state and federal health entities, the DOD, and academia have enabled me to apply public health approaches proven to be successful in other health areas to sports-related injury.

8. My greatest honor to date was an invitation to sit on a 5 member expert panel to speak at the White House Healthy Kids and Safe Sports Concussion Summit held May 29th, 2014 in the East Room of the White House following opening remarks given by President Barack Obama:

> *Dr. Comstock was also honored to be the invited keynote speaker for the Community Sports Huddle sponsored by the National Council on Youth Sports Safety held August 17, 2015 in Denver, CO following opening remarks given by Dr. David Satcher, 16th United States Surgeon General.*
>
> *Dr. Comstock has been honored for her academic work. She received the Faculty Excellence in Student Mentored Research Award from the Colorado School of Public Health in 2016, was elected for membership into the Delta Omega National Honor Society in Public Health in 2015, was the senior author of a manuscript which was the runner-up for the Kenneth L. Knight Award for the Outstanding Research Manuscript in 2008* (Gessel LM, Fields SK, Collins CL, Dick RW, and Comstock RD. Concussions Among High School and College Athletes. *Journal of Athletic Training* 42(4);495-503 (2007)), *and received the 2nd place poster of the session award at the Second North American Congress of Epidemiology in 2006 (*Knox CL, Yard EE, and Comstock RD. Internet-Based Surveillance of Injuries Sustained by US High School Rugby Players*) and the 2nd place poster of the conference award at the 7th World Conference on Injury Prevention and Safety Promotion in 2004 (*Comstock RD, Mallonee S, and Hasandzekaj A. Does a Community-Wide Change in Protective Actions Occur After a Severe Tornado?*).*
>
> *Dr. Comstock has also been honored for her efforts to translate research into action to keep young athletes as safe as possible while respecting each sport's unique culture. In 2015 she was named one of three inaugural Youth Sports Safety Ambassadors by the National Athletic Trainer's Association, "*for her contribution to protecting the health and safety of youth athletes in all sports*", in 2012 she received the Ohio Public Health Association Media Award for her media efforts on sports-related concussions, and in 2011 she received recognition for Outstanding Service to Youth Athletes by the Youth Sports Safety Alliance with an award which included the quote, "*As a result of her continued examination of youth sports and injury surveillance, Comstock is considered one of the country's leading experts on the topic, and her studies have had wide-reaching impact and attention across the national landscape. Comstock's dedication to her profession and continued publication of studies make her an invaluable resource to the organizations closely monitoring and adopting new medical protocols that protect today's young athletes."

9. I am a member of the American Public Health Association where I currently serve as the Chair of the APHA Injury Control and Emergency Health Services Section, and am a member of the Society for the Advancement of Violence and Injury Research (SAVIR) where I sponsor a student scholarship and for which I previously served as a member of the Board of Directors from 2008-2011, and I also sponsor a student scholarship for Safe States.

10. I serve as an Editorial Board Member for the journals *Injury Epidemiology* and *Journal of Athletic Training*. Additionally, I receive frequent requests to serve as a peer-reviewer for grant applications, professional meeting abstracts, and manuscripts submitted to multiple sports medicine, epidemiology, and public health journals.

11. I serve as an ex-officio member of the NFHS SMAC (National Federation of State High School Associations, Sports Medicine Advisory Committee) and the Pop Warner Medical Advisory Committee.

12. I also have accepted multiple invitations to serve on committees/task forces. I recently accepted an invitation to participate in a Pediatric Concussion Workshop sponsored by the National Institute of Neurological Disorders and Stroke, National Institute on Drug Abuse (NIDA), National Center for Medical Rehabilitation Research (NCMRR), and Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD). Currently I am serving on the Player Health & Wellness Working Group of the NBA and USA Basketball's Youth Basketball Initiative, the National Collaborative on Children's Brain Injury (NCCBI) Return to Learn Consensus, and on the NCAA ISP Independent Review Committee. Previously I have also served on a DOD USSOCOM Injury Prevention/Performance Optimization Musculoskeletal Research Review Panel, as a member of a Safe States Alliance State Technical Assessment Team, as an invited reviewer of the 2013 IOM report *Sports-Related Concussions in Youth: Improving the Science, Changing the Culture*, a WADA Prevalence of Doping Working Group, and an IOM/National Research Council Board on Children, Youth, and Families Planning Meeting on Concussions and Youth.

13. I currently serve as a paid consultant on the CDC NCIPC TBI Surveillance Project (15IPA1505496 from 7/1/2015 to 6/30/16 with subsequent extension from 7/1/2016 to 6/30/2017).

14. I was invited to testify before the US House of Representatives Committee on Energy and Commerce on Friday, May 13, 2016 in the Rayburn House Office Building at the Subcommittee on Oversight and Investigations hearing entitled "Concussion in Youth Sports: Evaluating Prevention and Research."

15. I frequently provide data from my High School RIO sports injury database to groups involved in litigation over sports injuries. The most recent example was in an agreement to serve as a potential expert witness for Martineau King, PLLC in the case Hampton v NFHS.

16. Additionally, I have been published extensively in the peer-reviewed literature. A Web of Science search conducted in July, 2016 indicated that I have 126 publications which have been cited 2,435 times (average citation per item 18.73), have an h-index of 25, and have two manuscripts which have been identified as Highly Cited Papers. Web of Science defines a Highly Cited Paper thusly, "As of January/February 2016, this highly cited paper received enough citations to place it in the top 1% of the academic field for Clinical Medicine based on a highly cited threshold for the field and publication years." One of these Highly Cited Papers (Gessel LM, Fields SK, Collins CL, et al. Concussions Among United States High School and Collegiate Athletes. *Journal of Athletic Training*, 42(4):495-503) has been cited 286 times and the other (Marar M, McIlvain NM, Fields SK *et al*. Epidemiology of Concussions Among United States High School Athletes in 20 Sports. *American Journal of Sports Medicine*, 40(4):747-755.) has been cited 149 times. A PubMed key word search for my name indicates 46 of 120 manuscripts published in PubMed indexed journals have covered concussions specifically with 92 (including the 46 on concussions) covering sports injuries more generally.

17. Attached as **Exhibit 1** is my most recent Curriculum Vitae, which includes a comprehensive list of my publications in the last ten years and civil cases in the last four

years in which I testified as an expert at deposition or trial. Attached as **Exhibit 2** is a list of materials reviewed in preparing this declaration.

18. I have been retained as a consultant and potential expert witness by plaintiffs' counsel for the action presently pending in United States District Court for the District of Minnesota entitled *In Re National Hockey League Players' Concussion Injury Litigation*, Case No. 14-2551. A Retainer Agreement between myself and plaintiffs' counsel was executed on 1/7/16. I bill at a rate of $450/hour for my services, and a total of $19,710 has been billed as of the date of this declaration.

II. SCOPE OF OPINIONS

19. I have been asked to provide an expert opinion on i) the epidemiology of concussions and repeated subconcussive impacts among NHL players, ii) the relative risk of concussions and repeated subconcussive impacts among NHL players compared to other sports, iii) the current state of knowledge regarding NHL players' risk of long-term negative health effects as a result of concussions and repeated subconcussive impacts, iv) how an epidemiologic study of retired NHL players would be beneficial to the health and safety of both retired and current NHL players, and v) methodological options for conducting such a study of retired NHL players.

III. SUMMARY OF OPINIONS

20. NHL hockey players are at increased risk for sustaining concussions and repeated subconcussive impacts compared to younger athletes, athletes playing at lower competitive levels, and athletes participating in most other team sports popular in the United States.

21. NHL hockey players are at significantly increased risk of sustaining concussions and repeated subconcussive impacts in competition compared to practice.

22. NHL hockey players who sustain concussions and repeated subconcussive impacts are at increased risk of developing long-term negative health effects compared to individuals who do not play ice hockey or some other full contact sport (*e.g.*, football, boxing, etc.).

23. Evidence outlining several risk factors for head injury in ice hockey is sufficient to drive new or enhanced concussion prevention efforts.

IV. A NOTE ON RESEARCH METHODOLOGY

24. I conducted an extensive review of the PubMed indexed peer-review literature. Given the large numbers of, and sometimes questionable quality of, reports which have been published over the past decade in the lay media as well as research outlets contained in broader search engines (*e.g.* SportDiscus, Google Scholar, etc.). I determined restricting the literature review to PubMed indexed journal articles would provide the most reliable and highly respected research results. Table 1 provides results of various keyword searches. Of particular note is the difference between numbers of publications on ice hockey compared to football.

Table 1: PubMed Keyword Search Results

Keyword Search Terms	# of Published Articles
National Hockey League	• 106
• National Hockey League and injury(ies)	• 57
• National Hockey League and brain	• 19
• National Hockey League and concussion(s)	• 26
• National Hockey League and (m)TBI	• 1
National Football League	• 454
• National Football League and injury(ies)	• 254
• National Football League and brain	• 94
• National Football League and concussion(s)	• 88
• National Football League and (m)TBI	• 16
Ice hockey	• 2612
• Ice hockey and injury(ies)	• 1221
• Ice hockey and brain	• 317
• Ice hockey and concussion(s)	• 308
• Ice hockey and (m)TBI	• 30
Football	• 8681
• Football and injury(ies)	• 4788
• Football and brain	• 881
• Football and concussion(s)	• 803

• Football and (m)TBI	• 80
Soccer	• 7720
• Soccer and injury(ies)	• 3325
• Soccer and brain	• 353
• Soccer and concussion(s)	• 256
• Soccer and (m)TBI	• 22
Sport(s)	• 240746
• Sport(s) and injury(ies)	• 57254
• Sport(s) and brain	• 12555
• Sport(s) and concussion(s)	• 2867
• Sport(s) and (m)TBI	• 588

25. A reference list for all scientific publications used to provide specific information cited in this declaration is attached. This declaration provides a summary of the current state of knowledge using examples from the existing literature but does not provide an exhaustive summary of every published manuscript.

V. ANALYSIS OF NHL HOCKEY EPIDEMIOLOGY

A. The Epidemiology of Sports-Related Concussion

1. Concussion Rates Across Sports

26. Although the phenomena of sports-related concussion was first noted in boxing, and there is growing concern regarding concussion risk in mixed martial arts as well as sports where impacts to the head – although they may occur with less frequency – are often sustain at high velocity/with great force (*e.g.*, sports highlighted in ESPN's X Games, mountain bike racing, rodeo, etc.), this declaration is focused primarily on popular team sports more commonly played by high school, collegiate, and professional athletes in the US. It should be noted however, that head injuries may range from mild (mTBI) to fatal across sports, with the force of impact sustained in the injury event being more important than the sport played at the time of injury.

27. Rates and patterns of concussion vary widely across sports. However, the epidemiologic evidence is overwhelming in its consistency across sports, levels of play, and age groups regarding concussion rates being highest in sports that not only allow, but also

encourage large amounts of athlete-athlete contact (*e.g.*, tackling, checking). Among the most popular sports played in the US, full contact sports (*e.g.*, football, ice hockey, male lacrosse) have high concussion rates, sports in which athlete-athlete contact frequently occurs despite largely being prohibited by the rules of the game (*e.g.*, soccer, basketball, female lacrosse) have moderate concussion rates, and sports in which athlete-athlete contact is rare (*e.g.*, baseball, softball, volleyball, swimming & diving, track & field) have low concussion rates. The one exception is wrestling which, although being a full contact sport, has concussion rates similar to basketball and soccer in some studies but concussion rates similar to or greater than football and ice hockey in others.

28. For example, an epidemiologic study of concussions in 20 high school sports found concussion rates were highest in football (6.4 per 10,000 AE), followed by boys' ice hockey (5.4), and boys' lacrosse (4.0) with the concussion rate in boy's wrestling (2.2) being more similar to those in boys' soccer (1.9) and boys' basketball (1.6).[1] However, that study found concussions represented a higher proportion of total injuries among boys' ice hockey players (22.2% of all injuries) than any other sport studied.[2]

29. Similarly, one study of 15 NCAA sports found the highest competition concussion rates in male sports were reported in football (4.15 per 1,000 AE), followed by wrestling (3.26), ice hockey (2.95), lacrosse (1.58), and soccer (1.56).[3] Another study reported overall concussion rates across 25 NCAA sports were highest in men's wrestling (10.92 per 10,000 AE), followed by men's ice hockey (7.91), women's ice hockey (7.50), and men's football (6.71).[4] Yet another 2016 publication reported overall concussion rates across 13 sports were highest in men's wrestling (0.89 per 1,000 AE), women's ice hockey

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1 M. Marar *et al.*, *Epidemiology of concussions among United States high school athletes in 20 sports*, 40 AM. J. SPORTS MED. 4, 747-55 (2012).

2 *Id.*

3 T. Cavassin *et al*., *Epidemiologic considerations of concussions among intercollegiate athletes*, 10 APPL. NEUROPSYCHOL. 1, 12-22 (2003).

4 S.L. Zuckerman *et al*., *Epidemiology Of Sports-Related Concussion in NCAA Athletes From 2009-2010 To 2013-2014: Incidence, Recurrence, And Mechanism*, 43 AM. J. SPORTS MED. 11, 2654-62 (2015).

(0.78), football (0.75), and men's ice hockey (0.74) but found that the average number of concussions per team-season was much higher in men's football (518) and men's ice hockey (253) than the sport with the next highest average number of concussions per team-season, women's ice hockey (94).[5] This helps to illustrate why rates are the most appropriate metric to use when comparing concussion burden across sports, since the number of games per team, numbers of players participating in a game, etc. can vary widely across sports making comparisons such as number of concussions per team-season less informative than concussion rates per 1,000 AEs.

30. Unfortunately, such direct comparisons of rates across sports is not possible at the professional level, elite level, or national level as there is currently no surveillance system capturing concussion data across sports at those levels utilizing the same methodology during the same time period. While it is possible to compare rates of concussion reported by different studies, such comparisons must be interpreted with extreme caution given differences in study methodologies, time periods, etc.

31. There have been several publications reporting concussions in professional/elite ice hockey players. For example, a 2003 publication reported ice hockey concussion rates were 4 per 1,000 games in 1986/87 and 25 per 1,000 games in 2001/02.[6] A 2008 publication reported ice hockey concussion rates were 1.81 per 1,000 AE in 1998/99 and 1.04 per 1,000 AE in 2005/06.[7] A 2011 publication reported ice hockey concussion rates over time ranged from a low of 4.6 per 100 players in 1997/98 to a high of 7.7 per 100 players in 2000/01 and estimated there were 1.8 concussions per 1,000 game player-hours

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[5] Z.Y. Kerr *et al*., *Epidemologic measures for Quantifying the Incidence of Concussion in National Collegiate Athletic Association Sports*, 51 J. ATHL. TRAIN. 6 (2016).

[6] R.A. Wennberg & C.H. Tator, *National Hockey League reported concussions, 1986-97 to 2001-02*, 30 CAN. J. NEUROL. SCI. 3, 206-09 (2003).

[7] R.A. Wennberg & C.H. Tator, *Concussion incidence and time lost from play in the NHL during the past ten years*, 35 CAN. J. NEUROL. SCI. 5, 647-51(2008).

during the study period.[8] A 2013 publication reported concussion rates in NHL players were 5.23 per 100 regular season games.[9]

32. Similarly, there have been several publications reporting concussions in professional football players. For example, a 2010 publication reported concussion rates in NFL players were 0.42 per NFL game in 1996 through 2001 and 0.38 per NFL game in 2002 through 2007.[10] A 2014 publication reported the concussion rate in NFL players was 64.3 per 10,000 game exposures.[11] A 2015 publication reported a football concussion rate of 27.8 per 1,000 athletes at risk.[12] A 2016 publication reported concussion rates among NFL players in several ways, finding 0.61 concussions per game and 6.61 concussions per 1,000 AEs.[13]

33. Although rates are the preferred way to compare burden of concussion across sports because rate calculations account for differences in team size, length of season, number of games or practices in a season, etc, there are other ways to evaluate concussion burden across sports. For example, a review article assessed burden of head injury across sports by evaluating % of participants injured.[14] That study reported estimates that between 4% and 20% of football players sustain mild traumatic brain injury ("mTBI") each season

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[8] B.W. Benson *et al*., *A prospective study of concussions among National Hockey League players during regular season games: the NHL-NHLPA Concussion Program*, 183 CAN. MED. ASS'N. J. 8, 905-11 (2011).

[9] L. Donaldson *et al*., *Bodychecking Rules and Concussion in Elite Hockey*, PLOS ONE (July 17, 2013), http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0069122.

[10] I.R. Casson *et al*., *Twelve Years of National Football League Concussion Data*, 2 SPORTS HEALTH 6, 471-83 (2010).

[11] G.D. Myer *et al*., *Rates of concussion are lower in National Football League games played at higher altitudes*, 44 J ORTHOP. SPORTS PHYS. THER. 3, 164-72 (2014).

[12] D.W. Lawrence *et al*., *Descriptive Epidemiology of Musculoskeletal Injuries and Concussions in the National Football League 2012-2014*, 3 ORTHOP. J. SPORTS MED. 5, (2015).

[13] J.T. Nathanson *et al*., *Concussion Incidence in Professional Football: Position-Specific Analysis With Use of a Novel Metric*, 27 ORTHOP. J. SPORTS MED. 4, (2016).

[14] J.E. Bailes & R.C. Cantu, *Head injury in athletes*, 48 NEUROSURGERY 1, 26-45 (2001).

and as many as 7% of ice hockey players sustain concussions during a single season, while the proportion of participants sustaining an injury in a single season was lower in rugby (6%), basketball (2%), and baseball (1%).

34. A systematic review published in 2003 reported that in a study of 63 published articles reporting concussion incidence in eight contact sports (football, boxing, ice hockey, judo karate, taekwondo, rugby, and soccer), they found ice hockey and rugby had the highest incidence of concussion although they concluded there were few high-quality studies on the incidence of concussion.[15]

2. Concussion Rates by Type of Activity

35. Also largely consistent across studies, concussion rates in most sports are significantly higher in competition compared to practice. This is true for both football and ice hockey across age groups and levels of play.

36. A review of ice hockey injuries published in 1998 reported the incidence of concussion was higher in game play than practice for elite players.[16]

37. A study of British Columbia Junior Hockey League players found higher rates of concussions occurred in games (5.95 per 1,000 player-game hours) versus practice (0.6 per 1,000 hours) for the 1998-1999 season and for the 1999-2000 season (4.63 concussions per 1,000 player-game hours with no concussion injuries reported during practices).[17]

38. In fact, the difference between competition and practice concussion rates is frequently more striking in ice hockey compared to other sports in general and football specifically. The epidemiologic study of concussions in 20 high school sports mentioned above found that ice hockey players were 13.2 times more likely to sustain a concussion in competition compared to practice while football players were only 7.4 times more likely to

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[15] J.O. Koh *et al*., *Incidence of concussion in contact sports: a systematic review of the evidence*, 17 BRAIN INJURY 10, 901-17 (2003).

[16] C.R. Honey, *Brain injury in ice hockey*, 8 CLIN. J. SPORT MED. 1, 43-46 (1998).

[17] D. Goodman *et al*., *Concussions in hockey: there is cause for concern*, 33 MED. SCI. SPORTS EXERC. 13, 2004-09 (2001).

be injured in competition and lacrosse players were 9.5 times more likely to be injured in competition.[18]

39. Similarly, the study of 15 NCAA sports mentioned above found men's ice hockey players were at 15.5 times greater risk for concussion during games compared to practice while football players were at 10.5 greater risk and men's lacrosse players were at 13.3 times higher risk.[19] In the study of 25 NCAA sports mentioned above in ice hockey players the competition concussion rate was 9.90 times higher than the practice concussion rate and in wrestlers it was 9.76 times higher; while in football it was 7.16 times higher and in men's lacrosse it was 4.78 times higher.[20]

40. Another study of Division I men's ice hockey players found 65% of injuries occurred during games although games accounted for only 23% of all exposures and that concussion was the most common injury (18.6%) with only 19% of all recorded concussions occurring in practice.[21]

B. Trends Over Time

41. Studies' findings have varied regarding concussion trends over time, though an upward trend has been generally observed.

42. A 1998 review of clinical studies of ice hockey injuries published from 1966 to 1997 reported a downward trend in concussions among players 5 to 14 years of age, but this trend was not seen in older players.[22]

43. Concussion rates increased dramatically in the NHL from 4 per 1,000 games in 1986/87 to 25 per 1,000 games in 2001/02 with researchers postulating that increased recognition and reporting was primarily responsible for the increase.[23]

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[18] Marar *et al.*, *supra* n.1.

[19] Cavassin *et al.*, *supra* n.3.

[20] Zuckerman *et al.*, *supra* n.4.

[21] K. Flik *et al.*, *American collegiate men's ice hockey: an analysis of injuries*, 33 AM. J. SPORT MED. 2, 183-87 (2005).

[22] Honey, *supra* n.16.

44. However, in the decade from 1997/98 through 2007/08, concussion rates per 1,000 AE reported by one study demonstrated a downward trend with researchers hypothesizing the decrease could have been due to either injury reduction efforts or, alternatively, due to increased adherence to return-to-play ("RTP") guidelines.[24]

45. Another study covering the 1997/98 through 2003/04 seasons reported concussion rates per 100 players rose and fell several times with a low of 4.6 per 100 players reported in 1997/98 and a high of 7.7 per 100 players reported in 2000/01. The researchers also noted that 21.8% of concussions sustained during the study period were their second concussive event, 6.0% the third, 2.3% the fourth, and 0.8% the fifth.[25]

46. At the high school level concussion rates have increased significantly over the past decade in most sports studied.[26] However, a study of NCAA sports-related concussions sustained during the 2009-2012 to 2013-2014 academic years reported that while the national estimate of reported concussions in men's football increased significantly over time, a liner trend did not exist in the national estimates for men's ice hockey across the study period.[27]

C. Concussion Symptomology

47. Due to variability in study methodologies, it is difficult to draw definitive conclusions regarding the similarity to or differences between concussions sustained by professional football and ice hockey players because the only accurate comparative evaluation is to utilize data from a surveillance system that included both sports and collected data on both sports over the same time period using the same methodology. There

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[23] Wennberg & Tator, *supra* n.6.

[24] Wennberg & Tator, *supra* n.7.

[25] Benson *et al*., *supra* n.8.

[26] A.E. Lincoln *et al*., *Trends in concussion incidence in high school sports: a prospective 11-year study*, 39 AM. J. SPORTS MED. 5, 958-63 (2011). *See also* J.A. Rosenthal et al., *National High School Athlete Concussion Rates From 2005-2006 to 2011-2012*, 42 AM. J. SPORTS MED. 7, 1710-15 (2014).

[27] Zuckerman *et al*., *supra* n.4.

are no such injury surveillance systems currently capturing data across sports at the professional level in the United States.

48. However, there are studies reporting concussion symptom prevalence and symptom resolution time in NHL players. A study of concussions sustained in regular season games by NHL players during the 1997/98 through 2003/04 seasons found the most common symptoms reported were headache (71%), dizziness (34%), nausea (24%), neck pain (23%), fatigue (22%), and blurred vision (22%) with amnesia reported in 21% and loss of consciousness in 18%.[28] In 20% of reported concussions the athlete endorsed four or more symptoms. The researchers concluded that headache, loss of consciousness, fatigue, and light sensitivity were significant predictors of time loss greater than 10 days in univariate analysis but only headache and fatigue remained significant predictors in multiple regression after controlling for athlete age and position.[28]

49. For the NHL seasons from 1997/98 through 2007/08 other researchers reported the average time lost from play due to concussion increased significantly.[29] The most likely explanation being increased adherence to return-to-play guidelines rather than increases in concussion severity, meaning prior to that time period NHL players were likely returning to play prematurely following a concussion. Unsurprisingly, another study covering a smaller number of years during the same time period (1997/98 through 2003/04) reported the proportion of NHL players who missed up to 10 days following concussion increased significantly from 19% to 43%. However, there was a significant difference in median time loss by number of concussions sustained with time loss increasing 2.25 times for every subsequent concussion sustained during the study period. Of concern was the finding that in 11% of concussion injuries the players continued to play because the injury was not observed and was not reported by the player. Yet more concerning, in 8% of concussion injuries the

[28] Benson *et al*., *supra* n.8.

[29] Wennberg & Tator, *supra* n.7.

players were evaluated/observed but were allowed to return to play in the same game in which they were injured.[30]

50. There are collegiate and high school surveillance systems which allow direct comparisons of concussion symptomology to be made. At both the collegiate and high school level a higher proportion of concussions sustained by male ice hockey players were recurrent compared to concussions sustained by male football players, and football and ice hockey players reported similar symptom prevalence as well as similar average numbers of symptoms across both age groups, but collegiate ice hockey players had extended symptom resolution time compared to football players while symptom resolution times between the two sports were quite similar at the high school level.

51. The NCAA Injury Surveillance Program captures concussion data on both football and ice hockey. Published manuscripts allow a direct comparison of concussion symptomology across these two sports. Two manuscripts provide this data.[31] The Zuckerman manuscript reported 20.1% of men's ice hockey concussions were recurrent (as opposed to new injuries) while only 5.0% of men's football concussions were recurrent.[32] The Wasserman manuscript reported results regarding concussion symptomology across sports with the prevalence of the various symptoms quite similar between injured men's football and men's ice hockey players – in both, the most commonly reported symptoms were headache, dizziness, and difficulty concentrating.[33] The total number of reported symptoms was also quite similar, with men's football players reporting an average of 5.06 symptoms, and men's ice hockey players reporting an average of 5.28 symptoms, but symptom resolution time varied with men's ice hockey players reporting a longer time until

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[30] Benson *et al*., *supra* n.8.

[31] Zuckerman *et al*., *supra* n.4. *See also*, E. B. Wasserman *et al*., *Epidemiology of Sports-Related Concussions in National Collegiate Athletic Association Athletes From 2009-2010 To 2013-2014: Symptom Prevalence, Symptom Resolution Time, and Return-To-Play Time*, 44 AM. J. SPORTS MED. 1, 226-33 (2016).

[32] Zuckerman *et al*., *supra* n.4.

[33] Wasserman *et al*., *supra* n.31.

all symptoms resolved compared to men's football players: approximately 70% of men's football players had symptoms resolve within 1 week while under 45% of men's ice hockey players had symptoms resolve within 1 week.

52. To further directly compare patterns of concussion between football and ice hockey players in this report, I conducted a study of my High School RIO data exclusively for this legal proceeding. The results comparing boy's football and boy's ice hockey, which have not been published in a peer-reviewed scientific paper as of yet, are below:

Table 2: Direct Comparison of Rates of All Injuries and Rates of Concussions Among US High School Football and Ice Hockey Players.

Football and ice hockey rates of all injuries and concussions, High School RIO 2008/09-2014/15							
	Football		Ice Hockey				
All injuries	N	Rate per 1,000 AE	N	Rate per 1,000 AE	Rate Ratio (Ice hockey as reference)	95% CI	
Total	21335	3.99	928	2.27	1.76	1.65	1.88
Competition	11381	12.53	742	5.45	2.30	2.13	2.47
Practice	9954	2.24	186	0.68	3.29	2.85	3.81
Concussions only	N	Rate per 10,000 AE	N	Rate per 10,000 AE	Rate Ratio (Ice hockey as reference)	95% CI	
Total	4777	8.94	279	6.82	1.31	1.16	1.48
Competition	2757	30.35	238	17.50	1.73	1.52	1.98
Practice	2020	4.56	41	1.50	3.03	2.23	4.13

53. In football, 90.5% of concussion were reported to be new injuries while 9.4% were reported to be recurrences (*i.e.*, not the first concussion sustained by the athlete). In ice hockey, 85.6% of concussions were reported to be new injuries while 14.1% were reported to be recurrences.

Table 3: Comparison of Concussion Symptomology Endorsed by US High School Football and Ice Hockey Players

Number and percent of concussed athletes in football and ice hockey that reported each symptom, 2008/09-2014/15*				
	Football		Ice hockey	
	N	%	N	%
Amnesia	953	20.2%	45	16.4%
Concentration difficulty	2853	60.5%	142	51.6%
Confusion/disorientation	2259	47.9%	105	38.2%
Dizziness/unsteadiness	3564	75.5%	192	69.8%
Drowsiness	1487	31.5%	95	34.5%
Headache	4472	94.8%	268	97.5%
Hyper excitability	133	2.8%	4	1.5%
Irritability	573	12.1%	32	11.6%
Loss of consciousness	148	3.1%	10	3.6%
Nausea	1484	31.5%	85	30.9%
Tinnitus	452	9.6%	32	11.6%
Sensitive to light/visual disturbance	2077	44.0%	116	42.2%
Sensitive to noise	1201	25.5%	72	26.2%

*Includes all concussions where athletic trainers provided data for the concussion symptom variable. There were 63 concussions (59 in football, 4 in ice hockey) where the athletic trainer did not report data for this variable (1.2% of injury reports had missing data for this variable).

54. Among the injury reports where the concussion symptom variable was completed, the number of symptoms endorsed by concussed football and ice hockey players were very similar. Concussed football players reported an average of 4.59 symptoms (median 4.0) with the number of symptoms reported by any individual athlete ranging from 1 to 13. Concussed ice hockey players reported an average of 4.35 symptoms (median 4.0) with the number of symptoms reported by any individual athlete ranging from 1 to 12.

55. Symptom resolution time was also quite similar between football and ice hockey players:

Table 4: Comparison of Concussion Symptomology Resolution Time in US High School Football and Ice Hockey Players

Concussion symptom resolution time in football and ice hockey, 2008/09-2014/15*				
	Football		Ice hockey	
	N	%	N	%
<1 day (same day return)	739	16.6%	61	22.6%
1-6 days	2195	49.2%	132	48.9%
≥ 7 days	1526	34.2%	77	28.5%
*Includes all concussions where athletic trainers provided data for the symptom resolution time variable. There were 326 concussions (317 in football, 9 in ice hockey) where the athletic trainer did not report data for this variable (6.4% of injury reports had missing data for this variable)				

D. Epidemiology of Concussion Across Age Groups and Level of Competitiveness

56. The majority of research indicates that across most sports, concussion rates in competition increase with increasing athletes' age and with increasing levels of competition although direct comparisons are difficult due to differences in study methodologies.

57. A review of ice hockey injuries published in 1998 reported the incidence of concussions per 1,000 player-hours ranged from 0.0 to 0.8 for players aged 5 to 14, from 0.0 to 2.7 for high school players, from 0.2 to 4.2 for university players, and from 0.0 to 6.6 for players on elite teams.[34] This study also found the incidence of concussion increased with higher levels of play.

58. A 2016 study of a surveillance system that captured data across youth, high school, and collegiate football players using consistent methodology found collegiate competition concussion rates were significantly higher than high school or youth competition concussion rates but practice concussion rates were highest among youth players, although practice rates did not differ significantly across age groups.[35] This study reported the mean number of concussion symptoms reported increased from 4.76 in youth, to 5.60 in high

[34] Honey, *supra* n.16.

[35] Z.Y. Kerr *et al*., *Concussion Symptoms and Return to Play Time in Youth, High School, and College American Football Athletes*, 170 JAMA PEDIATR. 70, 647-53 (2016).

school, and 5.56 in college. Additionally, a higher mean number of cognitive symptoms were reported in college and high school athletes compared to youth athletes.

59. A study of minor hockey in Canada reported that concussions were the most specific injury type, that there were significant differences in injury rates by age and division of play with injury rates increasing both as athlete age increased and as level of play increased, that injury rates were significantly higher in competition compared to practice across age levels, and that rates of injury from body checking also increased as athlete age increased.[36]

60. A cross-sectional study of ninety-six athletes, half of whom had a history of concussion, which including youth, adolescents, and adults found neuropsychological assessments demonstrated that concussed athletes across all age groups displayed persistent neurophysiological deficits at least 6 months following a concussion and that adolescents appear to be more sensitive to the consequences of concussion than either children or adults.[37]

61. Results of a study comparing the epidemiology of concussion in US high school boys' and collegiate men's ice hockey players sustained during the 2009/10 through 2014/15 academic years found concussion rates per 10,000 AE were 6.8 in high school athletes and 7.6 in their collegiate counterparts; however this difference was not statistically significant. Player-player contact was the most common general mechanism of injury in high school (46.6%) and college (71.5%) but contact with the boards comprised a larger proportion of concussions in high school (31.2%) than college (9.4%). The study also found

[36] C.A. Emery & W.H. Meeuwisse, *Injury rates, risk factors, and mechanisms of injury in minor hockey*, 31 AM. J. SPORT MED. 12, 1960-69, (2006).

[37] A. Baillargeon *et al., Neuropsychological and neurophysiological assessment of sport concussion in children, adolescents and adults*, 26 BRAIN INJ 3, 211-20 (2012).

checking was the sport specific activity during which concussion occurred for 42.7% of high school and 28.5% of collegiate injuries.[38]

E. Mechanisms Of and Risk Factors for Concussion

1. Mechanisms of Concussion

62. The vast majority of published research has identified athlete-athlete contact as the most common general mechanism of concussion across most sports studied. For example, an epidemiologic study of concussions in 20 high school sports reported player-player contact accounted for 87.8% of football concussions, 76.1% of boys' lacrosse concussions, and 63.6% of ice hockey concussions.[39] Similarly, an epidemiologic study of concussions in 25 NCAA sports reported player contact accounted for 86.7% of football concussions, 68.6% of men's lacrosse concussions, and 73.2% of men's ice hockey concussions.[40]

63. More specifically, the majority of published research indicates the most common sport-specific mechanism of concussion in ice hockey is body checking. For example, both the Marar and Zuckerman studies provided more detailed information on the sport-specific mechanism/activity associated with concussion.[41] These studies reported the most common activity associated with concussion in both boys' high school and men's collegiate ice hockey was athlete-athlete contact that occurred during checking (30.3% and 23.7% respectively).

64. A video analysis case series study of concussions diagnosed during regular season NHL games during the 2006-2010 seasons found 88% of concussions involved player-opponent contact and 8% were a result of fighting. Player-opponent contact concussions most commonly occurred when direct contact to the head was initiated by the

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[38] Z.Y. Kerr *et al*., *Concussions in United States high school boys' and college men's ice hockey players.*[Abstract accepted for presentation at the upcoming 2016 World Injury Conference.]

[39] Marar *et al*., *supra* n.1.

[40] Zuckerman *et al*., *supra* n.4.

[41] Marar *et al*., *supra* n.1. *See also* Zuckerman *et al*., *supra* n.4.

opponent's shoulder (42%), elbow (15%), or gloves (5%); that the player who sustained the concussion was often not in possession of the puck; and that no penalty was called on most of these plays.[42] A second publication reporting additional findings from the same study noted 37% of the concussions involved injured players' heads contacting the boards or glass.[43]

65. An NHL effort to reduce concussions via enforcement of bodychecking rules intended to regulate contact to the head introduced in 2010/11 and 2011/12 was evaluated in a study that analyzed concussion incidence in NHL and Ontario Hockey League games from 2009/10 through 2011/12 with a conclusion that the rules regulating bodychecking to the head did not reduce concussion incidence. Thus, the researchers stated further changes or stricter enforcement of existing rules may be required to minimize NHL players' concussion risk.[44]

2. Risk Factors for concussions and repeated subconcussive impacts in Ice Hockey

a. Bodychecking

66. In their essay on bodychecking in youth ice hockey, Drs. Marchie and Cusimano noted that despite multiple studies identifying bodychecking as a risk factor for injury, including concussions and repeated subconcussive impacts , some believe that even at the youth level bodychecking is a useful skill for winning games.[45] This review paper found that findings from meta-analyses, prospective studies, and retrospective studies all demonstrated the association between bodychecking and concussions and repeated subconcussive impacts and the available research indicated that learning to bodycheck when

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[42] H.G. Hutchison *et al*., *A systematic video analysis of National Hockey League (NHL) concussions, part I: who, when, where and what?*, 49 BR. J. SPORTS MED. 8, 547-51 (2015).

[43] H.G. Hutchison *et al*., *A systematic video analysis of National Hockey League (NHL) concussions, part II: how concussions occur in the NHL*, 49 BR. J. SPORTS MED. 8, 551-55 (2015).

[44] Donaldson *et al*., *supra* n.9.

[45] A. Marchie & M.D. Cusimano, *Bodychecking and concussion in ice hockey: Should our youth pay the price?*, 169 CAN. MED. ASS'N J. 2, 124-28 (2003).

young did not reduce players' rate of injury as they aged, though it did prolong their exposure to this risk factor.

67. Although checking is often used as physical and mental intimidation to gain control of games, research indicates the relation between aggressive play and winning is weaker than proponents believe. One study of the recorded penalties in all Stanley Cup final series from 1980 to 1997 found teams playing with less violence were more likely to win and that losing teams engaged in more violence early in games, suggesting their motivation was more likely the mistaken belief that violence would help them win, rather than frustration over being behind.[46]

68. Because body checking is the most common sport-specific activity during which concussions occur, eliminating body checking from ice hockey has great promise as an injury prevention strategy in general and a concussion prevention strategy specifically. However, as mentioned above, the Donaldson study found, a previous NHL effort to reduce concussions via enforcement of body checking rules did not demonstrate significant reductions in concussion rates indicating further changes or stricter enforcement of existing rules may be required.[47]

b. Fighting

69. Fighting is an obvious and well known risk factor for head injury as demonstrated by the multiple studies of boxing.

70. However, fighting has been allowed to persist in the NHL despite evidence from a study of the five seasons from 1987/88-1991/92 which found four significant negative correlations indicating a substantial inverse relationship between a team's number of major fighting penalties and final league standings.[48]

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[46] S.T. McCaw & J.D. Walker, *Winning the Stanley Cup Final Series is related to incurring fewer penalties for violent behavior*, 94 TEX. MED. 4, 66-69 (1999).

[47] Donaldson *et al*., *supra* n.9.

[48] G.M. Englehardt, *Fighting behavior and winning National Hockey League games: a paradox*, 80 PERCEPT. MOT. SKILLS 2, 416-18 (1995).

71. A recent study found NHL players were less likely to fight in the closing stages of games and that players were "significantly more violent in preseason games than during the regular season." leading the authors to conclude that players take into account penalties assessed for fighting and are less likely to fight when the stakes are high.[49]

72. A study of Division I men's ice hockey players reported 6 of 17 concussions that occurred in games were thought to be due to illegal activity with no penalty called on the play.[50]

73. Because fighting is prohibited by the rules of ice hockey and it has been established beyond any doubt that being punched in the head places individuals at high risk of brain injury, a commitment to eliminating fighting from ice hockey holds great promise as a concussion prevention strategy.

c. Rink size

74. Because athlete-athlete contact is known to be the main risk factor for sports related concussions and repeated subconcussive impacts, there has been a call for using larger, international size rinks, with one study reporting significantly fewer collisions of all types occurred in elite hockey games played on international size ice surfaces compared to North American size rinks.[51]

75. The authors of a study of Division I men's ice hockey players wrote: "When comparing injury data from American elite hockey players with that from their European counterparts, one must understand the subtle differences in the North American and European games. In general, the North American style of play is considered more aggressive and physical than that in Europe, where many prior studies were performed. In addition, the surface area of American rinks (approximately 1560 m^2) is considerably smaller than

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[49] N. Goldschmied & S. Espindola , *"I Went to a Fight the Other Night and a Hockey Game Broke Out": Is Professional Hockey Fighting Calculated or Impulsive?*, 5 SPORTS HEALTH 5, 458-62 (2013).

[50] Flik *et al*., *supra* n.21.

[51] R. Wennberg, *Collision Frequency in Elite Hockey on North American versus International Size Rinks*, 31 CAN. J. NEUROL. SCI. 3, 373-77 (2004).

European rinks (1800m^2). For these reasons, it may be reasonable to expect injury patterns to be different between American and European amateur elite hockey leagues."[52]

76. The NHL could evaluate each facility currently utilized for competitions to determine if rink sized could be expanded.

d. Concussion history

77. Although a single concussion seems to be well tolerated by most athletes, there is widespread concern that sustaining multiple concussions and repeated subconcussive impacts increases the risk of long-term negative health outcomes. How many concussions or subconcussive impacts it takes to be "too many" is unclear, and may vary from individual to individual, by severity of concussions sustained, and/or by the length of time between injuries. Some researchers have indicated long-term mental health morbidity may be associated with only a small number of concussions, perhaps as few as two.[53] In rare cases, cumulative injury sustained over a short period of time has been known to result in second impact syndrome, the history of which has been described.[54] The risk for second impact syndrome is highest in sports with likelihood of impacts to the head, including ice hockey, but second impact syndrome is highly preventable.[55] Concerns over the dangers of allowing athletes to return to sports activity have largely driven the RTP guidelines included in International Consensus Statements.[56]

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[52] Flik *et al*., *supra* n.21.

[53] M.W. Collins *et al*., *Relationship Between Concussion and Neuropsychological Performance in College Football Players*, 282 JAMA 10, 964-70 (1999), *See also* D. Gronwell & P. Wrightson, *Cumulative Effect Of Concussion*, 306 THE LANCET 7943, 995-97 (1975).

[54] Bailes & Cantu, *supra* n.14.

[55] J. Kelly, *Sports-Related Recurrent Brain Injuries – United States*, 46 MORB. MORTAL. WKLY. REP. 10, 224-27 (1997).

[56] P. McCrory *et al*., *Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004*, 39 BR. J. SPORTS MED., 96-204 (2005), *See also* P. McCrory *et al*., *Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport, Zurich, November 2012*, 47 BR. J. SPORTS MED., 250-58 (2013).

78. While ensuring all NHL teams are consistently applying consensus RTP guidelines is not a primary prevention mechanism, it is a secondary or tertiary concussion prevention mechanism that helps minimize the short- and long-term harm associated with concussions.

e. Personal Protective Equipment

79. Despite a study published in 1984 reporting a marked reduction in closed head injuries following implementation of helmet rules in ice hockey[57] and subsequent research showing helmet use in ice hockey unequivocally reduced the incidence of severe brain injury,[58] opponents of personal protective equipment ("PPE") contend helmets do not prevent concussions and believe helmets could actually increase concussion rates. A review of ice hockey injuries published in 1998 reported that concussion incidence was reduced by appropriate helmet use.[59] As the rules governing addition of mandatory use of helmets and face visors were evaluated, it was determined that both were effective at reducing some injuries (*e.g.*, eye injuries, non-concussion head injuries, etc.) without increasing concussions.[60] Unfortunately, since helmets have been made mandatory in the NHL there has been little literature published comparing the protective effects of different hockey helmets.[61]

80. There is ongoing debate regarding the effectiveness of mouthguards in preventing concussion, despite the overwhelming evidence that while mouthguards are very effective at preventing dental injuries, there is very little to no evidence they prevent concussions. For example during the 1960s and 1970s mouthguard use was mandated across

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[57] C.H. Tator & V.E. Edmonds, *National survey of spinal injuries in hockey players*, 130 CAN. MED. ASS'N J. 7, 875-80 (1984).

[58] F.H. Sim *et al.*, *Ice hockey injuries*, 15 AM. J. SPORTS MED. 1, 30-40 (1987).

[59] Honey, *supra* n.16.

[60] S.T. Stevens *et al.*, *The effect of visors on head and facial injury in National Hockey League players*, 9 J. SCI. MED. SPORT. 3, 238-42 (2006).

[61] D.H. Daneshvar *et al.*, *Helmets and mouth guards: the role of personal equipment in preventing sports-related concussions*, 30 CLIN. SPORTS MED. 1, 145-63 (2011).

many levels/age groups of football, ice hockey, lacrosse, field hockey, and boxing even though there was little evidence that mouth guards provide protection against concussion.[62] Mouthguards are not mandatory in the NHL. Although one study of 10,333 NHL players found rates of concussion were 1.42 times higher in players not wearing a mouthguard compared with those who did, the result was not statistically significant. However, there was a significant decrease in symptom severity among injured athletes wearing a mouthguard compared to injured athletes not wearing mouthguards.[63] Both the NCAA and the NFHS require mouthguard use in ice hockey as well as football.

81. Because helmets are effective at preventing skull fracture and may provide some protection against concussion, the NHL should continue to monitor advances in helmet engineering while enforcing current helmet rules. For example, players' helmets should be inspected frequently to ensure they meet all current standards (*e.g.*, have all appropriate padding, are not cracked, etc.) and players should be required to have properly fitted helmets and to wear them correctly.

F. Association Between Playing Contact Sports and Long-term Negative Cognitive or Psychological Health Effects

82. As noted in the abstract of a study published in 1978, "We often hear of retired professional athletes who become derelicts, alcoholics, commit suicide, or live in the past and can't hold a job. However, that's not the whole story."[64] Indeed, while athletes who had such experiences after retiring were oft thought to have simply had difficulty adjusting to the end of their careers, more recent research hypothesizes these negative outcomes may instead be indications of brain damage sustained during their athletic careers.

83. Pertinent to this proceeding, a very small survey of five former NHL players who were reported to have retired due to concussions relayed that these former NHL players related the physical and psychological symptoms they experienced as a result of their

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[62] *Id.*

[63] *Id.*

[64] B.D. McPherson, *Former Professional Athletes' Adjustment to Retirement*, 6 PHYS. SPORTSMED. 8, 52-61 (1978).

concussions to "the turmoil that is ever present in their lives."[65] Such associations, by both clinicians and athletes, between sports-related concussion and negative long-term cognitive or psychological health effects are bolstered by an ever-expanding body of research. In a 2001 publication, Dr. Bailes and Cantu explicitly outlined the concerns regarding long-term negative health effects following concussion, writing: "Because of the extreme popularity of sports in the United States and worldwide, the implications of athletic head injury are enormous."[66]

84. There are growing bodies of literature evaluating several negative consequences of traumatic brain injury, examples of which are discussed below.

1. Chronic Traumatic Encephalopathy

85. Repeated concussive and subconcussive trauma has been associated with subsequent development of chronic traumatic encephalopathy ("CTE") and CTE has been identified in athletes participating in boxing, football, soccer, ice hockey, baseball, and rugby.[67] Although there has been some debate regarding CTE in the literature, recent findings indicate the neuropathology of CTE is unique and can be readily distinguished from other neurodegenerative diseases and that exposure to repetitive head impacts, not the number of concussions, is the primary risk factor.[68] Clinical symptoms of CTE usually develop slowly over years to decades after the repetitive brain trauma with symptom onset occurring nearly 15 years after the athlete has retired on average.[69]

86. There was some criticism that CTE was only thought to be found more frequently in contact sport athletes because of systematic bias in the sample of brains evaluated. However, a recent study assessed presence of CTE pathology in brains of

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[65] J.G. Caron *et al*., *Effects of multiple concussions on retired national hockey league players*, 35 J. SPORT EXERC. PSYCHOL. 2, 168-79 (2013).

[66] Bailes & Cantu, *supra* n.14.

[67] B.R. Huber *et al*., *Potential Long-Term Consequences of Concussive and Subconcussive Injury*, 27 PHYS. MED. REHABIL. CLIN. N. AM. 2, 503-11 (2016).

[68] *Id.*

[69] *Id.*

individuals with a history of contact sports participation and age- and disease-matched controls, all from the same brain bank for neurodegenerative disorders. The researchers found CTE in 21 of 66 former athletes and none of the 198 controls, even though the control group included 33 individuals with documented single-incident TBI (sustained from falls, motor vehicle crash, assaults, etc.).[70] Brains of those with CTE did not differ from those without CTE in other noted clinicopathologic features. Researchers concluded contact sports participation was the greatest risk factor for CTE.

87. Even those researchers calling for cautious interpretations of the association between CTE and concussion history have found CTE in former football players' brains. A group that conducted brain autopsies on six retired Canadian Football League ("CFL") players with histories of multiple concussions and significant neurological decline found three had neuropathological findings consistent with CTE (although they had co-morbid pathology of cancer, vascular disease, and Alzheimer's Disease) and three had pathological diagnoses of Alzheimer's Disease, Amyotrophic Lateral Sclerosis, and Parkinson's Disease.[71]

2. Dementia

88. In a study of individuals who sustained traumatic brain injury ("TBI") as young adults, individuals who had sustained moderate TBI had 2.3 times the risk of Alzheimer's disease and those who had sustained severe TBI had 4.5 times the risk.[72]

89. A study of Taiwan's National Health Insurance program identified 28,551 people with mTBI and 692,382 people without mTBI and, after tracking each person for 5 years (2005-2009), concluding that mTBI is a significant risk factor for developing dementia

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[70] K.F. Bieniek *et al*., *Chronic traumatic encephalopathy pathology in a neurodegerative disorders brain bank*, 130 ACTA NEUROPATHOL. 6, 877-89 (2015).

[71] L.N. Hazrati *et al*., *Absence of chronic traumatic encephalopathy in retired football players with multiple concussions and neurological symptomatology*, 24 FRONT HUM. NEUROSCI. 7, 222 (2013).

[72] B.L. Plassman *et al*., *Documented head injury in early adulthood and risk of Alzheimer's disease and other dementias*, 55 NEUROLOGY 8, 1158-66 (2000).

after controlling for age, gender, urbanization level, socioeconomic status, diabetes, hypertension, coronary artery disease, hyperlipidemia, history of alcohol intoxication, history of ischemic stroke, history of intracranial hemorrhage, and Charlson Comorbidity Index Score (hazard ratio 3.26; 95% CI 2.69-3.94).[73] Another study utilizing Taiwan's Longitudinal Health Insurance Database compared 24,585 patients with mTBI to a cohort of 122,925 controls matched by sex, age, and year of index use of health care services. All patients were tracked for four years from their index use of health care, and 776 patients were identified who experienced frontotemporal dementia. After adjusting for demographic characteristics and selected comorbidities, frontotemporal dementia was more likely to occur in the mTBI group (HR 4.43, 95% CI 3.85-5.10).[74]

90. Researchers evaluating diffusion-tensor images from 64 consecutive patients with mTBI found a significant correlation between high total concussion symptom score and reduced fractional anisotropy at the gray matter-white matter junction ($p<0.05$), concluding "[t]he distribution of white matter abnormalities in patients with symptomatic mild TBI is strikingly similar to the distribution of pathologic abnormalities in patients with early Alzheimer dementia…."[75]

91. Researchers who applied a predictive model of normal ageing defined using machine learning to 99 patients with persistent neurological problems after TBI and 113 healthy controls found the model accurately predicted age in healthy individuals ($r=0.92$) but there was a mean predicted age difference between chronological and estimated brain age of 4.66 years older for gray matter and 5.97 years older for white matter in the TBI patients. Further they reported the predicted age difference predicted cognitive impairment and

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[73] Y.K. Lee *et al*., *Increased Risk of Dementia in Patients with Mild Traumatic Brain Injury: A Nationwide Cohort Study*, PLOS ONE (May 1, 2013), http://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0062422

[74] H.K. Wang *et al*., *Traumatic brain injury causes frontotemporal dementia and TDP-43 proteolysis*. 300 NEUROSCIENCE, 94-103 (2015).

[75] S. Fakhran *et al*., *Symptomatic white matter changes in mild traumatic brain injury resemble pathologic features of early Alzheimer dementia*, 269 RADIOLOGY 1, 249-57 (2013).

correlated strongly with the time since TBI, indicating brain tissue loss increased throughout the chronic post-injury phase.[76]

92. A study of 81 patients with self-reported history of TBI and 1,197 patients without TBI history included in the Alzheimer's Disease Neuroimaging Initiative (ADNI) database found a significantly earlier age of onset of cognitive impairment in the TBI group (68.2 +/- 1.1 years) compared to the non-TBI group (70.9 +/-0.2 years). Additionally, this study found age of onset of cognitive impairment decreased with increasing severity of TBI (68.5 +/-1.1 years for mTBI and 66.0 +/-3.4 for severe TBI) although this difference was not statistically significant.[77]

93. A study of retired professional football players reported that although there was no statistically significant association between recurrent concussion and Alzheimer's disease, there was an observation of an earlier onset of Alzheimer's disease in the retirees than in the general American male population.[78] Additionally, retired players with three or more reported concussions had a fivefold prevalence of mild cognitive impairment and a threefold prevalence of reported significant memory problems compared with retirees without a history of concussion.

94. A study of 64 male current and retired football players ranging in age from 25-81 years included in the LEGEND study had participants complete an online version of the BRIEF-A, a measure of executive functioning in everyday activities over the past 30 days. Effects of participation in football were examined by comparing age-adjusted scores with known population means from healthy adults. Significant differences were observed on seven of the nine scales, including inhibit, shift, emotional control, working memory, plan/organize, and task monitor. When age effects were evaluated, athletes ≥40 years of age

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[76] J.H. Cole *et al*., *Prediction of brain age suggests accelerated atrophy after traumatic brain injury*, 77 ANN. NEUROL. 4, 571-81 (2015).

[77] W. Li *et al*., *Traumatic brain injury and age of onset of cognitive impairment in older adults*, 263 J. NEUROL. 7, 1280-85 (2016).

[78] K.M. Guskiewicz *et al*., *Association between recurrent concussions and late-life cognitive impairment in retired professional football players*, 57 NEUROSURGERY 4, 719-26 (2005).

indicated more frequent problems than athletes <40 years of age. The authors concluded, "[i]n sum, football players reported more-frequent problems with executive functioning and these symptoms may develop or worsen in the fifth decade of life."[79]

3. Violence

95. A recent study comparing retired CFL players with a history of concussion to age and education level matched control subjects using MRI, to examine the uncinate fasciculus and connected gray matter as it relates to impulsivity and aggression found that the athletes had increased indicators of impulsivity and aggression compared to the controls.[80]

4. Depression

96. History of head injury during early adulthood has previously been identified as a risk factor for developing depression, with those who had sustained a TBI being 1.5 times more likely to have depression.[81]

97. A study of retired professional football players found an association between recurrent concussion and diagnosis of lifetime depression, suggesting that the prevalence of depression increased with increasing concussion history.[82] Another study of members of the National Football League Retired Players Association found the 9-year risk of being clinically diagnosed as depressed between 2001 and 2010 increased significantly with an increased number of self-reported concussions, ranging from 3.0% among those reporting no

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[79] D.R. Seichepine *et al*., *Profile of self-reported problems with executive functioning in college and professional football players*, 30 J. NEUROTRAUMA 14, 1299-304 (2013).

[80] R. Goswami *et al*., *Frontotemporal correlates of impulsivity and machine learning in retired professional athletes with a history of multiple concussions*, 221 BRAIN STRUCT. FUNCT. 4, 1911-25 (2016).

[81] T. Holsinger *et al*., *Head injury in early adulthood and the lifetime risk of depression*, 59 ARCH. GEN. PSYCHIATRY 1, 17-22 (2002).

[82] K.M. Guskiewicz *et al*., *Recurrent concussion and risk of depression in retired professional football players*, 39 MED. SCI. SPORTS EXERC. 6, 903-09 (2007).

concussions to 26.8% among those reporting 10 or more concussions.[83] The study also reported a strong dose-response relationship remained even after controlling for confounders such as the number of years since retirement. Additionally, the association between concussion and depression was independent of the association between physical health deficits and depression.

98. A recent study comparing retired CFL players with a history of concussion to age and education matched controls found the retired players had significantly higher incidence of neuropsychiatric and cognitive symptoms than healthy controls, with a worsening of these symptoms since their last concussion. Additionally, whole brain tract-based spatial statistics analysis revealed increased axial diffusivity in the right hemisphere of the retired players.[84]

99. A study of medical and military-specific data for over 49,000 active duty US Air Force members found Airmen with mTBI were at increased risk for depression (HR 2.72; 95% CI 1.97-3.76) as well as memory loss/amnesia, cognitive disorders, schizophrenia, and PTSD and that the hazard ratios for these outcomes remained significantly elevated for at least 6 months post-mTBI even after eliminating those with previous neuropsychiatric diagnoses.[85]

5. Suicide

100. There is a growing body of literature linking brain injury to suicide. A recent study of Canadian adults presenting to emergency departments with mTBI and who agreed to complete psychiatric and social demographic assessments at 3 and 6 months found

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[83] Z.Y. Kerr *et al*., *Nine-year risk of depression diagnosis increases with increasing self-reported concussions in retired professional football players*, 40 AM. J. SPORTS MED. 10, 2206-12 (2012).

[84] N. Multani *et al*., *The association between white-matter tract abnormalities, and neuropsychiatric and cognitive symptoms in retired professional football players with multiple concussions*, 263 J. NEUROL. 7, 1332-41 (2016).

[85] S.C. Miller *et al*., *Risk for broad-spectrum neuropsychiatric disorders after mild traumatic brain injury in a cohort of US Air Force personnel*, 72 OCCUP. ENVIRON. MED. 8, 560-66 (2015).

suicidal ideation was expressed by 6.3% at 3 months and 8.2% at 6 months.[86] A retrospective chart review of all patients with sports-related concussion referred to a multidisciplinary pediatric concussion program in 2013 and 2014 concluded emotional symptoms were commonly reported among pediatric patients with sports-related concussions and these symptoms contributed to development of novel psychiatric disorders, isolated suicidal ideation, and worsening symptoms of a preexisting psychiatric disorder.[87] A study of all persons born after 1953 in Sweden who received care for TBI from 1969 to 2009 concluded TBI was associated with substantially elevated risks of premature mortality, particularly for suicide injuries and assaults.[88] A review of a Danish population registry of hospital admissions from 1979-1993 showed the incidence of suicide among individuals with concussion (3.0), cranial fracture (2.7), or cerebral contusion or traumatic intracranial haemorrhage (4.1) were each increased relative to the general population.[89]

G. Number of Former NHL Players Who May be Affected by Long-Term Negative Cognitive or Psychological Health Effects

101. Because, to date, there is no equivalent to the NFL Retired Players Study, it is impossible to directly enumerate the number of former NHL players who have incurred long-term negative cognitive or psychological health effects. In fact, there is such scant clinical or research study data regarding long-term negative health effects in former NHL players that it is not possible to accurately estimate this number. Thus, the only method to determine the potential magnitude of the burden of long-term negative cognitive or

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[86] A. Bethune *et al*., *Suicidal Ideation After Mild Traumatic Brain Injury: A Consecutive Canadian Sample*, 16 ARCH. SUICIDE RES., 1-11 (2016); [Epub ahead of print] Abstract at: http://www.ncbi.nlm.nih.gov/pubmed/27310250.

[87] M.J. Ellis *et al*., *Psychiatric outcomes after pediatric sports-related concussion*, 16 J. NEUROSURG. PEDIATR. 6,708-18 (2015).

[88] S. Fazel *et al*., *Suicide, fatal injuries, and other causes of premature mortality in patients with traumatic brain injury: a 41-year Swedish population study*, 71 JAMA PSYCHIATRY 3, 326-33 (2014).

[89] T.W. Teasdale & A.W. Engberg, *Suicide after traumatic brain injury: a population study*, 71 J. NEUROL. NEUROSURG. PSYCHIATRY. 4, 436-40 (2001).

psychological health effects among former NHL players is to extrapolate data from other studies (e.g., of NFL players, of general population samples, etc.) to the population of interest here – former NHL players.

102. It must be noted that such extrapolation, intended to expand known experience into an area not known by applying the results of specific studies to a population which was not included in those studies, is inherently subject to uncertainty.

103. Extreme caution must be used when interpreting the results of extrapolation given these uncertainties. For example, the population of former NHL players may differ significantly from a general population sample with regard to risk factors for long-term negative cognitive or psychological health effects although former NHL players are likely more similar to former NFL players with respect to risk factors.

104. The data presented in Table 5 below is based on the most conservative extrapolations given the available data on number of documented concussions among NHL players. However, given the uncertainties associated with extrapolation the most appropriate use of these numbers is for hypothesis generation for future research efforts in former NHL players.

Table 5: Examples of Extrapolation of Results of Studies Reporting Long-Term Negative Cognitive or Psychological Health Effects of Concussion Injury to the Population of Former NHL Players.[90]

Prior Study	**Pertinent Results**	**Extrapolation to Former NHL Players**
CTE		
Bieniek et al., 2015[91]	21 of 66 (31.8%) former athletes in a neurodegenerative disease brain bank had cortical tau abnormalities consistent with CTE. This pathology was not detected in 198 individuals with no exposure to contact sports.	1,315 x 31.8% = 418 NHL players with concussion expected to have cortical tau abnormalities.
Dementia		
Lee et al., 2013[92]	Of 28,551 Taiwanese diagnosed with mTBI, 127 (0.44%) were diagnosed with dementia	1,315 x 0.44% = 6 NHL players with concussion expected to be diagnosed with dementia.

[90] As detailed in the Declaration of Thomas Blaine Hoshizaki §IV.A.3, there were an estimated 1,315 documented concussions among NHL players over the 14 seasons spanning 1997-2014. Based on data from *Benson et al.* there were 559 documented concussions in NHL players from 1997 through 2004, including the following number by year: 1997-98 (56), 1998-99 (88), 1999-2000 (66), 2000-01 (109), 2001-02 (96), 2002-03 (72), and 2003-04 (72). Additionally, based on data documenting diagnosed concussion injuries provided by the NHL for this case there were 756 concussions in NHL players from 2006 through 2014, including the following number by year: 2006-07 (80), 2007-08 (85), 2008-09 (81), 2009-10 (102), 2010-11 (148), 2011-12 (137), and 2013-14 (123). Thus all extrapolations in this table are based on the documented 1,315 concussions sustained by NHL players between 1997 and 2014 although this is undoubtedly an underestimate of the true number of concussions sustained by NHL players during that time frame due to imperfect reporting of concussions. This would likely be reduced by a number of players who have received multiple documented concussions. Finally, these figures would be significantly increased if extrapolated to the entirety of the retired player class, which encompasses many games played outside of the 1997-2014 period.

[91] *Supra* n. 70.

[92] *Supra* n. 73.

	within 4 years.	
Wang et al., 2015[93]	1.48% of Taiwanese patients with TBI experienced frontotemporal dementia (FTP) during a 4 year follow-up period.	1,315 x 1.48% = 20 NHL players with concussion expected to be diagnosed with FTP.
Li et al., 2016[94]	Of 81 individuals with documented TBI from the ADNI database, 45 (55.6%) had mild cognitive impairment (MCI) and 10 (12.3%) had Alzheimer's disease (AD).	1,315 x 55.6% = 731 NHL players with concussion expected to be diagnosed with MCI. 1,315 x 12.3% = 162 NHL players with concussion expected to be diagnosed with AD.
Depression		
Didehbani et al., 2013[95]	Of 42 retired NFL players, all of whom had sustained at least one concussion, 12 (28.6%) endorsed mild to moderate depressive symptoms.	1,315 x 28.6% = 376 NHL players with concussion expected to endorse mild to moderate depressive symptoms.
Miller et al., 2015[96]	Of 5,065 US Airmen with mTBI, 50 (0.99%) were diagnosed with depression post mTBI.	1,315 x 0.99% = 13 NHL players with concussion expected to be diagnosed with depression.
Suicide		
Bethune et al., 2016[97]	In a study of Canadian adults presenting to EDs with mTBI, suicidal ideation was expressed by 6.3% at 3 months and 8.2% at 6 months.	1,315 x 6.3% = 83 NHL players with concussion expected to have suicidal ideation 3 months post concussion and 1,315 x 8.2% = 108 expected to

93 *Supra* n. 74.

94 *Supra* n. 77.

95 *Infra* n. 99.

96 *Supra* n. 85.

97 *Supra* n. 86.

		have suicidal ideation 6 months post injury.

H. Comparison of Full Contact Athletes To the General Public

105. There is a growing body of research comparing full contact athletes to the general public, demonstrating that athletes participating in full contact sports are at increased risk of negative health consequences.

106. A study comparing former NFL players (with and without a history of concussion) to age, education, and IQ-matched controls (without a history of either concussion or of playing football) reported cognitive deficits and depression appeared to be more common among the former NFL players than the healthy controls, and that the observed cognitive deficits were correlated with white matter abnormalities and changes in regional cerebral blood flow.[98]

107. A second paper reporting results obtained from the same study sample found a significant correlation between the number of lifetime concussions and depressive symptom severity among the former NFL players. More specifically researchers found only the cognitive factor of depressive symptoms and not the affective or somatic factors were significantly related to concussions.[99]

I. Historical Review of Advances in Knowledge

1. Consensus Statements

108. There have now been four International Conferences on Concussion in Sport, each resulting in consensus statements that have been simultaneously published in multiple sports medicine journals (Journal of Athletic Training, British Journal of Sports Medicine, Journal of Science and Medicine in Sport, Clinical Journal of Sport Medicine, etc.), an

[98] J. Hart Jr. *et al*., *Neuroimaging of cognitive dysfunction and depression in aging retired National Football League players: a cross-sectional study*, 70 JAMA NEUROL. 3, 326-35 (2013).

[99] N. Didehbani *et al*., *Depressive symptoms and concussions in aging retired NFL players*, 28 ARCH. CLIN. NEUROPSYCHOL. 5, 418-24 (2013).

incredibly rare occurrence in peer-review publishing which highlights the importance placed on sharing what sports medicine experts believe is the most reliable and most up-to-date information on sports-related concussions.

109. The first, occurring in Vienna in 2001, reviewed the body of knowledge on concussions and produced the first internationally accepted consensus guidelines for concussion evaluation and management.[100] First, the consensus guideline recommended that injury grading scales be abandoned in favor of combined measures of recovery, in order to determine injury severity and prognosis. Second, the consensus guideline made recommendations for management when an athlete demonstrated any signs or symptoms of concussion including 1) remove the athlete from the game/practice, 2) monitor the athlete for deterioration, 3) medically evaluate the athlete, and 4) follow a medically supervised stepwise RTP protocol to ensure athletes never return to play while symptomatic. The consensus statement also highlighted the need for educating athletes and their healthcare providers on how to detect concussion and principles of safe return to play. Although the consensus statement acknowledged that there are relatively few methods by which concussive brain injury may be minimized in sport, they included sport specific recommendations for prevention in only one sport, ice hockey, in the following paragraph:

> Consideration of rule changes, such as no head checking in ice hockey, to reduce the head injury rate may be appropriate where a clear cut mechanism is implicated in a particular sport. Similarly, rule enforcement is a critical aspect of such approaches and referees play an important role.[101]

110. The second, occurring in Prague in 2004, updated the body of knowledge on concussions and produced additional internationally accepted consensus guidelines for concussion evaluation and management.[102] This consensus statement recommended a new concussion categorization to dichotomize injuries as simple or complex. In addition it noted

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[100] M. Aubry *et al*., *Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001*, 36 BR. J. SPORTS MED. 1, 6-10 (2002).

[101] *Id.*

[102] McCrory *et al*., *supra* n.56.

that loss of consciousness did not necessarily imply severity of concussion and thus the presence of loss of consciousness as a symptom would not necessarily classify the concussion as complex. The consensus statement recommended expanding the management guidelines outlined in the first consensus statement to include not only adult athletes but also children. The consensus statement also outlined a 6 step RTP protocol – 1) no activity, complete rest; 2) light aerobic exercise, no resistance training; 3) sport specific exercise with progressive addition of resistance training; 4) non-contact training drills; 5) full contact training drills; and 6) game play – with instruction that the athlete should proceed to the next level only if asymptomatic at the current level and that if any symptoms returned the athlete should be returned to the previous level for at least 24 hours. The consensus statement reiterated the recommendation that rule changes in ice hockey to eliminate head checking could reduce head injury rates and also reiterated the need to educate athletes and their healthcare providers on concussion detection and principles of safe RTP.

111. The third, occurring in Zurich in 2009, again updated the body of knowledge on concussions and produced additional internationally accepted consensus guidelines for concussion evaluation and management.[103] This consensus statement recommended abandonment of the previously recommended concussion categorization to dichotomize injuries as simple or complex. The consensus statement concluded that while loss of consciousness was not a good measure of injury severity, prolonged loss of consciousness (>1 min) would be considered a factor that may modify management of injured athletes. The consensus statement further refined the symptoms and signs of acute concussion and also further refined recommendations for evaluation and management of athletes. The consensus statement clarified the expectation that each step of the recommended RTP protocol should take 24 hours so that an athlete would take approximately 1 week to proceed through the full rehabilitation protocol once asymptomatic at rest and with no recurring symptoms as exercise increased. This consensus statement additionally outlined the criteria under which

[103] P. McCrory *et al*., *Consensus Statement on Concussion in Sport: The 3rd International Conference on Concussion in Sport held in Zurich, November 2008,* 44 J. ATHL. TRAIN. 4, 434-48 (2009).

adult athletes in very specific settings (*i.e.*, where there are team physicians experienced in concussion management with sufficient resources for immediate neurocognitive assessment) could be allowed to accelerate the RTP protocol, perhaps even be allowed same-day RTP. Although the consensus statement noted CTE and recommended clinicians be mindful of the potential for long-term problems in management of injured athletes, it indicated the conference participants could not reach consensus on the significance of CTE at that stage. Although the consensus statement did not make any ice hockey specific recommendations for concussion prevention it did make a general recommendation that sporting organizations should be encouraged to address violence that may increase head injury risk.

112. The fourth and most recent, occurring in Zurich in 2012, continued to update the body of knowledge on concussions and produced additional internationally accepted consensus guidelines for concussion evaluation and management.[104] The consensus statement continued refinement of concussion symptoms and signs as well as RTP guidelines. The consensus statement also noted that the appearance of symptoms or cognitive deficit might be delayed several hours after an injury and thus concussion should be seen as an evolving injury in the acute stage. This consensus statement backtracked a bit on RTP for elite athletes, with the statements, "All athletes, regardless of level of participation, should be managed using the same treatment and RTP paradigm" and "It was unanimously agreed that no RTP on the day of concussive injury should occur."[105] The consensus statement again reiterated that sporting organizations should be encouraged to address violence that may increase concussion risk. It also once again noted the importance of educating athletes, colleagues, and the general public regarding advancements in this field.

2. Position Statements/Workgroups

113. In addition to the International Consensus Statements outlined above, several professional clinical organizations have released policy statements/guidelines. For example, American Orthopaedic Society for Sports Medicine released a special report outlining the

[104] McCrory *et al.*, *supra* n.56.

[105] *Id.*

recommendations of a Concussion Work-shop Group in 1999,[106] the National Athletic Trainers' Association released position statements on management of sports-related concussion in 2004,[107] and in 2014,[108] and the American Medical Society for Sports Medicine released a position statement on concussion in sport in 2013.[109] Although they largely mirror the overarching points covered in the International Consensus Statements these four position statements (just a sampling of several professional organizations' published position statements) provide their target audience of sports medicine clinicians with updated synopses of publications relevant to their work and at times going into greater detail on items of specific interest to their constituency. For example even in 1999 the AOSSM report clearly stated "concussions are a form of traumatic brain injury" and recommended, among other things, that every athlete with a concussion should be evaluated by a physician, loss of consciousness should preclude return to play that day, persistence of (>15 min) or delayed symptoms should preclude return to play that day, great care should be exercised in returning asymptomatic athletes to practice or competition following prolonged symptoms (>15 min) with an acknowledgement that neurofunction may not return to normal without at least 5 to 7 days of rest, and that there was a need for the establishment of databases on all athletes with concussions.[110]

3. Peer-review Publications

114. There is a wealth of scientific literature on injuries in ice hockey, many of which appear to reiterate very similar recommendations to address injury concerns.

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[106] E.M. Wojtys *et al*., *Current concepts. Concussion in sports*, 27 AM. J. SPORTS MED. 5, 676-87 (1999).

[107] K.M. Guskiewicz *et al*., *National Athletic Trainers' Association Position Statement: Management of Sports-Related Concussion*, 39 J. ATHL. TRAIN 3, 280-97 (2004).

[108] S.P. Broglio *et al*., *National Athletic Trainers' Association Position Statement: Management of Sport Concussion*. 49 J. ATHL. TRAIN 2, 245-65 (2014).

[109] K.G. Harmon *et al*., *American Medical Society for Sports Medicine position statement: concussion in sport*, 47 BR. J. SPORTS MED. 1, 15-26 (2013).

[110] Wojtys *et al*., *supra* n.98.

115. For example, in a 1984 paper reporting results of a study of spinal injuries Tator and Edmonds noted, "Prevention must therefore involve several approaches by hockey leagues, players, equipment manufacturers, and health care professionals and researchers."[111] The study proposed several ways to reduce injury including: enforcing rules against boarding and cross-checking, introducing new rules against pushing or checking from behind, recommending muscle-conditioning programs to improve the strength of the neck muscles, maintaining accurate statistics on the occurrence of severe injuries, educating players about the possibility of major injuries, encouraging equipment manufacturers to improve helmet shape and shock absorbancy, continuing epidemiologic studies on the causes of injury and the effectiveness of preventive measures, and researching the biomechanics of injuries. It is striking how similar these recommendations are to more recent recommendations aimed at concussion prevention.

116. An international study of head injuries in ice hockey published nearly a decade later concluded that although mandatory helmets and face masks had reduced facial and eye injuries, the rates of head injury and concussion were still too high.[112] The authors concluded "[a] number of steps must be taken …" by hockey organizations and health care professionals, among others, including strictly enforcing rules (e.g., no checks from behind, high sticking, etc.).

117. The growing body of knowledge has now even resulted in researchers having the ability to conduct systematic reviews and meta-analyses. This is a notable advancement in the level of knowledge as these study methodologies can only be implemented when a critical mass of published scientific research has been accumulated. Both systematic reviews and meta-analyses apply specific research criteria to a critical evaluation of the body of published literature accumulated on a topic. For example, in 2003 Koh *et al* published a systematic review of the incidence of concussion in contact sports, concluding that ice

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[111] Tator & Edmonds, *supra* n.57.

[112] N. Biasca *et al*., *[Head injuries in ice hockey exemplified by the National Hockey League "Hockey Canada" and European teams]* [article in German], 96 UFALLCHIRURG 5, 259-64 (1993).

hockey showed the highest incidence of concussions among football, ice hockey, rugby, and soccer.[113] In 2016 Ruhe *et al* published a systematic review of the incidence of concussion in professional and collegiate ice hockey finding that North American/Canadian leagues had a higher incidence of concussion compared to European leagues and that while concussion rates varied based on study methodologies and time frames, there was no conclusive evidence that the incidence of concussion reduced over the years. The authors concluded there is a ". . . need for standardization of the diagnostic criteria and reporting protocols for concussion to allow interstudy comparisons in the future."[114] In a meta-analysis published in 2016, Perry *et al* evaluated 57 studies published between 1995 and 2012 reporting TBI as a risk factor for the development of neurological or psychiatric disease. Their random effects meta-analysis revealed a significant association between prior TBI and subsequent neurological and psychiatric diagnoses with a pooled odds ratio ("OR") for the development of any illness of interest being 1.67 (95% CI 1.44-1.93). Additionally, prior TBI was found to be independently associated with both neurological (OR 1.55; 95% CI 1.31-1.83) and psychiatric (OR 2.00; 95% CI 1.51-266) outcomes. Analyses of individual diagnoses found previous TBI was associated with higher odds of Alzheimer's disease, Parkinson's disease, mild cognitive impairment, depression, mixed affective disorders, and bipolar disorder.[115]

4. Timeline

118. Despite evidence of clinicians' and researchers' interest in sports injuries stretching back for centuries,[116] sports governing bodies specifically and athletic communities more broadly have not fully recognized the value of epidemiologic research as a means of providing the data required to drive effective evidence-based injury prevention

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[113] Koh *et al*., *supra* n.15.

[114] A. Ruhe *et al*., *The incidence of concussion in professional and collegiate ice hockey: are we making progress? A systematic review of the literature*, 48 BR. J. SPORTS MED. 2, 102-06 (2014).

[115] D.C. Perry *et al*., *Association of traumatic brain injury with subsequent neurological and psychiatric disease: a meta-analysis*, 124 J. NEUROSURG. 2, 511-26 (2016).

[116] Wojtys *et al*., *supra* n.98.

efforts. Public health practitioners recognize that the most effective injury prevention efforts are multi-factorial, often referring to a "three-legged stool" of prevention with education/behavior change, rule/policy/law implementation and enforcement, and equipment or environment improvements forming the core components of an effective injury prevention programs.[117] More specifically, a 1987 publication reviewed studies reporting ice hockey injury rates, patterns, and risk factors to assess the body of knowledge at that point and concluded, "[g]enerally, however, the prevention of injury in hockey, as in other sports, is multifactorial."[118] Unfortunately until very recently, sports governing bodies and athletic communities relied nearly exclusively on improved/increased equipment and the introduction of new/better enforcement of rules when they attempted to address injury concerns. Existing epidemiologic research too often went wanting for attention and there was little appetite for engaging in the large-scale surveillance studies needed.

119. In 1928, Martland first identified the association between chronic brain injury in boxers and the repeated impacts to the head these athletes sustained.[119] Although a preponderance of evidence published since then clearly demonstrated an association between impacts to the head and body sustained by athletes while playing contact sports, and both acute and chronic brain injury/concussion was well recognized as early as the mid 1900s with published sports injury studies from this time period frequently including recommendations to reduce injury rates and severities.[120] Responsive actions by sports governing bodies and team physicians has lagged behind this research.[121] As Lehman noted, by the mid 1980s it was apparent that chronic traumatic encephalopathy was a concern for

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[117] R.D. Comstock & L.B. McKenzie, *Injuries and Adverse Events in Sports Activities: Preventive Strategies for Young Athletes*, 16 ELEVATE HEALTH 2, 1-13 (2015). (A quarterly research digest of the President's Council on Fitness, Sports & Nutrition).

[118] Sim *et al*., *supra* n.58.

[119] H.S. Martland, *Punch Drunk*, 91 JAMA 15, 1103-07 (1928).

[120] L.B. Lehman, *Nervous system sports-related injuries*, 15 AM. J. SPORTS MED. 5, 494-99 (1987).

[121] *Id.*

participants of sports in which repeated impacts to the head were absorbed by the participant. In fact, Lehman called for neurologists and neurosurgeons providing care for athletes to "stand at the forefront in demanding the much needed reforms[,]" further stating that "[t]hey occupy a unique position" to organize improved teaching and training programs, to propose legislation requiring interval neurologic assessment of athletes at highest risk for developing chronic traumatic encephalopathy, encouraging "the earliest possible removal of the impaired and injured athlete" from incurring further trauma, and in collecting data to analyze injury trends and evaluate prevention programs.[122] Additionally, Drs. Bailes and Cantu wrote, "[t]he long-term consequences of repetitive-impacts to the head are now considered to be detrimental to the future well-being of the athlete."[123] Unfortunately, team physicians have too often hesitated to hold athletes out of play and/or to provide counseling regarding permanently discontinuing participation in the sport in which they were injured. Physicians have based their reticence on a lack of data (despite Lehman's call for them to collect data and advocate for injury surveillance) and legal concerns.

120. In the 2002 Refshauge Lecture, an annual conference keynote speech sponsored by the Australian Sports Medicine Federation, Dr. McCrory stated "[t]here are no evidence-based guidelines upon which a team physician can advise the athlete. All doctors involved in athlete care need to be aware of the potential for medicolegal problems if athletes are inappropriately returned to sport prematurely or in the case of professional athletes held out of sport or retired on the basis of non-scientific recommendations."[124] This indecision by team physicians, apparently primarily due to legal concerns, has affected athletes' care well into the 2000s.

121. In fact, a 2013 publication closely mirrored the sentiments expressed in 2002 with Dr. Gardner writing, "[t]he issue of retirement from athletic participation due to repetitive concussive injuries remains controversial. The complexity of providing

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[122] *Id.*

[123] Bailes & Cantu, *supra* n.14.

[124] P. McCrory, *2002 Refshauge Lecture. When to retire after concussion?*, 5 J. SCI. MED. SPORT 3, 169-82 (2002).

recommendations to elite athletes is highlighted by the prospect that offering inappropriate advice may foreseeably lead to engagement in a medico-legal challenge. Currently no evidence-based, scientifically validated guidelines for forming the basis of such a decision exist."[125]

122. The claim of a lack of evidence provides an interesting conundrum. During the decade between 2002 and 2013 there were 1,410 published manuscripts which are identified in PubMed using a keyword search for "sport(s) and concussion(s)" yet team physicians continue to claim the current body of scientific knowledge does not provide adequate guidance for them to discuss with players the possibility of medically indicated retirement following repeat concussions. While team physicians have appeared willing to rely upon research and consensus statements published over the past decade when making RTP decisions, they continue to claim insufficient data exists to guide discussions of retirement with athletes. At this point the question to team physicians that must be posed is, if there is truly a lack of data to develop guidelines for recommending retirement to an athlete, why haven't the very team physicians, who have access to the required data, conducted those studies to date? As Drs. Marchie and Cusimano opined, "too much emphasis is placed on *when* to return to play and not enough on *whether* to return …."[126]

123. Additionally, team physicians have largely ceded efforts to reduce sports-related concussion to sports governing bodies/policy makers, most of whom have implemented modest rule changes while calling for equipment makers to improve PPE. There have been too few efforts to address concussion prevention at the level of the interaction between athlete and physician. Efforts to capture the data required to make team physicians more comfortable in this role have also lagged. This failure to feature coaches and team medical personnel in concussion prevention efforts is unfortunate as noted by a review of the epidemiology of sports-related concussion across multiple sports, age groups,

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[125] A. Gardner, *The Complex Clinical Issues Involved in an Athlete's Decision to Retire from Collision Sport Due to Multiple Concussions: A Case Studyof a Professional Athlete*, 27 FRONT NEUROL. 4, 141 (2013).

[126] Marchie & Cusimano, *supra* n.45.

and genders.[127] The authors of that manuscript concluded, "[i]n general, there are simple things that can be done to reduce the incidence of concussion in sports."[128] They then provided several examples including providing concussion education to all athletes, particularly those competing in contact sports; encouraging proper strength and conditioning, especially strengthening the neck muscles; ensuring coaches, athletic trainers, and medical staff are properly trained regarding concussion diagnosis and management as well as the need to provide athletes with concussion education; and requiring quality officiating to help identify potentially dangerous situations and ensure the activity does not result in injury. These authors assert, "[i]f a physician or coach has questions about an athlete's readiness to compete, the athlete's safety should not be risked."[129]

124. While this focus on team medical personnel is warranted, there must also be a discussion of sports governing bodies'/policy makers' delay in utilizing available data to drive concussion prevention efforts. For example, the lethal potential of head impact in football were reported as early as 1961.[130] Drs. Bailes and Cantu have written that in the early 1970s, "[f]ootball was the frontier that allowed researchers to begin to understand the implications of athletic contests that, by design, had repetitive head impacts. In other athletic events, such as ice hockey, rugby, and boxing, there was no such organized effort to reduce the incidence of mTBI."[131] The implication is that during a period of time when a great deal of groundbreaking research on sports-related head injury was being conducted, of the sports with high risks of head injury, only football was actively engaging in and utilizing research to drive injury prevention efforts.

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[127] D.H. Daneshvar *et al*., *The epidemiology of sport-related concussion*, 30 CLIN. SPORTS MED. 1, 1-17 (2011).

[128] *Id.*

[129] *Id.*

[130] R.C. Schneider *et al*., *Serious and fatal football injuries involving the head and spinal cord*, 177 JAMA, 362-67 (1961). *See also* R.C. Schneider, *Serious and fatal neurosurgical football injuries*, 12 CLIN. NEUROSURG., 226-36 (1964).

[131] Bailes & Cantu, *supra* n.14.

125. More specific to ice hockey, as reported by Sim *et al*, the National Hockey League studied league office records of all injuries reported by teams over the 1960s and 1970s, as well as several studies of the epidemiology of ice hockey injuries which had been published by the mid 1980s providing data on the types of injuries and the mechanisms of those injuries which demonstrated "most of the injuries occurred in the head, scalp, face, or eye region."[132] Thus, it appears that evidence was available to allow the NHL to follow the lead of football's organized efforts to reduce head injury during the 1970s and 1980s. In fact, Sim *et al* stated, "[w]ith biomechanical studies evaluating the forces involved in ice hockey and epidemiologic studies outlining the causes and types of injuries, efforts to prevent injury are becoming more prevalent in hockey. Previously, injury in hockey was accepted as an unfortunate part of the game. That attitude, however, has slowly been replaced with a growing concern."[133]

126. Professional sports organizations are naturally best positioned to act upon emerging scientific evidence given their business structure and their complete control over rules/rule enforcement, athlete training, required and allowed equipment, availability and authority of team medical personnel, etc. Two areas, explored below, exemplify concerns regarding the NHL's failures to utilize the available scientific knowledge base regarding head injuries, including concussions, to the fullest extent possible.

127. The first example is the grandfathering of PPE (*e.g.*, helmets and face shields). Once an organization determines the evidence regarding the effectiveness of a piece of PPE is not only sufficient, but rather is so compelling that it justifies changing the rules of the sport to make use of that PPE required, it then becomes unconscionable – from an injury prevention perspective – to allow some players to intentionally place themselves at risk of injury by continue to play without that PPE. The NHL's grandfathering of helmet use is a perfect illustration of this point. As soon as the NHL determined there was enough evidence supporting the effectiveness of helmets in preventing skull fractures and serious brain injury

[132] Sim *et al*., *supra* n.58.

[133] *Id.*

that they made helmets a required piece of equipment in 1979, they had, in essence, decided their players were exposed to an unacceptable risk of head injuries unless a helmet was worn. At that point, allowing some players to make the personal decision to continuing playing without a helmet (whether they signed a wavier accepting personal responsibility or not), resulted in NHL players intentionally placing themselves in what the league itself had determined was an unacceptably high risk of head injury. Despite research clearly demonstrating the effectiveness of ice hockey helmets in reducing head injuries among NHL players,[134] "grandfathered" players continued to be allowed to put themselves at risk until Craig MacTavish retired in 1997. This illustrates one example in which the NHL did not fully utilize the existing body of scientific evidence to the fullest, as by the early 1980s there was widespread recognition that being concussed was no longer considered an acceptable occurrence for athletes due to mounting evidence that ongoing cerebral dysfunction could exist.[135] Given the state of knowledge regarding head injuries available at the time, no NHL players should have been allowed to play without a helmet during the 1980s, let alone into the 1990s.

128. The second example is the NHL's refusal to take the necessary efforts to eliminate fighting. There is simply no debate regarding the high risk of brain injury in boxing. The seminal 1928 manuscript by Martland which first identified the association between repeated impacts to the head during sports participation and brain injury was a report on boxing.[136] As a result of the high risk of head and facial injuries, the Canadian Paediatric Society and the American Academy of Pediatrics "vigorously" opposed boxing as a sport for children and adolescents, and recommended that physicians oppose boxing in youth and encourage patients to participate in alternative sports.[137] In light of the overwhelming evidence that boxers are at very high risk of head injury, it is alarming that the

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[134] Tator & Edmonds, *supra* n.57. *See also* Sim *et al*., *supra* n.58.

[135] Bailes & Cantu, *supra* n.14.

[136] Martland, *supra* n.111.

[137] L.K. Purcell *et al*., *Boxing participation by children and adolescents: A joint statement with the American Academy of Pediatrics*, 17 PAEDIATR. CHILD HEALTH. 1, 39-40 (2012).

NHL had not taken the necessary actions required to eliminate fighting. Although the NHL does penalize fighting, the penalties are typically relatively light (*i.e.*, penalty minutes rather than expulsion from games and multi-game, season, or even career suspensions) and players who indicate a mutual willingness to fight (*e.g.*, dropping gloves and facing each other) are allowed to do so by the referees prior to the assessment of penalties. Because the NHL has unilateral control over the rules of its game it possesses the ability to dramatically reduce, if not eliminate, fighting. The NHL should instruct referees to immediately call and enforce penalties and to separate players who attempt to drop their gloves and fight; should dramatically increase the penalties for fighting by following the NFL, NBA, and MLB in ejecting athletes who throw punches during games; and should levy multi-game or season suspensions for repeat offenders, as do other professional sporting leagues. Until they demonstrate that level of commitment to preventing fighting, an activity with irrefutable high risk of head injury, the NHL can not claim they are taking every evidence-based concussion prevention action possible to protect their players.

J. Summary of NHL Hockey Epidemiologic Data

129. Ice hockey players are at increased risk for sustaining concussion and repeated subconcussive impacts compared to athletes participating in most other team sports popular in the United States, with ice hockey concussion rates tending to be most similar to football concussion rates. Concussion rates appear to increase with increased athlete age and level of play, meaning NHL players are expected to have higher concussion rates than younger athletes as well as adult athletes playing at lower competitive levels. Taken together, this indicates NHL players' risk of concussions and repeated subconcussive impacts is very likely second only to NFL players among the various levels of play for the most popular team sports played in the United States.

130. Similar to athletes participating in nearly all other sports, ice hockey players are at significantly increased risk of sustaining concussions and repeated subconcussive impacts in competition compared to practice. This indicates a focus on effective concussion

prevention programs, implemented in the game setting, would be expected to have the biggest impact on reducing concussion risk in NHL players.

131. Ice hockey players who sustain concussion are at increased risk of developing long-term negative health effects compared to the general public, as well as individuals who participate in sports other than ice hockey or other full contact sports (*e.g.*, football, boxing). The overwhelming (and still rapidly growing) body of evidence indicates NHL players who sustain concussions and repeated subconcussive impacts are at increased risk of both neurologic and psychiatric negative health outcomes compared both to their uninjured teammates, as well as healthy individuals (i.e., individuals without a history of TBI) of similar age in the general population.

132. Evidence outlining several risk factors for head injury in ice hockey has, for some time, been sufficient to drive new or enhanced concussion prevention efforts. The NHL has not sufficiently utilized the body of scientific knowledge to drive effective, evidence-based concussion prevention programs. The most glaring example of this is the NHL's continued failure to take the necessary steps to reduce fighting despite overwhelming evidence of the high risk of TBI associated with being struck in the head.

VI. PROPOSED EPIDEMIOLOGIC STUDY OF RETIRED NHL PLAYERS

133. There is a crucial need to learn as much as possible about the short and long term health concerns affecting retired NHL players. Just as "[f]ootball was the frontier that allowed researchers to begin to understand the implications of athletic contests that, by design, had repetitive head impacts. In other athletic events, such as ice hockey, rugby, and boxing, there was no such organized effort to reduce the incidence of mTBI."[138] Today's studies of retired football players represent the frontier which has allowed researchers and clinicians to begin to understand the short and long term effects of concussions and repeated subconcussive impacts on athletes who have retired after playing contact sports. History has

[138] Bailes & Cantu, *supra* n.14.

repeated itself however as, again, there has been no equivalent effort to conduct studies of retired ice hockey players.

134. The need for additional research on sports-related concussions and repeated subconcussive impacts and improved care for retired athletes is, by now, an oft repeated call. According to Drs. Bailes and Cantu, one of the groundbreaking contributions of the Committee on Medical Aspects of Sports' initial National Conference on Head Protection for Athletes held in 1962 was the understanding "that an accurate accounting of injury patterns was needed to effect meaningful change."[139] In 1987 Lehman wrote, "[e]stablishing a fund for the long-term treatment and rehabilitation of neurologically impaired athletes would go far in filling a void that exists currently."[140] However, both enhanced concussion prevention efforts and improvements in care of injured athletes must be data-driven if they are to be effective. Additionally, such efforts must be evaluated to determine their effectiveness. Currently there is no effort by the NHL to support the epidemiologic studies required to provide the data necessary to drive these efforts. A recent review of the epidemiology of sports-related concussion across multiple sports, age groups, and genders concluded, "[c]oncussions and head injuries may never be completely eliminated from sports. However, with better data comes an improved understanding of the types of actions and activities that typically result in concussions. With this knowledge can come improved techniques and rule changes to minimize the rate and severity of concussions and repeated subconcussive impacts in sports."[141]

135. Concussion prevention is an incredibly important point of focus which, as demonstrated in the report above, has great room for improvement in the NHL, in particular. However, just as important, if not more-so, is the need to ensure the best possible care for those NHL athletes who were injured playing the game before concussion prevention became the point of focus it is today. Given what is now known about concussions and

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[139] *Id.*

[140] Lehman, *supra* n.112.

[141] Daneshvar *et al*., *supra* n.119.

repeated subconcussive impacts, it is critical that the NHL collect and act upon the best possible evidence to protect those current and future NHL players who will continue to sustain injuries. There is no one-time "fix," as concussion prevention efforts and care for injured players must continue to evolve and improve.

136. It is time to establish a large scale epidemiologic study of retired NHL players similar to the research done by the Center for the Study of Retired Athletes at UNC Chapel Hill in collaboration with the NFL Players' Association.[142] In this long-standing prospective study of retired professional football players, teams of clinicians and researchers are investigating the spectrum of physical, cognitive, and psychosocial challenges that former professional football players encounter across different phases of their lifespan and work to help retired players access needed clinical care. Such a study of retired NHL players will provide much-needed data to drive evidence-based concussion prevention efforts, will provide guidelines for team physicians on both injury management and retirement counseling, and will also increase the knowledge base required to provide the best care to retired NHL players.

137. It is important to note that the proposed studies could provide valuable information regarding the general health of retired players as well as any health concerns they have and any negative health events they are experiencing. Any study investigating concussions and repeated subconcussive impacts should also capture data on all other health issues. Once any study of retired ice hockey players is implemented, the benefit of exploring all health issues would simply be too great to focus only on concussions and repeated subconcussive impacts. The greatest expense lies in establishing and implementing the studies, so expanding the studies to include all health issues rather than just focusing on concussions and repeated subconcussive impacts adds relatively little expense. That said, for the purpose of this report, the proposals below focus only on concussions and repeated subconcussive impacts simply to provide examples of the type of studies which are needed.

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[142] *See, e.g.*, *UNC selected as clinical site for NFLPA program on former players' health*, UNIV. OF NORTH CAROLINA AT CHAPEL HILL (Nov. 14, 2013), http://www.unc.edu/campus-updates/nflpa-former-players-health/.

1. Retrospective Study

138. Retrospective studies are usually faster to perform and cheaper than prospective studies. However, retrospective studies are subject to recall bias when study participants are asked to self-report variables that are difficult to verify using biological testing or medical records. While this is a concern for retired NHL players, researchers have found self-reported concussion history had moderate reliability in a study of retired professional football players. A majority (62.1%) of athletes reported the same number of concussions on a survey administered first in 2001 and again in 2010 but recall appeared to vary by health status, with those former athletes suffering from more deficits reporting a greater number of concussions in 2010 compared to those suffering from fewer deficits (Kerr, 2012).[143] Additionally, a mixed method approach which utilizes both existing medical records and study participant self-reporting will also reduce the influence of recall bias. The overwhelming advantage of this approach is that the epidemiologic research can be accomplished within approximately one year via a two-phase process, yet it will provide initial evidence to drive concussion prevention efforts as well as efforts to improve the short- and long-term health of retired NHL players. While a retrospective study is a logical place to begin a line of research into the health of retired NHL players given the current paucity of information, and it is attractive because of its ability to produce valuable information in the shortest time period, retrospective studies should merely be the first step toward the establishment of an extended prospective study of retired NHL athletes.

a. Time Frame

139. The first phase, the retrospective review of existing medical records from NHL teams, can begin as soon as funding is made available and can be completed relatively quickly (an estimated 4 to 8 months). The second phase, a survey of retired NHL players will take longer due to the need to develop the athlete survey, to collect contact information

[143] Z.Y. Kerr *et al*., *Reliability of concussion history in former professional football players*, 44 MED. SCI. SPORTS EXERC. 3, 377-82 (2012).

for retired players, and to implement the survey among the convenience sample of retired players willing to participate before data analysis can begin (an estimated 8 to 16 months).

b. Methods

140. The most expedient yet most thorough retrospective study design would be a mixed method study consisting of three arms.

141. Arm 1: a retrospective review of de-identified existing medical records. Existing medical records would be analyzed to produce concussion rates (overall, game vs. practice, new vs. recurrent concussions, etc.); to describe concussion symptomology (number of symptoms, type of symptoms, symptom resolution time, etc.); to describe average individual player level outcomes (average number of concussions during career, average length of time between concussions, etc.); to describe the concussion events (general injury mechanism, sport-specific activity during which injury occurred, location on rink where injury occurred, protective equipment in use at time of injury, role of foul play/illegal action, etc.); and to evaluate concussion management and outcomes (how was concussion diagnosed, was athlete removed from play, how long was athlete kept out of play, did athlete receive any clinical care/therapy to assist with recovery, etc.). Each of these factors would be evaluated overall as well as for subgroups of interest (positions played, year of entry into the NHL, number of years played, year of retirement, team(s) played for, etc.). Additionally, each factor would be analyzed to determine trends over time.

142. Arm 2: a survey of retired NHL players. Utilizing UNC's studies of retired professional football players as a template, an athlete survey would be developed and pilot tested in a small group of retired NHL players. Available contact information for all retired NHL players would be obtained from the NHL/NHLPA so an explanation of the study and an invitation to participate could be distributed to all retired NHL players. The athlete survey would ask athletes to briefly self-report several variables evaluated in the medical record review (how many concussions did the athlete sustain, what symptoms did they experience, how did each concussion occur, how long were they kept out of play following each concussion, did they receive any clinical care/therapy to assist with recovery, etc.). In

addition the athlete survey would capture the athlete's self-reported current physical, cognitive, and psychosocial health status as well as their health history since retirement. Researchers would evaluate potential differences between survey respondents and non-respondents (age, number of years played, year of retirement, etc.). Survey data from respondents would be used to replicate many of the analyses from Arm 1 as well as to describe the health history since retirement and current health of retired NHL players. Analyses would compare players' concussion history to their health history since retirement and current health to determine if there are any associations between concussion history and specific health outcomes.

143. Arm 3: a comparison of the existing de-identified medical records to the self-reported injury history from the athlete surveys. Finally, a comparison of data captured from existing medical records and athlete surveys will be evaluated to determine the relative reliability of both sources of data and to see if levels of concurrence vary over time.

c. Estimated Budget

144. $300,000 in direct costs. Budget will consist almost entirely of personnel costs to cover the time and effort of the principle investigator (PI), a board of expert scientific consultants, a project manager, and research assistants/data analysts.

2. Prospective Study

145. Prospective studies are more expensive and do take longer than retrospective studies, however, the biggest advantage of prospective studies is the potential to definitively demonstrate causal associations. To be most effective, prospective studies must be maintained over time. For example, a prospective study of retired NHL players conducted over an extended time period would allow researchers to follow an athlete's injury history during their playing career and then to follow the individual's health history after retirement. This eliminates recall bias and provides researchers the opportunity to demonstrate cause and effect of variables within the context of a known timeline. The overwhelming advantage of this approach is the ability to provide invaluable levels of detailed evidence on large numbers of exposures of interest as well as outcomes of interest. This is the research needed to drive

effective concussion prevention efforts as well as effective efforts to improve the short and long term health of retired NHL players.

a. Methods

146. The retired professional football players' studies conducted at UNC, Harvard, University of Michigan, etc. would be used as models for the development of an extended prospective study of retired NHL players. The prospective study would consist of three arms.

147. Arm 1: retired NHL players would be surveyed annually to capture the athlete's self-reported current physical, cognitive, and psychosocial health status. Additionally, any retired player entering the study for the first time would also be surveyed regarding their health history since retirement.

148. Arm 2: annually, a sample of study participants would be invited to travel to the study site to undergo extensive clinical assessments of their physical, cognitive, and psychosocial health. The aim would be to have every retired player clinically evaluated at least once every 5 years. However, there could be an interest in clinically evaluating some athletes more frequently (older athletes, athletes who are diagnosed with early onset dementia, etc.). Over the course of the study, the frequency of visits for clinical assessments as well as the number and type of clinical evaluations performed during each visit would be dependent upon available funding, input from the board of expert scientific consultants, and advancements in clinical tools (imaging technology, biomarker testing, etc.).

149. Arm 3: upon enrollment into the study, athletes' NHL medical records with personal identifiers would be shared with the research team, with written approval from the athlete, to enable direct comparison of retired athletes medical histories during their playing career to their subsequent health experiences post retirement.

150. The three arms of the proposed prospective study of retired NHL players would enable researchers to provide the most complete description of retired athletes' health experience over the age continuum as well as allowing analyses of the potential effects of

athletes' injury experiences during their ice hockey carriers on their subsequent short- and long-term health after retirement.

b. Estimated Budget

151. $800,000 per year in direct costs. Budget will include personnel costs to cover the time and effort of the principle investigator, a board of expert scientific consultants, a project manager, and research assistants/data analysts. Costs of clinicians conducting health assessments and any diagnostic/assessment costs (*e.g.*, lab work, imaging, etc.) will also be included. Budget will also cover travel and lodging expenses to bring retired players to the study site for health assessments. Note: budget will likely vary as new clinical tools (new imaging technologies, new biomarker tests, etc.) become available.

VII. CONCLUSION

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 12/5/16

R. Dawn Comstock, Ph.D

EXHIBIT “1”

R. Dawn Comstock, Ph.D. (EIS 2002)

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Education

Ph.D.	University of California San Diego/San Diego State University. Epidemiology. Dissertation: *Patterns of Injury Among Female Rugby Players.*
M.S.	University of Iowa, Iowa City, Iowa. Epidemiology.
B.S.	Colorado State University, Fort Collins, Colorado. Microbiology. Honors Thesis: *Viral DNA Interactions With Host DNA in MAV-2(0) Induced Avian Osteopetrosis.*

Academic Appointments and Teaching Experience

6/16-present *Professor,* Colorado School of Public Health, University of Colorado Denver, Epidemiology, Aurora, CO. Primary appointment.

1/13-6/16 *Associate Professor,* Colorado School of Public Health, University of Colorado Denver, Epidemiology, Aurora, CO. Primary appointment.

- Courses taught

  - Summer 2013. Capstone course (PUBH6955) co-instructor

  - Fall 2013. Capstone course (PUBH6955) coordinator and co-instructor

  - Spring 2014. Undergraduate (downtown campus) Introductory Epidemiology course (PBHL 3001) co-instructor

  - Fall 2014. Applied Global Health Epidemiology course (EPID6670 002 temp course code for first time this new course was offered) co-developer and co-instructor

  - Spring 2015. Undergraduate (downtown campus) Introductory Epidemiology course (PBHL 3001) co-instructor

  - Fall 2015. Undergraduate (downtown campus) Introductory Epidemiology course (PBHL 3001) co-instructor

  - Fall 2015. Applied Global Health Epidemiology course (EPID6634) co-instructor

- Guest lectures given

  - Fall 2013. Maternal and Child Health class (instructor Dr. Jenn Leiferman). "Concussion Among High School Athletes, What Do We Know?"

  - Spring 2014. Injury Epidemiology and Control class (instructor Dr. Carolyn

DiGuiseppi). "Sports Injury Surveillance"

- Spring 2014. Pediatric Emergency Medicine Fellows Lecture (instructor Dr. Rakesh Mistry). "Study Design and Bias"

- Fall 2014. Environmental & Occupational Health DrPH students' Methods Class (instructor Dr. Allison Bauer). "Interventional Designs"

- Fall 2014. Maternal and Child Health class (instructor Dr. Jenn Leiferman). "Concussion Among High School Athletes, What Do We Know?"

- Fall 2014. Pediatric Emergency Medicine Fellows Journal Club (instructor Tien Vu). "Systematic Reviews" – via discussion of the article "Interventions to Reduce Pediatric Medication Errors: A Systematic Review."

- Fall 2014. Mini-School for Public Affairs & Public Health: an inititive of the Graduate School at CU Denver Anschutz in collaboration with Colleges and Departments at the Downtown Denver Campus (coordinator Inge Wefes, Associate Dean, Graduate School). "Youth Sports-realted Concussion Prevention."

- Spring 2015. "Lunch and Learn" for Physical Therapy students in the University of Colorado Physical Therapy Program (coordinator Lisa Dannemiller). "Current state of concussion knowledge."

- Spring 2015. "Comm Days" for University of Colorado Denver Undergraduate Communication's Class, Communication in Sport (Professor Dr. Sarah Fields). "How Injury Surveillance Can Drive Discussions Leading to Injury Prevention: Using Concussions as an Example"

- Fall 2015. University of Colorao Anschutz, Physical Therapy Program (instructor Wendy Kriekels). "Sports-Related Concussions"

- Fall 2015. Colorado State University, Pueblo, Department of Psychology (instructor Patricia Levy). "Traumatic Brain Injury"

1/13-present *Associate Professor,*University of Colorado School of Medicine, Department of Pediatrics, Aurora, CO. Secondary appointment.

10/05-12/12 *The Ohio State University Graduate School, Graduate Faculty,* graduate faculty status.

10/09-12/12 *Associate Professor,* Department of Pediatrics, The Ohio State University College of Medicine, Columbus, OH.
- Mentoring student research projects.
- Biostatistics, Epidemiology, Research Methods, and Ethics (BEER) course coordinator, and co-instructor Introductory Epidemiology for 1st year medical students– Oct 2009-Jan 2010

10/09-12/12 *Associate Professor,* Division of Epidemiology, The Ohio State University College of Public Health, Columbus, OH.
- Mentoring student research projects.
- Co-instructor for Injury Epidemiology (spring 2011).

7/04-10/09 *Assistant Professor,* Department of Pediatrics, The Ohio State University College of Medicine, Columbus, OH.

- Mentoring student research projects.
- Course coordinator and co-instructor Introductory Epidemiology for 1st year medical students. (Course was taught to 2nd year students one quarter.) – 2004 -2009
- Instructor Injury Prevention Mini Module – 2008
- Created Biostatistics, Epidemiology, Research Methods, and Ethics (BEER) Curriculum – Oct 2008-Jan 2009

4/05-10/09 *Assistant Professor,* Division of Epidemiology, The Ohio State University College of Public Health, Columbus, OH.
- Mentoring student research projects.
- Course coordinator and co-instructor for Injury Epidemiology (spring 2007).
- Course instructor for Epidemiology for Experienced Health Professionals (fall 2008).

8/02–7/04 *Adjunct Assistant Professor*, Department of Biostatistics and Epidemiology, University of Oklahoma Health Sciences Center College of Public Health, OKC, OK.
- Spring 2004, mentored masters students' field work projects
- Spring and Fall, 2003, co-taught Injury Epidemiology and Prevention course.
- Guest lectured

6/00-8/00 *Teaching Associate II*, San Diego State University, San Diego, CA. Taught one section of Confronting AIDS in the general education program.

8/99-6/00 *Graduate Teaching Assistant*, San Diego State University, Graduate School for Public Health, San Diego, CA for Introductory Epidemiology classes.
- Prepared lectures, led review sessions, guest lectured, and determined grades.
- Produced on line course using Blackboard.

1/99-5/99 *Adjunct Instructor*, Kirkwood Community College, Iowa City, IA.
Taught two sections of Introductory Environmental Science.

Public Health Experience

7/02-7/04 *Epidemic Intelligence Service (EIS) Officer*, Centers for Disease Control and Prevention, Epidemiology Program Office, Division of Applied Public Health Training, Epidemic Intelligence Service Branch, Assigned to: Oklahoma State Department of Health, Injury Prevention Service, OKC, OK. Working under the direction of Sue Mallonee, RN, MPH.
- Conducted field investigations.
  - A large nosocomial outbreak of hepatitis C and B.
  - Injury patterns and preventive behaviors associated with the May 8-9, 2003, tornadoes.
- Performed research.
  - Evaluating violent injury death surveillance systems.
  - Describing the epidemiology of homicide-suicide cluster events.
- Manuscript preparation.
- Presented at international, national, and local scientific meetings, academic sessions, and local stakeholder meetings.

8/01-6/02 *Associate Schools of Public Health Fellow*, Environmental Health Services Branch, National Center for Environmental Health, Centers for Disease Control and

Prevention. Worked under the direction of Sharunda Buchanan, PhD and John Sarisky, RS, MPH, participating in field investigations on the effect of mold on indoor air quality and working on issues related to drinking water and recreational water safety.

2/99-5/99 *Program Planner II*, Iowa Department of Public Health, Center for Acute Disease Epidemiology, Des Moines, IA. Worked under the direction of Patricia Quinlisk, MD, coordinating the writing of multiple grants.

10/98 *Intern*, Iowa Department of Public Health, Center for Acute Disease Epidemiology, Souixland District Health Department, IA. Worked under the direction of EIS officers Bill Trick, MD and Belinda Ostrowsky, MD, Center for Disease Control, assisted an Epi-aide studying the prevalence of VRE in nursing home residents.

8/98-9/98 *Intern*, Iowa Department of Public Health, Center for Acute Disease Epidemiology, Des Moines, IA. Worked under the direction of Patricia Quinlisk, MD, State Epidemiologist.

- Foodborn outbreak investigations.
- Occupational CO poisoning investigations.
- Investigation of a potential waterborne outbreak of *E coli* O157.
- "Epi Manual" chapter production on bioemergencies.
- Fact sheet production on CO, enteroviruses, pandemic flu, and plague.

Research Experience

7/16-present *Professor, Professor,* Colorado School of Public Health, University of Colorado Denver, Epidemiology, and Program for Injury Prevention, Education, and Research (PIPER), Aurora, CO.

1/13-6/16 *Associate Professor,* Colorado School of Public Health, University of Colorado Denver, Epidemiology, and Pediatric Injury Prevention, Education, and Research (PIPER) program, Aurora, CO. Note name of PIPER was subsequently changed to Program for Injury Prevention, Education, and Research.

7/04-12/12 *Research Faculty,* Center for Injury Research and Policy, The Research Institute at Nationwide Children's Hospital (Research Institute changed name from Columbus Children's Research Institute in Sept. 2007), Columbus, OH. Focus of research was injury among the physically active, more specifically sports and recreation injury epidemiology.

9/99-6/01 *Research Assistant*, Naval Health Research Center, Clinical Epidemiology Division, San Diego, CA. Worked under the direction of Rick Shaffer, PhD, and Stephanie Brodine, MD, on projects involving the effectiveness of the military's suicide prevention program, patterns of condom use among HIV infected military personnel, and health-related behaviors, alcohol use, and stress among Marines.

- Survey preparation and administration.
- Data entry, data management, and epidemiological analyses.
- Manuscript preparation.

5/98-8/98 *Research Assistant I*, University of Iowa, State Health Registry of Iowa, Iowa Cancer Registry, Iowa City, IA. Worked under the direction of Paul Romitti, PhD, Department of Preventive Medicine, studying associations between cervical cancer and pregnancy history.

- Manipulation and analysis of a large database using SAS.

7/95-7/99 *Research Assistant I*, University of Iowa, Iowa City, IA. Worked under the direction of Fred Dietz, MD, Department of Orthopedic Surgery, studying the genetics of idiopathic clubfoot.
- pcr and PAGE analysis.
- Allele scoring and pedigree analysis.
- General lab management duties.

6/90-7/92 *Research Assistant II*, National Jewish Center for Immunology and Respiratory Medicine, Denver, CO. Worked under the direction of Leonid Heifets, MD, studying experimental and approved drugs and their effects on mycobacteriaciae.
- Determination of Post Antibiotic Effect.
- Determination of MIC and MBC.

2/90-6/90 *Lab Technician*, Colorado State University, Fort Collins, CO. Worked under the supervision of Kenneth Hossner, PhD, Department of Animal Science.
- Design and performance of parentage tests for bovines.
- Instruction and supervision of graduate students doing parentage tests.

9/86-5/89 *Undergraduate Researcher*, Colorado State University, Fort Collins, CO. Worked under the direction of Ralph E. Smith, PhD, Professor and Chair, Department of Microbiology, studying recombination of retroviral and host cell DNA in avians.
- Restriction mapping.
- DNA extraction and purification.
- Southern blot and PAGE analyses.

Administrative Experience

6/06-11/11 *Director of Internal Operations*, Center for Injury Research and Policy, The Research Institute at Nationwide Children's Hospital, Columbus, OH. Responsible for overseeing day to day operations of the center including personnel issues, allocation of space, facility management, etc.

Industry and Military Experience

7/92-4/95 *Biochemistry Technician and Team Leader*, PASCO Laboratories, Wheat Ridge, CO. Worked as a team member in this medical device manufacturing subsidiary of Difco Laboratories.
- Supervision and training of assistants.
- Production of solutions for MIC plates.
- Procedure writing for all laboratory activities.
- Maintaining FDA and ISO 9000 compliance.

5/89-11/95 *Medical Laboratory Specialist*, United States Army Reserves, 406th Combat Support Hospital, Aurora, CO.
- Phlebotomy and blood typing.
-

Bibliography student co-authors (including medical residents and fellows) italicized

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133.*Witsaman RJ*, **Comstock RD**, and Smith GA. Pediatric Fireworks-Related Injuries in the United States: 1990-2003. *Pediatrics* 118(1);296-303 (2006).

134.Knox CL and **Comstock RD**. Nonparticipant injuries associated with skating activities. *Pediatric Emergency Care* 22(3);164-167 (2006).

135.Knox CL and **Comstock RD**. Video Analysis of Falls Experienced by Pediatric Ice-Skaters and Roller/In-Line Skaters. *British Journal of Sports Medicine* 40(3);268-271 (2006).

136.**Comstock RD** and Mallonee S. Comparing the Reactions to Two Severe Tornadoes in One Oklahoma Community. *Disasters* 29(3);277-287 (2005).

137.**Comstock RD**, Mallonee S, Kruger E, Rayno K, Vance A, and Jordan F. Epidemiology of Homicide-Suicide Events, Oklahoma — 1994-2001. *American Journal of Forensic Medicine and Pathology* 26(3);229-235 (2005).

138.**Comstock RD,** Fields SK, and Knox CL. Protective Equipment Use Among Female Rugby Players. *Clinical Journal of Sport Medicine* 15(4);241-245 (2005).

139.**Comstock RD** and Mallonee S. Get Off the Bus: Sound Strategy for Injury Prevention During a Tornado? *Prehospital and Disaster Medicine* 20(3);189-192 (2005).

140.**Comstock RD** and Fields SK. The Fair Sex? Foul Play Among Female Rugby Players. *Journal of Science and Medicine in Sport* 8(1);101-111 (2005).

141.Dietz FR, Cole WG, Tosi LL, Carroll NC, Wemer RD, **Comstock D**, and Murray JC. A Search for the Gene(s) Predisposing to Idiopathic Clubfoot. (Letter to the Editor). *Clinical Genetics* 67;361-362 (2005).

142.**Comstock RD**, Mallonee S, and Jordan F. A Comparison of Two Surveillance Systems for Deaths Related to Violent Injury. *Injury Prevention* 11(1);58-63 (2005).

143.**Comstock RD**, Erceg L, Powell G, and Scanlin M. Healthy Camp Initiative. *Camping Magazine* 78(3);78-79 (2005).

144.**Comstock RD** and Archer P. Planning + Practice = Preparedness: A Case Study in Injury Prevention. *WORK* 23(3);199-204 (2004).

145.**Comstock RD**, Mallonee S, Fox JL, Moolenaar RL, Vogt TM, Perz JF, Bell BP, and Crutcher JM. A Large Nosocomial Outbreak of Hepatitis C and Hepatitis B Among Patients Receiving Pain Remediation Treatments. *Infection Control and Hospital Epidemiology* 25(7);576-583 (2004).

146. **Comstock RD**, Castillo EM, and Lindsay SP. A Four Year Review of the Use of Race and Ethnicity in Epidemiologic and Public Health Research. *American Journal of Epidemiology* 159(6);611-619 (2004).

147. Balter S, Layton M, Bornschlegel K, Crutcher M, Mallonee S, Fox J, Scott P, Safranek T, Lechinsky D, White K, Perz JF, Williams IA, Bell BP, Chiarello L, Panlilio A, Phillips M, Marx M, Macedo de Oliveira A, **Comstock RD**, Malakmadze N, Samandari T, and Vogt T. Transmission of Hepatitis B and C Viruses in Outpatient Settings—New York, Oklahoma, and Nebraska, 2000—2002. *Morbidity and Mortality Weekly Report (MMWR)* 52(38);901-906 (2003).

148. Naso M, **Comstock RD**, and Archer P. Funnel Vision: Practice and Preparation Save 1,200 GM Employees From a Tornado. *Safety+Health* 168(3);44-50 (September 2003).

149. **Comstock RD**. Patterns of Injury Among Female Rugby Players. *Kinesiology Abstracts* 16(1);20 (2003).

150. McClenny B and **Comstock RD**. (2000). Alcohol Use, Alcohol-Related Problems, and Perceived Stress and Coping Among U.S. Marine Corps Personnel. (Government Technical Report Number 00-41). San Diego, CA: NHRC.

151. **Comstock RD**, Currier RW, Markiewicz KV, Welke RL, Quinlisk MP, and Griener TH. Carbon Monoxide Poisoning Associated with Use of LPG-Powered (Propane) Forklifts in Industrial Settings-Iowa, 1998. *JAMA* 283(3);331-332 (2000) – (*JAMA* reprint of *MMWR*).

152. **Comstock RD**, Currier RW, Markiewicz KV, Welke RL, Quinlisk MP, and Griener TH. Carbon Monoxide Poisoning Associated with Use of LPG-Powered (Propane) Forklifts in Industrial Settings-Iowa, 1998. *Morbidity and Mortality Weekly Report (MMWR)* 48(49);1121-1124 (1999).

153. Heifets LB, Lindholm-Levey PJ, and **Comstock RD**. Bacteriostatic and Bacteriocidal Activities of Gentamicin Alone and in Combination with Claritromycin Against Mycobacterium avium. *Antimicrobial Agents and Chemotherapy* 36;1695-1698 (1992).

154. Heifets LB, Lindholm-Levey PJ, and **Comstock RD**. Clarithromycin Minimal Inhibitory and Bacteriocidal Concentrations Against Mycobacterium avium. *American Review of Respiratory Disease* 145;856-858 (1992).

155. Aurigemma RE, **Comstock RD**, and Smith RE. Persistent Viral DNA Synthesis Associated With an Avian Osteopetrosis-Inducing Virus. *Virology* 171;626-629 (1989).

Invited Presentations before Federal Entities

1. **Comstock RD**. Invited to testify before the US House of Representatives Committee on Energy and Commerce on Friday, May 13, 2016 in the Rayburn House Office Building, at the Subcommittee on Oversight and Investigations hearing entitled "Concussion in Youth Sports: Evaluating Prevention and Research"
2. **Comstock RD**. Invited speaker. Invited to sit on a 5 member expert panel to speak at the White House Healthy Kids and Safe Sports Concussion Summit held May 29th, 2014 in the East Room of the White House.

Presentations at Scientific Conferences/Meetings/Sessions/Seminars

student co-authors (including medical residents and fellows) italicized

1. Hosea Harvey (presentor), Yang J, Coxe K, and **Comstock RD**. Youth Sports TBI Laws: Evaluating Effects of Evidence-Based Policy Design and Law Revision on Rates of Initial and Recurrent Concussions. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
2. *Currie DW (presentor), Kraeulter MJ,* Kerr ZW, Roos K, McCarty EC, and **Comstock RD**. Comparing the Need for Surgery in New and Recurrent Shoulder Dislocations Sustained During High School and Collegiate Athletics. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
3. *Pierpoint LA (presentor), Currie DW,* Fields SK, and **Comstock RD**. Epidemiology of Injuries Resulting in Athlete Withdrawal from US High School Sports Despite No Medical Disqualification, 2005/06-2014/15. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
4. *Carry P (presentor),* Sontag M, Zhaoxing P, Carollo J, and **Comstock RD**. Comparison of the Performance of Wearable Sensor Based Movement Metrics Relative to a Three-Dimensional Motion Capture System. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
5. *Currie DW (presentor), Kraeulter MJ, Pierpoint LA,* McCarty EC, and **Comstock RD**. Examining Factors Related to Increasing Concussion Rates among US High School Football Players, 2005/06-2014/15. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
6. Kucera K, Register-Mihalik J, Marshall SW, Yau R, **Comstock RD**, Kerr Z, Casa D, Dompier T, Drezner J, Klossner D, Stearns R, Cox Thomas L, Wolf S, Wolff C, Cantu R, and Guskiewicz K. Catastrophic Sport-Related Traumatic Injury Fatalities in United States High School Football. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
7. Kucera K, Marshall SW, **Comstock RD**, Cox Thomas L, Wolf S, Casa D, Drezner J, Guskiewicz K, Register-Mihalik J, Dompier T, Kerr Z, Klossner D, Stearns R, Wolff C, Yau R, and Cantu R. Improving National Surveillance of Catastrophic Sports-Related Injuries and Illnesses in High School and College Sports. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
8. Kerr ZY (presentor), *Pierpoint LA, Currie DW,* Rosene JM, Visich PS, Dompier TP, and **Comstock RD**. Concussions in United States High School Boys' and College Men's Ice Hockey Players. To be presented at Safety 2016 World Conference, Tampere, Finland, Sept 18-21, 2016.
9. *Pierpoint LA (presentor), Currie DW,* Fields SK, and **Comstock RD**. Epidemiology of Injuries Leading to Voluntary Withdrawl from US High School Sports, 2005/06-2014/15. To be presented at Safety 2016 World Conference, Tampere, Finland, Sept 18-21, 2016.
10. Kucera KL (presentor), Casa DJ, Drezner J, Guskiewicz KM, Register-Mihalik JK, **Comstock RD**, Dompier TP, Kerr ZY, Klossner D, Marshall SW, Siebert D, Stearns RL, Thomas LC, Wolff K, Wolf S, Yau RK, and Cantu R. Surveillance of Catastrophic Sport-related Injury and Illness among Middle School, High School, and College Athletes, 2013/14 to 2015/16.

To be presented at the 2016 National Athletic Trainers' Association (NATA) Clinical Symposia & AT Expo, Baltimore, MD, June 22-25, 2016.

11. *Tirabassi J (presentor),* Brou L, Khodaee M, Lefort R., Fields SK, and **Comstock RD**. Epidemiology of High School Sports-Related Injuries Resulting in Medical Disqualification, 2005/2006 Through 2013/2014 Academic Years. The American Medical Society for Sports Medicine Annual Meeting, Dallas, TX, April 15-20, 2016.
12. *Harris-Spinks C (presentor),* Johnson B, Brou L, Fields SK, Khodaee M, and **Comstock RD**. Epidemiology of Shoulder Injuries Amongh US High School Athletes Across 22 Sports from 2007/2008 to 213/2014. The American Medical Society for Sports Medicine Annual Meeting, Dallas, TX, April 15-20, 2016.
13. *Currie DW (presentor)* and **Comstock RD**. Epidemiology of High School Cheerleading Injuries Relative to Other Sports, 2009/10-2013/14. The American Public Health Association (APHA) 143rd Annual Meeting, Chicago, IL, Nov 4, 2015.
14. Kerr Z (presenter), *Currie DW, Pierpoint LA*, and **Comstock RD**. Epidemiologic Comparisons of Soccer-Related Injuries Presenting to Emergency Departments and Reported within High School and Collegiate Settings. The American Public Health Association (APHA) 143rd Annual Meeting, Chicago, IL, Nov 3, 2015.
15. *Pierpoint LA (presenter), Currie DW,* Fields SK, and **Comstock RD**. Epidemiology of Severe Injuries Among US High School Athletes, 2005/06-2012/13. The American Public Health Association (APHA) 143rd Annual Meeting, Chicago, IL, Nov 2, 2015.
16. **Comstock RD**. Sports Concussion Data, Gender and Concussion Treatment Paths. Invited speaker, 26th Annual State of the States in Head Injury Meeting: Westward Bound: New Frontiers in Brain Injury. Denver, CO, October 28, 2015.
17. **Comstock RD**, Guskiewicz KM, and Whitlow CT. Sports Concussion 1: Epidemiology, Prevention, Imaging. Invited speakers, 16th Annual UC Neurotrauma Symposium. Santa Barbara, CA, September 20, 2015.
18. **Comstock RD**. Epidemiology of Youth Sports Related Concussion. Invited keynote speaker, Community Sports Huddle sponsored by the National Council on Youth Sports Safety. Invited keynote address presented following opening remarks given by Dr. David Satcher, 16th United States Surgeon General. Denver, CO, August 17, 2015.
19. **Comstock RD.** Concussion Epidemiology Update. Invited speaker, 2015 AAN (American Academy of Neurology) Sports Concussion Conference. Denver, CO, July 24-26, 2015.
20. **Comstock RD**, Guskiewicz G, and Goia G (co-presentors) (Giza C, moderator). Clinical Science of Sports Concussion. Invited speaker, National Neurotrauma Society 2015 Symposium. Santa Fe, NM, June 28-July 1, 2015.
21. Marshall SW, **Comstock RD**, and Kerr ZY (co-presentors) (de la Motte S, moderator). Injury Surveillance in High School and Collegiate Sport – What Do We Know? What Don't We Know? Selected as the Researchers' Forum. Invited speaker, National Athletic Trainers' Association 66th Clinical Symposia & AT Expo. St. Louis, MO, June 23-26, 2015.
22. Fonseca Jand **Comstock RD** (co-presentors) (Mihalik JP, moderator). Risk Factors for Prolonged Recovery Following Concussion in Young Athletes. Selected as the Evidence Based Forum. Invited speaker, National Athletic Trainers' Association 66th Clinical Symposia & AT Expo. St. Louis, MO, June 23-26, 2015.

23. **Comstock RD**. Concussion in Youth: Advances in What We Currently Know. Invited Speaker, The 9th Annual National Summit on Sports Concussion: Sports & Concussion Outcomes. Los Angeles, CA, June 5, 2015.
24. *Schussler E (presenter)*, Grooms D, Miller M, Clifton D, *Starkel C*, Best T, Borchers J, Chaudhari A, **Comstock D**, Cortes N, Hertel J, Hewett T, Pan X, Van Lunen B, and Onate J. Comparison of 2-Demensional Measurement of Knee Frontal Plane Projection Angle in ACL Injured Athletes. American College of Sports Medicine (ACSM) Annual Meeting. San Diego, CA , May 26-30, 2015.
25. Haarbauer-Krupa JK (presenter), **Comstock RD**, Lionbarger M, Hirsch S, Kavee A, and Lowe B. Medical Professional Presence and Return to Play Compliance in Concussed High School Athletes. North Ameican Brain Injury Society's 12th Annual Conference on Brain Injury. San Antonio, TX , April 29-May 2, 2015.
26. *Nowlan M*, Dabelea D, **Comstock RD**, Tung G, *Currie D*, and Rewers A (presenter). Increased Incidence of Injuries in Children and Adolescents with Type 1 Diabetes. 50th European Diabetes Epidemiology Group (EDEG). Chantilly, France , April 25-27, 2015.
27. **Comstock RD.** 2015 High School RIO Update. Invited speaker, NFHS-SFIA-NCAA Meeting. Indianapolis, IN, April 15, 2015.
28. **Comstock RD**. How Injury Surveillance Can Prevent Injury. Invited speaker, 3rd Matthew Gfeller Neurotrauma Symposium. Chapel Hill, NC, March 6, 2015.
29. **Comstock RD**. Denver/Youth Sports Perspectives. Invited speaker, National Youth Concussion Registry Meeting hosted by the National Collegiate Athletic Association. Indiannapolis, IN, March 2, 2015.
30. **Comstock RD**. What Does the Research Tell Us? Invited speaker, NATA Youth Sports Safety Summit. Dallas, TX, March 2, 2015.
31. **Comstock RD**, Parsons J, Stull R. and Lincoln A. Trends in Lacrosse Injuries Types and Public Health Interventions. Invited Speaker, US Lacrosse Sports Medicine Symposium. Baltimore, MD, Jan 23, 2015.
32. **Comstock RD**. Neck Strenght of Young Athletes for Screening and Prevention. Invited speaker, Safe Sports Think Tank 2014, Concussions in Youth Sports: How Do We Advance the Science of Prevention? Washington D.C., Nov 24, 2014 .
33. Fields SK (presenter), Tung G, and **Comstock RD**. Brains and Law: Examining the Youth Post-Concussion Return to Play Laws. 2014 North American Society for the Sociology of Sport conference. Portland, OR, Nov 5-8, 2014.
34. **Comstock RD**. Applied Public Health: Using Evidence to Drive Change. Invited keynote speaker, Colorado School of Public Health Fall Visit Day, Aurora, CO, 2014.
35. **Comstock RD**. NFHS ISS Update: Review of High School RIO 2013/14 data. Invited speaker, Fall 2014 NFHS Sports Medicine Advisory Committee. Indianapolis, IN, 2014.
36. **Comstock RD**. Sports-Related Concussions from a Football Official's Perspective. Invited speaker, 2014 Green Mountain, Colorado Youth Football Officials Meeting. Littleton, CO, 2014.
37. **Comstock RD**. NFHS ISS Update: Review of High School RIO Data on Concussions. Invited speaker, 2014 NFHS Concussion Summit. Indianapolis, IN, 2014.

38. **Comstock RD**. Invited speaker, Saint Mary's College of California Colloquium 2014 – Silently Injured: Student-Athletes, Concussions, and Mental Health. San Francisco, CA, 2014.
39. **Comstock RD**. Prevention of "Mild" TBI/Concussion Panel Discussion. Invited speaker, Finding Solutions to the Public Health Crisis: "Mild" TBI/Concussion in Youth Held May 8th (During NFL Draft Weekend). Presented by the Sarah Jane Brain Foundation. New York City, NY, 2014.
40. **Comstock RD**. The State of Concussion Outcomes in Youth: What We Currently Know. Invited speaker in plenary session. National Summit on Sports Concussion: Sports and Concussion Outcomes. Los Angeles, CA, 2014.
41. **Comstock RD**. Integrated Data Analytics of Concussed Athletes: From the Clinic to the General Population. Invited speaker and session moderator for Track A: Advances in Concussion Dignostics – Emerging Technologies and Methods. National Summit on Sports Concussion: Sports and Concussion Outcomes. Los Angeles, CA, 2014.
42. **Comstock RD**. Invited speaker. National Federation of State High School Associations (NFHS) Spring Sports Medicine Advisory Committee Meeting. Indianappolis, IN, 2014.
43. **Comstock RD**. High School Sports Injury Surveillance, Epidemiology, and Prevention: Focus on Concussion. Invited speaker. MIRECC PI meeting, Denver VAMC, Denver, CO, 2014.
44. **Comstock RD**. NFHS Injury Surveillance System. Injury Trends in High School Sports: Some Good News Finally? Invited speaker. NFHS-SFIA-NCAA Meeting. Indianapolis, IN, 2014.
45. **Comstock RD**. Trends in High School Sports Concussion: Some Good News Finally? Invited speaker, National Youth Sports Safety Summit, Washington D.C., 2014.
46. Tung G (presenter), **Comstock RD**, and Fields S. State Legislation to Address Concussion in Youth Sports: Current Status and Future Directions. The American Public Health Association (APHA) 151st Annual Meeting, Boston, MA, 2013.
47. *Collins C (presenter)*, Yeates K, Pommering T, Andridge R, and **Comstock RD**. Evaluating True Cost of Pediatric Traumatic Brain Injury by Analyzing Total Charges Across Multiple Clinical Settings. The American Public Health Association (APHA) 151st Annual Meeting, Boston, MA, 2013.
48. *Kerr Z (presenter)*, *Collins C*, Mihalik J, Marshall SW, Guskiewica K, and **Comstock RD**. Role of Impact Location in Concussion Outcomes Among US High School Football Players. The American Public Health Association (APHA) 151st Annual Meeting, Boston, MA, 2013.
49. **Comstock RD**. It's Not Just a Ding: Concussion as a Public Health Concern. Invited speaker, 1st Annual Colorado School of Public Health Public Health Exchange, Aurora, CO, 2013.
50. Medina McKeon JM (presenter), Adkins SG, Bush HM, and **Comstock RD**. Return-to-Play Probability Estimates are Affected by Which Knee Ligament is Injured. The 2013 NATA Annual Meeting and Clinical Symposium, Las Vegas, NV, 2013.
51. *Kerr ZY (presenter)*, Casa DJ, Comstock RD, and Marshall SW. Athletic Trainer Staff Size, Number of Exertional Heat Illness Events, and Use of Exertional Heat Illness Prevention

Strategies in US High School Football Programs. The 2013 NATA Annual Meeting and Clinical Symposium, Las Vegas, NV, 2013.

52. *Quatman K* (presenter), Fields SK, and **Comstock RD**. Shifting Responsibilities: A Multi-Level Approach to Concussion Management within Adolescent Sport. The 2013 NASSM Conference, Austin, TX, 2013.
53. Collins MW, **Comstock RD**, Greenwald R, Guskiewicz KM, and Torg JS. Moderator Boden BP. New Concepts Regarding Athletic Induced Mild Traumatic (Concussions) and Catastrophic Brain Injuries. Invited Speaker, American Academy of Orthopaedic Surgeons (AAOS) 2013 Annual Meeting, Chicago, IL, 2013.
54. **Comstock RD**. Sports-Related Concussions: Past, Present, and Future Research. Invited speaker, Colorado Youth Sports Concussion Special Interest Group, Denver, CO, 2013.
55. **Comstock RD**. High School Sports-Related Injury: Recent Trends and Research Findings. Invited speaker, National Youth Sports Safety Summit, Washington D.C., 2013.
56. *Collins CL (presenter)*, Fields SK, and **Comstock RD**. Using Sports Injury Surveillance Data to Drive Policy Discussions. The 2012 American Public Health Association (APHA) Annual Meeting, San Francisco, CA, 2012.
57. Corlette JD (presenter), LaBella CR, *Collins CL*, Henke NM, and **Comstock RD**. Athletic Trainers, a First Line of Defense for High School Injury Prevention among Girls' Soccer and Basketball Players (2006/07-2008/09). The 2012 American Public Health Association (APHA) Annual Meeting, San Francisco, CA, 2012.
58. LaBella C (presenter), Henke N, and **Comstock RD**. A Comparative Analysis of Injury Rates and Patterns Among Girls' Soccer and Basketball Players at Schools With and Without Athletic Trainers from 2006/07-2008/09. The 2012 American Academy of Pediatrics (AAP) National Conference, New Orleans, LA, 2012.
59. **Comstock RD**. The Risk of Rare Injuries and Conditions in High School Athletes. Presenter, Sub-topic for Affiliate Session: Catastrophic Injuries in High School and Collegeiate Athletes: Practice Considerations for the Clinical Athletic Trainer, Athletic Training Educators, and Researchers. The 63rd National Athletic Trainers' Association (NATA) Annual Meeting & Clinical Symposia, St. Louis, MO, 2012.
60. **Comstock RD**. Concussions Among US High School Athletes: From the Field to the State House – Implications for Clinicians. Invited Speaker, Practical Applications in Sports Medicine Symposium, Palm Springs, CA, 2012
61. **Comstock RD**. From Computer to Community: Translational Research vis Sports Injury Surveillance. Invited "visiting scholar" lecture, Colorado School of Public Health, Department of Epidemiology, Denver, CO, 2012.
62. **Comstock RD**. Cheerleading Injury Epidemiology. Invited Speaker, Inagural USA Cheer/ASMI Cheer Safety Symposium, Orlando FL, 2012.
63. **Comstock RD**. NFHS Injury Surveillance System Update. Invited Speaker, 2012 National Federation of State High School Associations (NFHS)/National Collegiate Athletic Association (NCAA)/Sporting Goods Manufacturers' Association (SGMA) Meeting, Indianapolis, IN, 2012.

64. **Comstock RD**. From Computer to Community: Translational Research via Sports Injury Surveillance. Invited "visiting scholar" lecture, Univeristy of North Carolina, Department of Exercise and Sports Studies, Chapel Hill, NC, 2012.
65. Udall T, Gilchrist J, Gioia G, Marshall S, Colgate B, Klossner D, Schwarz A, and **Comstock RD**. Key Note and Panel Session: A Community Approach to Address Traumatic Brain Injury in Sports and Recreation. Invited moderator, American Public Health Association (APHA) 139th Annual Meeting, Washington, DC, 2011.
66. **Comstock RD**. Sports Injuries: An Epidemiological Approach. Invited Speaker, Young Scientist Seminar Series, The Research Institute at Nationwide Children's Hospital, Columbus, OH, 2011.
67. **Comstock RD**. NFHS Injury Surveillance System. Invited Speaker, 2011 National Federation of State High School Associations (NFHS)/National Collegiate Athletic Association (NCAA)/Sporting Goods Manufacturers' Association (SGMA) Meeting, Indianapolis, IN, 2011.
68. Collins CL (presenter), McIlvain NM, and **Comstock RD**. Injury Surveillance: From Computer to Community. 2011 Joint Annual Meeting of the Safe States Alliance, SAVIR, & CDC Core I & II State Injury Grantees, Iowa City, IA, 2011.
69. **Comstock RD**, McKenzie L, and Mehan T. Speaker, group presentation, Talking to The New York Times – Why You Should Share Your Reserch with the Media and How to Get the Media Interested. SAVIR Webinar, Jan 20th, 2011.
70. **Comstock RD**. The National High School Sports-Realted Injury Surveillance Study – Cheerleading Data. Invited speaker, innaugural meeting of the USA Cheer Safety Council. Orlando, FL, 2011.
71. **Comstock RD**. Sex Differences in Concussion Symptoms of High School Athletes. Invited speaker, Youth Sport Safety Alliance Summit, One Year Later: A Report Card on the Youth Sports Safety Crisis. Washington, DC, 2010.
72. Schmutz J, Pommering T, and **Comstock RD**. The Impact of Concussions on High School and Youth Sport Athletes: A Call to Action – How Can We Improve Concussion Prevention and Methods for Concussion Management? Invited speaker, The Ohio Association of Health, Physical Education, Recreation and Dance (OAHPERD) 81st Annual State Convention, Columbus, OH, 2010.
73. Collins CL (presenter), Swenson D, *Yard EE*, McIlvain N, Fields S, and **Comstock RD**. Epidemiology of Fractures Sustained by US High School Athletes, 2005-09. American Public Health Association (APHA) 138th Annual Meeting, Denver, CO, 2010.
74. McIlvain N (presenter), *Joseph A*, Collins CL, and **Comstock RD**. A National Representative Multi-Sport Study of ACL Injuries Sustained by High School Athletes in the US, 2007-09 School Years. American Public Health Association (APHA) 138th Annual Meeting, Denver, CO, 2010.
75. Agrawal S, *Walton E (presenter)*, McIlvain N, **Comstock RD**, Garst B, Baird S, Erceg L. Injury Patterns at US Residential Summer Camps: a Longitudinal Study (2006-2010). Society for Academic Emergency Medicine Midwest Regional Conference, Dayton, OH, 2010.

76. **Comstock RD**. High School RIO: The National High School Sports Injury Surveillance Study. Invited speaker, American Academy of Pediatrics National Conference & Exhibition, Council on Sports Medicine & Fitness Program Section, San Francisco, CA, 2010.
77. **Comstock RD**. Injury Tracking/HS RIO. Invited speaker, Ohio Athletic Trainers' Association (OATA) 2010 Symposium, Columbus, OH, 2010.
78. **Comstock RD**. The National High School Sports-Related Injury Surveillance System. Invited Speaker, 2010 National Federation of State High School Associations (NFHS)/National Collegiate Athletic Association (NCAA)/Sporting Goods Manufacturers' Association (SGMA) Meeting, Indianapolis, IN, 2010.
79. **Comstock RD**. Lessons from Sports Epidemiology: Trends in Youth Sports. Invited speaker, 6th Annual Capital City Sports Medicine Symposium, Columbus, OH, 2010.
80. Marshall S, **Comstock RD**, Corlette J, and Klossner D. Sports Injury Differences Across Age Groups in Women's Competitive Sports. Invited speaker for group presentation, AAHPERD 2010 National Convention & Expo, Indianapolis, IN, 2010.
81. **Comstock RD**. Sports Injury Surveillance: It's Not Just a Research Tool. Invited speaker, NOCSAE Winter Board Meeting, Phoenix, AZ, 2010.
82. **Comstock RD**. Introduction to Epidemiology. Invited speaker, COSI Academy: Science career exploration for high school students, Columbus, OH, 2009.
83. **Comstock RD** and Chisolm DJ. Top 10 Public Health Issues in 2009. Invited speaker, OSU MedNet 21 program originally aired 10/16/2009, Columbus, OH, 2009.
84. **Comstock RD**. Concussions and the Pediatric Dentist. Invited speaker, 2009 Practical Reviews in Pediatric Dentistry (PRPD) recording series, Columbus, OH, 2009.
85. **Comstock RD**, Tackett J, and Gibson K. The NFHS Injury Surveillance System: A Systematic Approach to Risk Management Issues in Rules Writing. Invited Speaker, 2009 NFHS (National Federation of State High School Associations) Summer Meeting, Chicago, IL, 2009.
86. **Comstock RD**, *Yard EE*, and Collins CL. A Comparison of High School Sports Injury Surveillance Data Reporting by Certified Athletic Trainers, Coaches, and Athletes. Presenter, National Athletic Trainers' Association (NATA) 60th Annual Meeting & Clinical Symposia, San Antonio, TX, 2009.
87. **Comstock RD**. Injury Surveillance: Its' Not Just a Research Tool. Invited speaker. 2009 National Federation of State High School Associations (NFHS)/National Collegiate Athletic Association (NCAA)/Sporting Goods Manufacturers' Association (SGMA) Meeting, Indianapolis, IN, 2009.
88. *Yard EE (presenter)* and **Comstock RD**. Return to Play Patterns Following Concussion. 2009 National Injury & Violence Prevention Research Conference, Atlanta, GA, 2009.
89. Collins CL, *Darrow CJ*, and **Comstock RD**. A Nationally Representative Study of Severe Injuries Sustained by High School Athletes in the US, 2005-07 School Years. Presenter, American Public Health Association (APHA) 136th Annual Meeting, San Diego, CA, 2008.

90. *Yard EE*, Collins CL, and **Comstock RD**. Injury Among Children Attending US Summer Camps, 2006-07. Presenter, American Public Health Association (APHA) 136th Annual Meeting, San Diego, CA, 2008.

91. **Comstock RD**. Injury Surveillance: It's Not Just a Research Tool. Invited speaker. Greater Columbus Athletic Trainers' Society (GCATS) Meeting, Columbus, OH, 2008.

92. Dietrich A and **Comstock RD**. Pediatric Concussion: A Need for Injury Prevention. Invited speaker. Bench to Outcomes Seminar Series (BOSS), The Research Institute at Nationwide Children's Hospital, Columbus, OH, 2008.

93. *Yard EE (presenter)*, *Schroeder MJ*, Fields SK, Collins CL, and **Comstock RD**. Epidemiology of High School Soccer Injuries in the US. Pediatric Academic Societies (PAS) and Asian Society for Pediatric Research 2008 Joint Meeting, Honolulu, HI, 2008.

94. *Borowski L*, *Yard EE (presenter)*, Collins CL, and **Comstock RD**. Epidemiology of High School Basketball Injuries in the US. Pediatric Academic Societies (PAS) and Asian Society for Pediatric Research 2008 Joint Meeting, Honolulu, HI, 2008.

95. **Comstock RD**. Epidemiology of Pediatric Sports and Recreation Fall-Related Injuries. Invited speaker, Fall-Related Injury Prevention Symposium, Ohio Department of Health Injury Prevention Program and Ohio Injury Community Planning Group, Columbus, OH, 2008.

96. **Comstock RD**. The National High School Sports Injury Surveillance Study: High School RIO™. Invited speaker, National Federation of State High School Associations (NFHS) Board of Directors Meeting, Indianapolis, IN, 2008.

97. *Yard EE (presenter)* and **Comstock RD**. Comparison of Children's Freestyle and Greco-Roman Wrestling Injuries. 8th World Conference On Injury Prevention and Safety Promotion, Merida, Mexico, 2008.

98. **Comstock RD**. Nationwide High School Injury Surveillance: What Can We Learn? Invited Speaker, Nationwide Children's Hospital Sports Medicine Conference, Columbus, OH, 2008.

99. **Comstock RD**. Pediatric Non-Automobile Motorized Vehicle-Related Injuries. Invited Speaker, International Consumer Product Health and Safety Organization (ICPHSO), 2008 Annual Meeting & Training Symposium, Washington, DC, 2008.

100. **Comstock RD**. The National High School Sports-Related Injury Surveillance Study: Methodology, Results, and Impact. Invited Speaker, University of Alaska Anchorage, College of Health and Social Welfare, Public Health Program Public Seminar, Anchorage, Alaska, 2008.

101. *Yard EE (presenter)* and **Comstock RD**. Effects of Time in Competition, Phase of Play, and Field Location on Injury Severity in High School Football. American Public Health Association (APHA) 135th Annual Meeting, Washington, DC, 2007. (Received the student paper award for the Injury Control and Emergency Health Services (ICEHS) Section.)

102. *Rechel JA (presenter)*, *Yard EE*, and **Comstock RD**. Epidemiology of High School Competition and Practice Injuries. American Public Health Association (APHA) 135th Annual Meeting, Washington, DC, 2007.

103. Collins CL and **Comstock RD**. An Evaluation of Illegal Activity/Foul Play as a Potential Risk Factor for Injury. Presenter, American Public Health Association (APHA) 135th Annual Meeting, Washington, DC, 2007.

104. **Comstock RD**. Sports Violence: Serious Problem or Just Part of the Game? Invited speaker, The Center for Injury Research and Control at the University of Pittsburgh Online Webinar Series 2007-2008: Injury Control Research Grand Rounds. Internet-based lecture, Columbus, OH, 2007.

105. **Comstock RD**, *Yard EE*, and Collins CL. Exposure-Based Injury Rates and Patterns of Injury Among a Nationally Representative Sample of US High School Athletes, 2005-2006. Presenter, National Athletic Trainers Association 58th Annual Meeting & Clinical Symposia, Anaheim, CA, 2007.

106. Collins CL, **Comstock RD**, and Smith GA. Pediatric Non-Automobile Motorized Vehicle-Related Injuries. Presenter, Society for Epidemiologic Research, 40th Annual Meeting, Boston, MA, 2007.

107. **Comstock RD**. Sports and Recreation Injury Prevention. Invited speaker, The Depth and Breadth of CCRI: 2007 Columbus Children's Research Institute Annual Research Retreat, Columbus, OH, 2007.

108. Fields SK (presenter) and **Comstock RD**. It's All in Her Head: Myths and Realities of Concussions. Girls and Women Rock: Celebrating 35 Years of Sport & Title IX, Academic and Legal Conference, Cleveland, OH, 2007.

109. *Yard EE* and **Comstock RD**. Comparison of Pediatric Ice Hockey, Lacrosse, and Field Hockey Injuries Presenting to United States Emergency Departments, 1990-2003. Presenter, American Public Health Association 134th Annual Meeting and Exposition, Public Health and Human Rights, Boston, MA, 2006.

110. Knox CL and **Comstock RD**. Using Epidemiological Research to Shape Injury Prevention. Presenter, American Public Health Association 134th Annual Meeting and Exposition, Public Health and Human Rights, Boston, MA, 2006.

111. **Comstock RD** and Fields SK. Pay for Pain? Patterns of Injuries Among High School Athletes. Co-Presenter, 2006 North American Society for the Sociology of Sport Annual Meeting, Re-Imagining Community/Re(En) Visioning Sport, Vancouver, British Columbia, Canada, 2006.

112. **Comstock RD**. Making a Difference – Prevent Trauma Before it Happens. Invited speaker, Columbus Children's Hospital, Patient Care Services Grand Rounds, Columbus, Ohio, 2006.

113. **Comstock RD**. High School Sports Injury Surveillance – Collecting Incidence and Exposure. Invited speaker, National Center for Injury Prevention and Control (NCIPC) New Investigator/Dissertation Grantee Workshop, Atlanta, GA, 2006.

114. **Comstock RD**. Sports-Related Violence: Serious Problem or Just Part of the Game? Invited speaker, Central Ohio Interscholastic Athletic Administrators Association (COIAAA) Meeting, Alexandria, OH, 2006.

115. **Comstock RD**. High School Sports Injury Surveillance: Collecting Incidence and Exposure Data Using an Internet-Based Data Collection Tool. Invited speaker, National Federation of State High School Associations (NFHS) Meeting, Indianapolis, IN, 2006.

116. **Comstock RD**. Peer Review and Collaborative Science. Invited speaker, Columbus Children's Research Institute 2005 Responsible Conduct of Research Conference, Columbus, OH, 2005.

117. **Comstock RD**. Using Internet-Based Surveys for Research Purposes: The RIO™ Experience. Invited speaker, Columbus Children's Research Institute 2005 Research Training Series, Columbus, OH, 2005.

118. **Comstock RD**. Sports-Related Violence: Serious Problem or Just Part of the Game? Invited speaker, Columbus Children's Research Institute 2005 Research Training Series, Columbus, OH, 2005.

119. **Comstock RD**. What Proportion of Sports-Related Injuries Can Be Attributed to Foul Play? Presenter, 2005 National Injury Prevention and Control Conference, Injury and Violence in America: Meeting Challenges, Sharing Solutions, Denver, CO, 2005.

120. **Comstock RD**. Sports-Related Violence: Serious Problem or Just Part of the Game? Invited speaker, Columbus Children's Research Institute 2005 Annual Research Conference, Columbus, OH, 2005.

121. **Comstock RD** and Archer P. Planning + Practice = Survival. Invited speaker, The Oklahoma Safety Council's 2004 Governor's Conference on Safety & Health, Enid, OK, 2004.

122. **Comstock RD**. Importance of Data Collection. Invited speaker, Chickasaw Nation Injury Prevention & Health Promotion Conference 2004, Sulphur, OK, 2004.

123. **Comstock RD**. Warnings Received and Actions Taken – Results of a Post-tornado Community Survey. Invited speaker, 2004 National Severe Weather Workshop, Norman, OK, 2004.

124. **Comstock RD**. Assessing Violent Injury Death Reporting in Oklahoma: Implications for National Violent Death Reporting Systems. Invited speaker, 28th Convocation of Southern State Epidemiologists, Oklahoma City, OK, 2003.

125. **Comstock RD**, Mallonee S, Vogt T, Scott P, Fox J, Perz J, Bell B, Moolenaar R, and Crutcher M. Health-care—related Transmission of Hepatitis B Virus and Hepatitis C Virus Associated with Reuse of Needles/Syringes in a Pain Management Clinic—Oklahoma, 2002. Presenter, 131st Annual Meeting of the American Public Health Association, San Francisco, CA, 2003.

126. **Comstock RD**, Mallonee S, Kruger E. Homicide-Suicide Clusters, Oklahoma, 1994-2001. Presenter, National Center for Injury Prevention and Control Safety in Numbers Conference, Atlanta, GA, 2003.

127. **Comstock RD**. A Large Healthcare-Related Outbreak of Hepatitis B and C Viruses — Oklahoma, 2002. Invited speaker, Association for Professionals in Infection Control and Epidemiology Meeting, Tulsa, OK, 2003.

128. **Comstock RD**, Mallonee S, Scott P, Fox J, Vogt T, Perz J, Moolenaar R, Bell B, and Crutcher M. Healthcare-Related Transmission of Hepatitis B and C Viruses — Oklahoma, 2002. Presenter, 52nd Annual Epidemic Intelligence Service (EIS) Conference, Atlanta, GA, 2003.

129. **Comstock RD**. Highly Efficient Nosocomial Transmission of Hepatitis from Reuse of Needles in a Pain Management Clinic. Invited speaker, Epidemiologists and Professionals in Infectious Control Meeting, Oklahoma City, OK, 2003.
130. **Comstock RD**, Mallonee S, Scott P, Fox J, Vogt T, Perz J, Moolenaar R, Bell B, and Crutcher M. Health-Care – Related Transmission of HBV and HCV Associated with the Reuse of Needles/Syringes in a Pain Management Clinic – Oklahoma, 2002. Presenter, Epidemic Intelligence Service Midwest Regional Conference, Ann Arbor, MI, 2003.
131. **Comstock RD** and Castillo EM. An Examination of the Use of Race and Ethnicity in the American Journal of Public Health and the American Journal of Epidemiology, 1996-1999. Presenter, 130th Annual Meeting of the American Public Health Association, Philadelphia, PA, 2002.
132. **Comstock RD**, Lee R, Sarisky J, Mainzer H, Stock A, Brown C, and Mijal R. Applying a Systems-Based Approach to Investigating Mold in the Indoor Environment. Presenter, 130th Annual Meeting of the American Public Health Association, Philadelphia, PA, 2002
133. **Comstock RD**. Violent Injury Death – Oklahoma, 2001. Presenter, CDC EIS Fall Surveillance Course, Atlanta, GA, 2002.
134. **Comstock RD**. Grumpy Old Men – Are They Healthier Than Sweet Little Old Ladies?: Investigating the Hypothesis that Hostility is Associated with Better Health in the Elderly. Presenter, San Diego Epidemiology Research Exchange. San Diego, CA, 2001.

Posters and Published Abstracts from Scientific Meetings/Sessions

student co-authors (including medical residents and fellows) italicized

1. *Currie DW, Kraeutler MJ, Pierpoint LA,* McCarty EC, and **Comstock RD**. Comparing Injury Rates and Patterns in High School Ice Hockey and Football. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
2. *Pierpoint LA, Kraeutler MJ, Currie DW,* and **Comstock RD**. Epidemiology of Injuries on Artificial Turf Compared to Natural Grass among US High School Athletes, 2005/06-2014/15. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
3. Brou L, *Wiersma A,* Fields SK, **Comstock RD**, and Kerr Z. Comparison of Ankle Injuries Presenting to US Emergency Departments, High School Athletic Trainers and NCAA Athletic Trainers 2005/06 through 2013/14. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
4. Yang J, **Comstock RD**, Li H, Coxe K, Xun P, and Harvey H. Effect of State Youth Traumatic Brain Injury Laws on Rates of Initial and Recurrent Concussions among High School Athletes. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.
5. Roberts K, Kaercher R, *Currie DW*, Abdel-Rasoul M, Dixon L, Ganczak A, Bardsley S, **Comstock RD**, and McKenzie LB. Evaluation of a Concussion Injury Management App for Youth Sports. To be presented at American Public Health Association (APHA) Annual Meeting & Expo, Denver, CO, Oct 29-Nov 2, 2016.

6. *Pierpoint LA (poster pitching session presentor),* Kerr ZY, *Currie DW*, and **Comstock RD**. Epidemiology of Knee Sprains in US High School and Collegiate Athletics. To be presented at Safety 2016 World Conference, Tampere, Finland, Sept 18-21, 2016.
7. *Currie DW (poster pitching session presentor), Pierpoint LA,* Kerr ZW, and **Comstock RD**. Recurrent Concussions in United States High School Athletes. To be presented at Safety 2016 World Conference, Tampere, Finland, Sept 18-21, 2016.
8. *Ashack KA, Burton KA,* Johnson TR, *Currie DW*, **Comstock RD**, and Dellavalle RP. Skin Infections among US High School Athletes: A National Survey. Presented at the Annual Meeting of the American Academy of Dermatology, March 4-8, 2016 in Washington DC.
9. *Ewald M*, Fields SK, and **Comstock RD**. Gender Differences in Time Loss among High School and Collegiate Athletes Participating in Soccer, Basketball, and Baseball/Softball Following a Concussion. The American Public Health Association (APHA) 143rd Annual Meeting, Chicago, IL, Nov 2, 2015
10. *Currie DW* and **Comstock RD**. Epidemiology of High School Cheerleading Concussions in the United States, 2009/10-2013/14. Society for Epidemiologic Research 48th Annual Meeting , June 16-19, 2015 in Denver, CO.
11. *Pierpoint LA*, Williams CM, Fields SK, and **Comstock RD**. Injuries in US Track & Field High School Student-Athletes, 2008/09-2013/14. Society for Epidemiologic Research 48th Annual Meeting, June 16-19, 2015 in Denver, CO.
12. *Ewald M,* Fields SK, and **Comstock RD**. High School and Collegiate Soccer, Basketball, and Baseball/Softball Athletes' Injury Recovery Time Differences. Society for Epidemiologic Research 48th Annual Meeting, June 16-19, 2015 in Denver, CO.
13. *Ewald M,* Fields SK, and **Comstock RD**. Gender Differences in High School and Collegiate Soccer, Basketball, Baseball and Softball Athletes' Injury Recovery Time. Society for Epidemiologic Research 48th Annual Meeting, June 16-19, 2015 in Denver, CO.
14. *Starkel C*, Grooms D, Best T, Borchers J, Chaudhari A, Clifton D, **Comstock RD**, Cortez N, Hertel J, Hewett T, Miller M, Schussler E, Van Lunen B, Pan X, and Onate J. Single Leg Hop Limb Asymmetry and Lower Extremity Injury Risk in Healthy High School Athletes: The FPPE Project. American College of Sports Medicine (ACSM) Annual Meeting, May 26-30, 2015 in San Diego, CA.
15. Nagle K, Johnson B, Brou L, Landman T, and **Comstock RD**. Impact of Fatigue on Lower Extremity Sports Injuries: Timing, Severity, and Type of Lower Extremity Injuries within Multiple High School Sports' Practices and Competition. American Medical Society for Sports Medicine 24th Annual Meeting, April 14-19, 2015 in Hollywood, FL.
16. *Dizdarevic I*, *Low S*, *Currie D*, **Comstock RD**, Hammoud S, Atanda A (presenter). Epidemiology of Elbow Dislocation in High School Athletes. Poster presented at the 2015 Annual Meeting, Pediatric Research in Sports Medicine Society, Weston, FL, Feburary 20-12, 2015.
17. *Roos KG*, Kerr ZY, Golightly YM, Kucera KL, Myers JB, Marshall SW, Rosamond WD, and **Comstock RD**. The Epidemiology of Overuse Injuries in US Collegiate and High School Athletics. Poster presented at the 2014 Annual Meeting, World Congress on Exercise is Medicine, and World Congress on the Role of Inflammation in Exercise, Health and Disease of the American College of Sports Medicine, Orlando, FL, May 27-31, 2014.

18. *Schroeder AN*, **Comstock RD**, *Collins CL*, Everhart J, Flanigan D, and Best TM. Epidemiology of Overuse Injuries Among High-School Athletes in the United States. Poster presented at the 2014 Annual Meeting, World Congress on Exercise is Medicine, and World Congress on the Role of Inflammation in Exercise, Health and Disease of the American College of Sports Medicine, Orlando, FL, May 27-31, 2014.
19. Onate J, Chaudhari A, Borchers J, Hewett T, Pan J, **Comstock RD**, Cortes N, Van Lunen B, Hertel J, Grooms D, Miller M, Schussler E, *Starkel C*, and Best TM. Comparison of High School vs. Collegiate Single Leg Balance and Single Leg Hop Characteristics: The Functional Pre-Participation Physical Evaluation (FPPE) Project. Poster presented at the 2014 Annual Meeting, World Congress on Exercise is Medicine, and World Congress on the Role of Inflammation in Exercise, Health and Disease of the American College of Sports Medicine, Orlando, FL, May 27-31, 2014.
20. Johnson B, *Currie D*, **Comstock RD**. Epidemiology of Chest, Abdominal, and Thoracic Spine Injuries Among U.S. High School Athletes. Poster presented at the 2014 Pediatric Academic Societies and Asian Society for Pediatric Research Joint Meeting, Vancouver, Canada, May 3-6, 2014.
21. *Riederer M*, *Carry P*, *Grubenhoff J*, and **Comstock RD**. Compliance of Return-to-Play Guidelines of US High School Athletes After Sports-Related Concussion from 2005/06 to 2012/13. Poster presented at the 2014 American Medical Society for Sports Medicine (AMSSM) 23rd Annual Meeting, New Orleans, LA, April 5-9, 2014.
22. *Riederer M*, Brou L, Johnson B, and **Comstock RD**. Epidemiology of US High School Sports-Related Finger, Hand, Thumb, and Wrist Injuries, 2005/06 to 2012/13. Poster presented at the 2014 American Medical Society for Sports Medicine (AMSSM) 23rd Annual Meeting, New Orleans, LA, April 5-9, 2014.
23. *Collins C*, Pommering T, Yeates K, Andridge R, and **Comstock RD**. Clinical Presentation Patterns and Settings for Pediatric Traumatic Brain Injury at One, Large Midwest Children's Hospital. Poster presented at the American Public Health Association (APHA) 151st Annual Meeting, Boston, MA, 2013.
24. *Collins C*, McKenzie LB, Roberts K, Fields S, and **Comstock RD**. Mouthguard BITES (Behavior, Impulsivity, Theory Evaluataion Study): What Drives Mouthgurad Use among High School Basketball and Baseball/Softball Athletes. Poster presented at the American Public Health Association (APHA) 151st Annual Meeting, Boston, MA, 2013.
25. McKenzie LB, Roberts K, Fletcher E, **Comstock RD**, Fernandez SA, Abdel-Rasoul M, Casavant MJ, and Mihalov L. Carbon Monoxide Detector Use: Results of a Randomized Controlled Trial in a Pediatric Emergency Department. Poster presented at the American Public Health Association (APHA) 151st Annual Meeting, Boston, MA, 2013.
26. Roberts K, Fletcher E, McKenzie L, **Comstock RD**, Fernandez S, Abdel-Rasoul M, Mihalov L, and Casavant M. Carbon Monoxide Detector Use among Parents: Results of a Randomized, Controlled Trial in a Pediatric Emergency Department. Poster presentated at the 2013 National Meeting of the Safe States Alliance and SAVIR, Baltimore, MD, 2013.
27. Fletcher EN, McKenzie LB, and **Comstock RD**. Epidemiological Comparison of High School Basketball Injuries Reporting to Emergency Departments and the Athletic Training Setting. Poster presentated at the 2013 National Meeting of the Safe States Alliance and SAVIR, Baltimore, MD, 2013.

28. Corlette JD, TePoel MRW, Fields SK, and **Comstock RD**. Differences in Football Injury Rates and Patterns by Age (High School vs. Middle School-Aged) and Type of Youth League (Middle School vs. Pop Warner Teams). Poster presented at the 2013 National Meeting of the Safe States Alliance and SAVIR, Baltimore, MD, 2013.
29. McKeon JM, Adkins SG, Bush HM, and **Comstock RD**. Ankle Sprain Severity Affects the Probability of Return-To-Play in High School Athletes. Poster presented at the 60th Annual Meeting and 4th World Congress on Exercise is Medicine of the American College of Sports Medicine (ACSM) conference, Indianapolis, IN, 2013.
30. *Swenson DM*, **Comstock RD**, Flannigan DC, and Best TM. Epidemiology of Meniscal Injuries in US High School Boys' Football, Ice Hockey, and Lacrosse. Poster presented at the 59th Annual Meeting and 3rd World Congress on Exercise is Medicine, of the American College of Sports Medicne (ACSM) conference, San Francisco, CA, 2012.
31. *Stacey AW*, Czyz CN, Foster JA, and **Comstock RD**. Eye Injuries in US High School Athletes: Results of a Six-Year Epidemiologic Study. Poster presented at the 2012 Association of Research in Vision and Ophthalmology (ARVO) Conference, Translational Research: Seeing the Possibilities, Ft Lauderdale, FL, 2012.
32. Pommering TL, Diehl JJ, *Collins C*, Kluchurosky L, **Comstock RD**, and Best TM. A Randomized Double Blind Trial of the Effectiveness of Pulsed Electromagnetic Energey for Lower Extremity Stress Fractures in Pediatric and Adult Athletes. Poster presented at the 2012 American Medical Society for Sports Medicine (AMSSM) conference, Atlanta, GA, 2012.
33. Torg JS, Hirsch H, Fowler JR, Boden BP, **Comstock RD**, and Gaughan JP. Helmet Characteristics as Profile Elements Indentifying Susceptibility to Mild Traumatic Brain Injury (Concussion) in Tackle Football. Poster presented at the 2012 American Orthopaedic Society for Sports Medicine (AOSSM) Specialty Day, San Francisco, CA, 2012.
34. *Gage BE*, McIlvain NM, Collins CL, Fields SK, and **Comstock RD**. Epidemiology of 6.6 Million Knee Injuries Presenting to US Emergency Departments from 1999 through 2008. Poster presented at the 2011 Joint Annual Meeting of the Safe States Alliance, SAVIR, & CDC Core I & II State Injury Grantees, Iowa City, IA, 2011.
35. Agrawal S, *Walton E*, McIlvain N, **Comstock RD**, Garst B, Baird S, Erceg L. Injury Patterns at US Residential Summer Camps: A Longitudinal Study (2006-2010). Poster presented at the Pediatric Academic Socieities and Asian Societies for Pediatric Research (PAS/ASPR) Annual Meeting, Denver, CO, 2011.
36. Collins CL, *Marar M*, McIlvain N, and **Comstock RD**. Epidemiology of Concussions Sustained in 18 US High School Sports, 2008-09. Poster presented at the American Public Health Association (APHA) 138th Annual Meeting, Denver, CO, 2010.
37. *Nelson N*, Collins CL, **Comstock RD**, and McKenzie LB. Exertional Heat-Related Injuries Treated in Emergency Departments in the US, 1997-2006. Poster presented at the American Public Health Association (APHA) 138th Annual Meeting, Denver, CO, 2010.
38. Collins CL, *Kerr ZY*, and **Comstock RD**. Epidemiology of Dislocations/Separations among US High School Athletes. Poster presented at the 10th World Conference on Injury Prevention and Safety Promotion, London, 2010.

39. Collins CL, *Rechel JA*, and **Comstock RD**. Epidemiology of Injuries Requiring Surgery among US High School Athletes. Poster presented at the 10th World Conference on Injury Prevention and Safety Promotion, London, 2010.
40. *Nelson N*, Alhajj M, *Yard EE*, **Comstock RD**, and McKenzie L. Physical Education Class Injuries. Poster presented at the 2009 National Injury & Violence Prevention Research Conference, Atlanta, GA, 2009.
41. *Swenson D*, *Yard EE*, Fields SK, Collins CL, and **Comstock RD**. Epidemiology of US High School Fractures. Poster presented at the 2009 National Injury & Violence Prevention Research Conference, Atlanta, GA, 2009.
42. *Yard EE*, Collins CL, and **Comstock RD**. High School Sports Injury Surveillance Reporting. Poster presented at the 2009 National Injury & Violence Prevention Research Conference, Atlanta, GA, 2009.
43. Collins CL, *Yard EE*, and **Comstock RD**. Epidemiology of Pediatric Concussions. Poster presented at the 2009 National Injury & Violence Prevention Research Conference, Atlanta, GA, 2009.
44. *Darrow CJ*, Collins CL, and **Comstock RD**. Epidemiology of Severe Injuries Among US High School Athletes, 2005-07. Poster presented at the American Medical Association – Medical Student Section Interim Meeting, Orlando, FL, 2008.
45. *Yard EE*, Collins CL, and **Comstock RD**. Illness Among Children Attending US Summer Camps, 2006-07. Poster presented at the American Public Health Association (APHA) 136th Annual Meeting, San Diego, CA, 2008.
46. *Huffman EA*, *Yard EE*, Fields SK, Collins CL, and **Comstock RD**. Epidemiology of Rare Injuries and Conditions among US High School Athletes during the 2005-06 and 2006-07 School Years. Poster presented at the 7th Annual OSUMC Research Day, Columbus, OH, 2008.
47. *Yard EE* and **Comstock RD**. An Epidemiologic Comparison of Pediatric Freestyle and Greco-Roman Wrestling Injuries. Poster presented at the 7th Annual OSUMC Research Day, Columbus, OH, 2008.
48. Collins CL, *Yard EE*, and **Comstock RD**. Preventing Sports-Related Injuries Using a Public Health Approach. Poster presented at the 9th World Conference On Injury Prevention and Safety Promotion, Merida, Mexico, 2008.
49. **Comstock RD** and Collins CL. Advantages and Disadvantages of Using an Internet-Based Data Collection Tool for Research Purposes. Poster presented at the American Public Health Association (APHA) 135th Annual Meeting, Washington, DC, 2007.
50. Collins CL and **Comstock RD**. Illegal Activity/Foul Play as a Risk Factor for Injury among US High School Athletes. Poster presented at the 2007 National Injury & Violence Prevention Research Conference, Columbus, OH, 2007.
51. *Ingram J*, Fields SF, *Yard EE*, and **Comstock RD**. A Joint Problem: Epidemiology of Knee Injuries among Boys and Girls in US High School Athletics. Poster presented at the 2007 National Injury & Violence Prevention Research Conference, Columbus, OH, 2007.
52. *Yard EE* and **Comstock RD**. An Epidemiologic Comparison of Injuries Presenting to Pediatric ED and UC Facilities. Poster presented at the 2007 National Injury & Violence Prevention Research Conference, Columbus, OH, 2007.

53. Collins CL, *Yard EE*, and **Comstock RD**. Injuries Sustained by High School Baseball Players when Hit by a Batted Ball. Poster presented at the Society for Epidemiologic Research, 40th Annual Meeting, Boston, MA, 2007.
54. *Yard EE*, and **Comstock RD**. An Epidemiologic Comparison of Pediatric Freestyle and Greco-Roman Wrestling Injuries. Poster presented at the Society for Epidemiologic Research, 40th Annual Meeting, Boston, MA, 2007.
55. *Yard EE*, Collins CL, and **Comstock RD**. Epidemiology of High School Wrestling Injuries. Poster presented at the Society for Epidemiologic Research, 40th Annual Meeting, Boston, MA, 2007.
56. *Yard EE*, Knox CL, and **Comstock RD**. Illness and Injury Among Children Attending Summer Camp, United States 2005. Poster presented at the American Public Health Association 134th Annual Meeting and Exposition, Public Health and Human Rights, Boston, MA, 2006.
57. *Yard EE*, Knox CL, and **Comstock RD**. An Internet-based Surveillance System for Collection of Sports Injury and Exposure Information, United States 2005-2006. Poster presented at the 1st European Conference on Injury Prevention and Safety Promotion, Vienna Austria, 2006.
58. Knox CL and **Comstock RD**. Moving Research from Knowledge to Practice. Poster presented at the Second North American Congress of Epidemiology, Seattle, WA, 2006. (Received 2nd place for poster of session two award.)
59. *Yard EE*, Knox CL, and **Comstock RD**. Internet-Based Surveillance of Injuries Sustained by US Campers. Poster presented at the Second North American Congress of Epidemiology, Seattle, WA, 2006.
60. Knox CL, *Yard EE*, and **Comstock RD**. Internet-Based Surveillance of Injuries Sustained by US High School Rugby Players. Poster presented at the Second North American Congress of Epidemiology, Seattle, WA, 2006.
61. Knox CL and **Comstock RD**. Using Internet-Based Surveys for Research Purposes: The RIO™ Experience. Poster presented at the 8th World Conference On Injury Prevention and Safety Promotion, Durban, South Africa, 2006.
62. *Yard EE* and **Comstock RD**. Comparison of Pediatric Ice Hockey, Lacrosse, and Field Hockey Injuries Presenting to US Emergency Departments, 1990-2003. Poster presented at the Columbus Children's Research Institute 2005 Annual Research Conference, Columbus, OH, 2006.
63. *Witsaman RJ*, **Comstock RD**, and Smith GA. Pediatric Fireworks-Related Injuries in the United States, 1990-2003. Poster presented at the Columbus Children's Research Institute 2005 Annual Research Conference, Columbus, OH, 2006.
64. **Comstock RD**, Knox CL, and Fields SK. Is Sports-Related Violence a Public Health Issue or is it "Just Part of the Game?" Poster presented at the 2005 Epidemiology without Borders, A Joint Meeting of the Society for Epidemiologic Research and Canadian Society for Epidemiology and Biostatistics, Toronto, Canada, 2005.
65. Knox CL, Fields SK, and **Comstock RD**. Sports-Related Violence: A Unique but Unstudied Subset of Violence. Poster presented at the 2005 Epidemiology without Borders, A Joint

Meeting of the Society for Epidemiologic Research and Canadian Society for Epidemiology and Biostatistics, Toronto, Canada, 2005.

66. **Comstock RD** and Knox CL. A Two-Year Review of Rugby-Related Injuries Presenting to United States Emergency Departments, 2002-2003. Abstract published, 2005 Pediatric Academic Societies' Annual Meeting, Washington DC, 2005.
67. **Comstock RD** and Knox CL. When the Rules of the Game are Broken: What Proportion of Sports-Related Injuries can be Attributed to Illegal Activity? Abstract published, 2005 Pediatric Academic Societies' Annual Meeting, Washington DC, 2005.
68. Knox CL and **Comstock RD**. Nonparticipant Injuries Associated with Skating Activities. Abstract published, 2005 Pediatric Academic Societies' Annual Meeting, Washington DC, 2005.
69. Knox CL, **Comstock RD**, McGeehan JM, and Smith GA. Is Ice-Skating More Dangerous Than Other Skating Activities? Epidemiology of Ten Years of Pediatric Skating-Related Injuries in the United States. Poster presented at the 2005 Pediatric Academic Societies' Annual Meeting, Washington DC, 2005.
70. **Comstock RD**, Knox CL, and Fields SK. Sports-Related Violence: Public Health Issue or Just "Boys Being Boys?" Poster presented at the 2005 National Injury Prevention and Control Conference, Injury and Violence in America: Meeting Challenges, Sharing Solutions, Denver, CO, 2005.
71. Knox CL and **Comstock RD**. Gender Differences in Ice Hockey Injuries Attributed to Illegal Activity: What Proportion of Sports-Related Injuries Can Be Attributed to Foul Play? Poster presented at the 2005 National Injury Prevention and Control Conference, Injury and Violence in America: Meeting Challenges, Sharing Solutions, Denver, CO, 2005.
72. **Comstock RD**, Mallonee S, and Hasandzekaj A. Does a Community-Wide Change in Protective Actions Occur After a Severe Tornado? Poster presented at the 7th World Conference on Injury Prevention and Safety Promotion, Vienna, Austria, 2004. (Received 2nd place for poster of the conference award.)
73. **Comstock RD** and Fields SK. The Fair Sex? Foul Play Among Female Rugby Players. Poster presented at the 7th World Conference on Injury Prevention and Safety Promotion, Vienna, Austria, 2004.
74. **Comstock RD** and Fields SK. Patterns of Injury Among USA Female Rugby Players. Poster presented at the 7th World Conference on Injury Prevention and Safety Promotion, Vienna, Austria, 2004.
75. Mallonee S, **Comstock RD**. Accuracy of Violent Death Reporting in Oklahoma, 2001. Poster presented at the 131st Annual Meeting of the American Public Health Association, San Francisco, CA, 2003.
76. Heifets LB, Lindholm-Levey PJ, and **Comstock RD**. MICs and MBCs of Clarithromycin for M. avium Isolated From AIDS Patients. Abstract presented to the American Society of Microbiology. Dallas, Texas, 1991.
77. Aurigemma RE, **Comstock RD**, and Smith RE. Persistent Viral DNA Synthesis Associated With MAV 2-(0) Induced Osteopetrosis. Abstract presented to the American Society for Virology. Austin, Texas, 1988.

Funded Research Projects

2016-2017 PI: High School Sports Injury Surveillance Study Expansion. A continuation of the expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $100,000 provided by the National Federation of State High School Associations via charitable donation to Colorado School of Public Health.

2015-2016 Paid Consulting Expert to the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Division of Unintentional Injury Prevention, TBI Group (CDC, NCIPC, DUIP/TBI) at 20% FTE to assist with the CDC NCIPC's design of a national surveillance system to capture sports-and recreation-related concussions among youth. Assignment agreement 15IPA1505496.

2015-2016 PI: High School Sports Injury Surveillance Study Expansion. A continuation of the expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $100,000 provided by the National Federation of State High School Associations via charitable donation to Colorado School of Public Health.

2015-2016 Co-investigator (PI: Grubenhoff): Outpatient Follow-up after ED Evaluation of Concussion in Children: Barriers, Facilitators and Benefits. Funding provided by CO Brain Injury Trust (State of Colorado/Colorado Department of Human Services).

2014-2016 Co-investigator (PI: Yang): Studying the Impact on the Health of Young Athletes of Laws on Secondary Prevention of Concussions and on Recurrent Concussions. Study to evaluate the effectiveness of state level concussion legislation taking compliance and enforcement into account. Total grant funding in the amount of $149,499 provided by Robert Wood Johnson Foundation (RWJF). Grant ID number: 72273.

2014-2015 PI: High School Sports Injury Surveillance Study Expansion. A continuation of the expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $75,000 provided by the National Federation of State High School Associations via charitable donation to Colorado School of Public Health.

2013-2015 Co-PI (Co-PI: McKenzie): Evaluation of Spot Light: A Concussion Injury Management APP for Youth Sports. A study to determine if a free concussion APP will increase reporting rates of sports-related concussion, increase referrals to physicians, and increase athlete compliance with return to play guidelines. Total grant funding in the amount of $426,035 provided by NIH. Grant number: 1R21HD080377-01.

2012-2017 Co-investigator (PI: Onate): Functional Evaluation to Predict Lower Extremity Musculoskeletal Injury. A study to determine if a functional pre-participation

physical evaluation (F-PPE) will better predict lower extremity injury than traditional PPE. Total grant funding in the amount of $1,952,090 provided by NIH. Grant number: 1RO1AR062578-01A1.

2012 – 2015 PI: Evaluating the Effectiveness/Outcomes of State Level Concussion Policies. A study to evlaute the effectiveness of state level concussion legislation using High School RIO concussion data. Funding in the amount of $600,000 provided by the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Grant number: 1R49CE001172-01.

2013-2014 PI: High School Sports Injury Surveillance Study Expansion. A continuation of the expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $75,000 provided by the National Federation of State High School Associations via charitable donation to Colorado School of Public Health.

2012- 2013 PI: High School Sports Injury Surveillance Study Expansion. A continuation of the expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $75,000 provided by the National Federation of State High School Associations via charitable donation to Nationwide Children's Hospital Foundation ($25,000) and Colorado School of Public Health ($50,000).

2011- 2012 PI: TBI Sports Evaluation & Surveillance Project. A series of three concussion projects including: 1) an evaluation of the effectiveness of prominent concussion educational interventions, 2) a proposal for novel methodology to conduct longitudinal concussion surveillance in athletes from youth sports through high school and collegiate sports, and 3) an epidemiologic description of the burden and cost of pediatric mTBI across a wide range of clinical settings. Funding in the amount of $150,000 provided by the the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Contract number: 200-2011-M-41924.

2011- 2012 PI: High School Sports Injury Surveillance Study Expansion. A continuation of the expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $75,000 provided by the National Federation of State High School Associations via charitable donation to Nationwide Children's Hospital Foundation

2011- 2012 PI: Concussion Surveillance Among a Large National Sample of Middle School Football Players: Middle School RIO. A study to establish a surveillance system to record rates and patterns of concussions among a large national sample of middle school aged football players. Funding in the amount of $90,000 provided by the National Football League (NFL) Charities.

2010 - 2011 PI: High School Sports Injury Surveillance Study Expansion. An expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 20 sports. Funding in the amount of $75,000 provided by the National

Federation of State High School Associations via charitable donation to Nationwide Children's Hospital Foundation.

2010 - 2012 PI: Can Anthropometric Measurements Explain Gender Differences in Concussion Rates Among High School Basketball, Soccer, and Lacrosse Players. Study to determine if readily obtainable anthropometric measurements that can be captured by certified athletic trainers in the high school setting can be used to predict concussion risk among high school soccer, basketball, and lacrosse players. Funding in the amount of $256,693 provided by the National Operating Committee on Standards for Athletic Equipment.

2009 - 2013 PI: High School Sports Injury Surveillance: Monitoring Rates and Patterns of Injury Over Time. A continuation of the National High School Sports Injury Surveillance Study with a special emphasis on improving data collection on protective equipment use. Funding in the amount of $168,000 provided by the National Operating Committee on Standards for Athletic Equipment.

2009 - 2011 Mouthguard BITES (Behavior, Impulsivity, Theory Evaluation Study): Pilot project to identify specific behavioral factors influencing high school basketball, baseball, and softball players' decision making regarding use of mouthguards. Funding in the amount of $216,000 provided by the National Institutes of Health, National Institute of Dental and Craniofacial Research. Grant Number: 1RO3DE019176-01A1.

2008 - 2012 Co-investigator (PI-McKenzie) : Emergency Department Brief Intervention to Increase Carbon Monoxide Detector Use. A study to determine whether a brief intervention will increase carbon monoxide detector use. Funding in the amount of $396,000 provided by the National Institutes of Health, Eunice Kennedy Shriver National Institute of Child Health and Human Development. Grant Number: RO1HD057155.

2008 - 2012 PI: High School Sports Injury Surveillance and Intervention Evaluation. A continuation and expansion of the National High School Sports Injury Surveillance Study with a special emphasis on evaluating evidence-based interventions driven by data collected by the surveillance system. Funding in the amount of $300,000 provided by the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control as part of the Injury Control Research Center Grant awarded to the Center for Injury Research and Policy at Nationwide Children's Hospital. Grant Number: R49/CE001172-01.

2009 - 2010 PI: High School Sports Injury Surveillance Study Expansion. An expansion of the National High School Sports Injury Surveillance Study to continue capturing data on 18 sports and to expand to include two more sports (boys' volleyball and cheerleading). Funding in the amount of $75,000 provided by the National Federation of State High School Associations via charitable donation to Nationwide Children's Hospital Foundation.

2008 - 2009 PI: High School Sports Injury Surveillance Study Expansion. An expansion of the National High School Sports Injury Surveillance Study from 100 schools to 200 schools to capture data on an additional nine sports (boys' ice hockey, lacrosse, swimming & diving, and track & field and girls' field hockey, lacrosse, gymnastics, swimming & diving, and track & field). Funding in the amount of $70,000 provided by the National Federation of State High School Associations via charitable donation to Nationwide Children's Hospital Foundation.

2008 PI: National High School Sports Injury Surveillance Study, High School RIO™. A continuation of an internet-based injury surveillance system to monitor injuries to student athletes in nine sports using a nationally representative sample consisting of 100 US High Schools. Funding in the amount of $10,000 provided by the National Federation of State High School Associations via charitable donation to Nationwide Children's Hospital Foundation.

2008 PI: National High School Sports Injury Surveillance Study, High School RIO™. A continuation of an internet-based injury surveillance system to monitor injuries to student athletes in nine sports using a nationally representative sample consisting of 100 US High Schools. Funding in the amount of $15,000 provided by the Development Board of Nationwide Children's Hospital.

2007 PI: National High School Sports Injury Surveillance Study, High School RIO™. A continuation of an internet-based injury surveillance system to monitor injuries to student athletes in nine sports using a nationally representative sample consisting of 100 US High Schools. Funding in the amount of $100,000 provided by DJO via charitable donation to Nationwide Children's Hospital Foundation.

2006 - 2011 PI: The Healthy Camp Study. Project to implement an internet-based surveillance system among US summer camps to monitor injuries and illnesses among campers and staff using a nationally representative sample of camps. Funding in the amount of $45,000 provided by the American Camp Association.

2006 PI: On-Line Surveillance of High School Sports Injuries. Project to compare the quality of athletic exposure and injury data reported by coaches and student athletes using an internet-based injury surveillance system to data reported by certified athletic trainers. Funding in the amount of $84,811 provided by the National Athletic Trainers Association (NATA) Research & Education Foundation.

2006 PI: Rugby RIO™ (Reporting Injuries Online) 2006: A Continuation of Internet-Based Surveillance of Injuries Sustained by US High School Rugby Players. Project to continue an internet-based injury surveillance system among US high school rugby teams begun in 2005. Funding in the amount of $14,000 provided by the US Rugby Football Foundation (USRFF).

2006 PI: Analysis of Pediatric Freestyle and Greco Roman Wrestling Injuries: An injury surveillance project to describe the epidemiology of injuries among pediatric freestyle and Greco Roman wrestling participants. Funding in the amount of $6,553 provided by Dollamur Sport Surfaces, Dollamur, LLP.

2005 PI: High School RIO™ (Reporting Injuries Online): An Internet-Based Surveillance of Injuries Sustained by US High School Athletes. Project to implement an internet-based injury surveillance system to monitor injuries to student athletes in nine sports using a nationally representative sample consisting of 100 US High Schools. Funding in the amount of $100,000 provided by the Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, New Investigator Grant. Grant Number: R49/CE000674-01.

2005 PI: Rugby RIO™ (Reporting Injuries Online): An Internet-Based Surveillance of Injuries Sustained by US Rugby players. Project to implement an internet-based injury surveillance system among US high school rugby teams. Funding in the amount of $11,000 provided by the US Rugby Football Foundation (USRFF).

2001 PI: Identification of Injury Patterns Among Female Rugby Players in the United States and Factors Associated With Such Injuries. Project to conduct a cross-sectional injury epidemiology study among US female rugby players. Funding in the amount of $2,672 provided by the San Diego State University, School of Public Health, Dean's Research Award Dissertation Grant.

1999 Grant writer: Iowa Department of Public Health Preparedness and Response for Bioterrorism Grant. Funding in the amount of $280,725 provided by HHS CDC announcement #99051.

1999 Grant writer: Iowa Department of Public Health Epidemiology and Laboratory Capacity for Infectious Diseases Grant. Funding in the amount of $285,804 provided by HHS CDC announcement #99032.

1987 PI: A Study of the Interaction of MAV-2(0) DNA with Host Cell DNA. Funding in the amount of $544 provided by the Sigma Xi Undergraduate Grant-in-Aid of Research.

Consulting

Paid Consultant – CDC NCIPC TBI Surveillance Project (15IPA1505496 from 7/1/2015 to 6/30/16 with subsequent extension from 7/1/2016 to 6/30/2017).

Paid Consultant and Potential Expert Witness – litigation involving concussions and other brain injuries suffered by former National Hockey League (NHL) ice hockey players for Zimmerman Reed, LLP (Jan 2016-present).

Paid Consultant and Potential Expert Witness – Hampton v NFHS, et al for Martineau King, PLLC (June 2016-present).

Awards

Faculty Excellence in Student Mentored Research Award, presented by the Colorado School of Public Health Awards Committee. Denver, CO, 2016.

Delta Omega National Honor Society, Elected for membership into the Delta Omega National Honor Society in Public Health, Colorado School of Public Health Chapter. Denver, CO, 2015.

Youth Sports Safety Ambassador Award, named one of three inaugural Youth Sports Safety Ambassadors by the National Athletic Trainer's Association, "for her contribution to protecting the health and safety of youth athletes in all sports". Dallas, TX, 2015.

Ohio Public Health Association Media Award, the Center for Injury Research and Policy at Nationwide Children's Hospital received this award in Columbus, OH, 2012. Dr. Comstock's work in the area of pediatric sports-related injuries, specifically sports-related concussions, was has been highlighted by the media for several years. CIRP has released several press releases and fact sheets on Dr. Comstock's work. Columbus, OH, 2012.

Youth Sports Safety Alliance Recognition for Outstanding Service to Youth Athletes, Quote from the award: "As a result of her continued examination of youth sports and injury surveillance, Comstock is considered one of the country's leading experts on the topic, and her studies have had wide-reaching impact and attention across the national landscape. Comstock's dedication to her profession and continued publication of studies make her an invaluable resource to the organizations closely monitoring and adopting new medical protocols that protect today's young athletes." Washington, D.C., 2011.

GroundWork Group Nonprofit Creativity Awards, awards for creative use of information technology in eleven categories. Dr. Comstock's innovative use of RIO™, the internet-based data collection tool created for her by Nationwide Children's RIS, for sports injury surveillance research was nominated in three categories. RIO™ won the award for the Reporting category (the nonprofit that meets reporting requirements and conducts organizational, financial and management, outcome measurement and board reporting with advance tools). Additionally, RIO™ was a semifinalist in the Training & Education (the nonprofit that has enacted a technology training and education plan for staff that includes documentation of skills and matches skills to job requirements) and Technology Maturity (the nonprofit that demonstrates overall technology maturity when looking at all nine of the business functions together) categories. Columbus, OH, 2011.

SAVIR Board Appreciation Award, 2011 Joint Annual Meeting of the Safe States Alliance, SAVIR, & CDC Core I & II State Injury Grantees, Iowa City, IA, 2011.

Award from Nationwide Children's Hospital for mentoring high school students: "in gratitude for your dedication to the Mechanisms of Human Health and Disease Program through the provision of internships that change the lives of future young scientists," Columbus, OH, 2009.

Runner-up Kenneth L. Knight Award for the Outstanding Research Manuscript (Gessel LM, Fields SK, Collins CL, Dick RW, and **Comstock RD**. Concussions Among High School and College Athletes. *Journal of Athletic Training* 42(4);495-503 (2007)). Presented at the National Athletic Trainers' Association 2008 National Meeting, St. Louis, MO, 2008.

Second Annual SHEA Top "10" Papers of the Year. Manuscript selected by Dr. Loreen Herwaldt (Comstock et al. A Large Nosocomial Outbreak of Hepatitis C and Hepatitis B Among Patients Receiving Pain Remediation Treatments. *ICHE* 25(7);576-583 (2004) and recognized at the Society for Healthcare Epidemiology of America (SHEA) Annual Scientific Meeting, Chicago, IL, 2006.

2nd place poster of session 2 award, Second North American Congress of Epidemiology, Seattle, WA, 2006 (Knox CL, Yard EE, and **Comstock RD**. Internet-Based Surveillance of Injuries Sustained by US High School Rugby Players).

2nd place poster of the conference award, 7th World Conference on Injury Prevention and Safety Promotion, Vienna, Austria, 2004 (**Comstock RD**, Mallonee S, and Hasandzekaj A. Does a Community-Wide Change in Protective Actions Occur After a Severe Tornado?).

Professional Associations and Service

Professional Organizations Memberships:

American Public Health Association (APHA)

Society for Epidemiologic Research (SER)

International Society for Child and Adolescent Injury Prevention (ISCAIP)

International Society for Violence and Injury Prevention (ISVIP)

Society for Advancement of Violence and Injury Research (SAVIR)

EIS Alumnae Association

State and Territorial Injury Prevention Directors Association (STIPDA) – name changed to Safe States Alliance in 2010

Sigma Xi: The Scientific Research Society

Editorial Boards:

Editorial Board of the journal *Injury Epidemiology* (2013-present, asked to serve on the first Editorial Board of this new journal).

Editorial Board of the *Journal of Athletic Training* (Jan 2010 – present, currently in 3rd of 3 consequtive terms)

Editorial Board of the *Asian Journal of Exercise & Sport Science* (2011-2013)

Committees/Task Forces/Boards:

Invited Participant – NBA and USA Basketball's Youth Basketball Initiative, Player Health & Wellness Working Group (April 2016-present).

Invited Participant – National Collaborative on Children's Brain Injury (NCCBI) Return to Learn Consensus (April 2016-present).

American Public Health Association, Injury Control and Emergency Health Services Section, Chair (Sept 2015-present).

Department of Defense, USSOCOM Injury Prevention/Performance Optimization Musculoskeletal Research Review Panel, Invited Member (Feb 24-25, 2015. Fort Detrick, Maryland).

American Public Health Association, Injury Control and Emergency Health Services Section, Chair Elect (Sept 2014-Aug 2015).

Member, Safe States Alliance State Technical Assessment Team (STAT) review of the Washington State Injury and Violence Prevention Program and lead for review of the Data and Surveillance core component. (July 14-18, 2014)

Invited Advisor, National Council on Youth Sports Safety, Research and Science Work Group (2014-present)

Invited Board of Advisors Member, Moms TEAM Institute – organization launching national youth sports safety certification program called "Smart Teams" (2014-2016)

Invited Reviewer, IOM Report, *Sports-Related Concussions in Youth: Improving the Science, Changing the Culture"* (Aug, 2013)

American Public Health Association, Injury Control and Emergency Health Services Section, Recreation and Sports Injury Subcommittee (2010-*present*)

USA Cheer Safety Council (2010-2012)

NCAA ISS Independent Review Committee (IRC) (2010-*present*)

Serve as Ex-Officio member, National Federation of State High School Associations (NFHS), Sports Medicine Advisory Committee (SMAC) (Fall 2009-*present*)

Invited Participant – SAVIR nominating committee convened to identify new Board members (Feburary, 2013).

Invited Participant – NIH convened multidisciplinary Sports Medicine mild traumatic brain injury (mTBI) working group for a Common Data Elements Project – tasked with developing common data elements that are relevant to the sports medicine research community and applicable to the Federal Interagency Traumatic Brain Injury Research (FIBIR) database (December, 2011)

Member of an expert panel of injury prevention researchers convened by NIH to provide a white paper to Dr. Guttmacher to provide the rationale on the need for and basic value of more NIH sponsored research in the injury field as well as potential research questions that, if funded, would have "game changing" impact (December, 2011)

Invited Participant – WADA (World Anti-Doping Agency), Prevalence of Doping Working Group Meeting (October 2011-2012)

The Research Institute at Nationwide Children's Hospital, The Clinical and Translational Research Intramural Funding Program, Review Committee (July 2011 – December 2012)

The Research Institute at Nationwide Children's Hospital, Planning Committee for the 2012 Research Retreat (July 2011 – December 2012)

The Research Institute at Nationwide Children's Hospital, Research Information Technology Advisory Council (RITAC) (2011-2012)

Ohio State Univeristy, College of Medicine, Department of Pediatrics, Promotion and Tenure Committee (P&T) (2011-2012)

The Research Institue at Nationwide Children's Hospital, Finance and Sponsored Projects Collaboration Group (2011-2012)

Invited Participant – WADA (World Anti-Doping Agency) Prevalence of Doping Working Group Meeting (January 2011)

Invited Participant – USA Cheer Safety Council, inaugural council meeting (January 2011)

IOM/National Research Council Board on Children, Youth, and Families, Planning Meeting on Concussions and Youth, October (2010)

International Programme Committee member of the Safety 2010 World Conference (2010)

Served on the Research Institute at Nationwide Children's Hospital IMPROVE Committee, a committee tasked with identifying ways to reduce wasted and increase employee efficiency (Summer 2009)

Served on the Conference Committee for the 2009 National Injury & Violence Prevention Research Conference: From Discovery to Practice – Innovative Translational Approaches to Injury Prevention and Care (Fall 2008-Spring 2009)

Served on expert panel on carbon monoxide detector use as part of NIH funded project, "Emergency Department Brief Intervention to Increase Carbon Monoxide Detector Use" (Aug, 2008)

SAVIR Board of Directors (2008-2011)

SAVIR Training and Infrastructure Committee (co-chair Nov 2007-March 2009, member March 2009-present) and Sustainability Committee (Sept 2008-Sept 2009)

Healthy Camp Advisory Committee (2005-2010)

<u>Peer Reviewer:</u>
American Journal of Epidemiology
American Journal of Public Health

American Journal of Sports Medicine
British Journal of Sports Medicine
Clinical Journal of Sport Medicine
Disasters
Homicide Studies
Injury Epidemiology
Injury Prevention
JAMA Pediatrics
Journal of Athletic Training
Journal of Physical Activity and Health
Journal of Sport Rehabilitation
Medicine & Science in Sports & Exercise
Public Health Reports (journal of the U.S. Public Health Service and Office of the Surgeon General)

Reviewer of abstracts:

2016 American Public Health Association Annual Meeting, Denver, CO, October 29- November 2.

2015 American Public Health Association Annual Meeting, Chicago, IL, October 31- November 4.

2013 American Public Health Association Annual Meeting, Boston, MA, November 2-6.

2013 National Meeting of the Safe States Alliance, SAVIR, and the CDC Injury Center, Baltimore, MD, June, 2013.

Safety 2010 World Conference, London, UK, September, 2010

2009 National Injury & Violence Prevention Research Conference, Atlanta, GA, March, 2009.

41st Annual Meeting of the Society for Epidemiologic Research, Chicago, IL, June,2008.

2007 National Injury & Violence Prevention Research Conference, Columbus, OH, October, 2007.

40th Annual Meeting of the Society for Epidemiologic Research, Boston, MA, June, 2007.

The Second North American Congress of Epidemiology, Seattle, WA, June, 2006.

Reviewer of grants:

NIH review meeting for a SBIR Medical Technologies to Reduce Health Disparities special emphasis panel (review of proposals submitted in response to FOA RFA-EB-15-001), Oct, 23, 2015.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), Nov, 2015.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), Nov, 2014.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), May, 2014.

NATA (National Athletic Trainers Association) Research & Education Foundation, April, 2014.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), November, 2013.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), November, 2012.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), November, 2011.

NATA (National Athletic Trainers Association) Research & Education Foundation, October, 2011.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), November, 2010.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), November, 2009.

NATA (National Athletic Trainers Association) Research & Education Foundation, October, 2009.

NATA (National Athletic Trainers Association) Research & Education Foundation, August, 2009.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), December, 2008.

NATA (National Athletic Trainers Association) Research & Education Foundation, April, 2008.

NOCSAE (National Operating Committee on Standards for Athletic Equipment), December, 2006.

CDC NCIPC, Research Grants to Prevent Unintentional Injuries, Atlanta, GA, April, 2006.

CDC NCIPC, National Academic Centers of Excellence for Youth Violence, Atlanta, GA, May, 2005.

Media Consulting:

Multiple media interviews (media log available upon request, includes New York Times, CNN, ABC Evening News, ESPN, People Magazine, Time Magazine, USA Today, NBC Evening News, NPR, the Charlie Rose Show, and other international, national, regional, and local media outlets).

Service to CSPH:

Past President – Faculty Senate, Aug 2016-present.

Member – EPI MS and Epi PhD Admissions Committees, 2016.

President – Faculty Senate, Aug 2015-Aug 2016.

Chair – EPI MPH Admissions Committee, 2015.

Member – search committee for new Associate Dean for Public Health Practice, Spring 2015.

Reviewer – Epi Dept. Hamman-Hoffman scholarships, Fall 2014.

President-Elect – Faculty Senate, Aug 2014-Aug 2015.

Member – Council of Graduate Educators, 2014-present.

Member – Faculty Senate, 2013-July 2014.

Member – DAPTCO, 2013-present.

Member – EPI MPH Admissions Committee, 2014.

Member – EPI PhD Admissions Committee, 2014.

Service to Students/Trainees:

PhD Academic Advisor and research mentor – Dustin Currie, University of Colorado Denver, School of Public Health, Department of Epidemiology, Fall, 2014 - present.

PhD Academic Advisor and research mentor – Lauren Pierpoint, University of Colorado Denver, School of Public Health, Department of Epidemiology, Fall, 2014 - present.

Committee Chair – Danielle Ostendorf, University of Colorado Denver, School of Public Health, Department of Epidemiology, Doctoral Dissertation work, Fall 2015 – present.

Committee Member – Erin Martinez, University of Colorado Denver, School of Public Health, Department of Epidemiology, Doctoral Dissertation work, Spring 2013 - present.

MS Thesis Committee Member – Patrick Carry, Spring 2015-Spring 2016 (degree conferred 2016).

MPH Capstone Advisor – Karen Shimamoto, Spring 2016.

MPH Capstone Advisor – Brandi Vollmer, Spring 2016.

Invited Session Moderator: EIS Regional Conference, Denver, CO, Spring 2016.

MS in Clinical Science (through CCTSI) Committee Chair – Joe Grubenhoff, Spring 2015-Fall 2015 (degree conferred 2015).

MPH Practicum Advisor – Brandi Vollmer, Fall 2015.

MPH Capstone Advisor – Melanie Ewald, Spring 2015.

Doctoral Program Advisor and Dissertation Committee Member – Christy Collins, Ohio State University, College of Public Health, Division of Epidemiology – Fall 2011 – Spring 2015 (degree conferred 2015).

Doctoral Thesis External Examiner – Christina Louise Ekegren, Monash University, Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Fall 2014.

MPH Practicum Advisor – Melanie Ewald, Fall 2014.

MPH Capstone Advisor – Veronica Fialkowski, Spring 2014.

MPH Practicum Advisor – Veronica Broslawik, Spring 2013.

Judge – Ohio State Science Day, Ohio Public Health Association sponsored award for 9th through 12th graders, The Future of Public Health Award, Spring 2012.

Committee Member – Joe Rosenthal, Ohio State University, College of Medicine and College of Public Health, MD/MPH student, Division of Epidemiology, Clinical MPH practicum project, Fall, 2012.

Committee Member – David Swenson, Ohio State University, College of Medicine and College of Public Health, MD/MPH student, Division of Epidemiology, Clinical MPH practicum project, Spring, 2012.

Reader – David Swenson, Ohio State University, College of Medicine and College of Public Health, MD/MPH student, Division of Epidemiology, MPH practicum project proposal, Winter, 2012.

Graduate Faculty Representative – Ivan Hovermale, Ohio State University, Linguistics, Doctoral defense, Fall 2011

Faculy Representative – 1st Generation Luncheon, OSU Parent Weekend, Fall 2011.

Committee Member – Jennifer Klima, Ohio State University, College of Public Health, Division of Epidemiology, Doctoral defense, Fall 2011.

Reader/Examiner – Douglas King, Auckland University of Technology, School of Sport and Recreation, Doctoral Thesis, Spring 2010

Reader – Zachary Kerr, Ohio State University, College of Public Health, Division of Epidemiology, MPH culminating project, Winter 2010

Reviewer – Applications for Nationwide Children's Hospital Mechanisms of Human Health and Disease program for high school students who excel in science and math, Spring 2009

Reviewer – Ohio State University College of Medicine Samuel J. Roessler Memorial Medical Scholarship Applications, Spring 2009

Reader – Jeff Deits, Ohio State University, College of Education and Human Ecology, School of Physical Activity and Educational Services, MA thesis, Winter 2009.

Graduate Faculty Representative – F.J. Duncan, Ohio State University, Integrated Biomedical Sciences Graduate Program, Doctoral defense, Winter 2009

Committee Member – Ellen Yard, Ohio State University, College of Public Health, Division of Epidemiology, Doctoral defense, Winter 2009

Grader – Ellen Yard, Ohio State University, College of Public Health, Division of Epidemiology, Doctoral candidacy exam, Spring 2008

Reader – Michael Jaung, Ohio State University undergraduate senior honors thesis, Spring 2008

Reader – Matt Schroeder, Ohio State University, College of Public Health, Division of Epidemiology, MPH culminating project, Spring 2008

Judge – 7th Annual OSUMC Research Day, Ohio State University, College of Medicine, Spring 2008

Reviewer – Applications for Nationwide Children's Hospital Mechanisms of Human Health and Disease program for high school students who excel in science and math, Spring 2008

Grader – Ohio State University, College of Public Health, Division of Epidemiology Doctoral Qualifying Exam, Winter 2008

Reader – Laurel Borowski, Ohio State University, College of Public Health, Division of Epidemiology, MPH culminating project, Fall 2008

Reader – Ellen Yard, Ohio State University, College of Public Health, Division of Epidemiology, MPH culminating project, Spring 2005

Students' Awards

2015 **Dustin Currie**, Colorado School of Public Health, University of Colorado Anschutz, Department of Epidemiology PhD student, was the runner up for the 2015 Student Paper Award from the American Public Health Association, Injury Control and Emergency Health Services (ICEHS) section for his study of the epidemiology of high school cheerleading injuries, receiving a monetary award to cover conference registration fees.

2015 **Dustin Currie**, Colorado School of Public Health, University of Colorado Anschutz, Department of Epidemiology PhD student, was selected as a winner of the 2015 Injury and Violence Student Paper Prize awarded by the Program for Injury Prevention, Education and Research (PIPER), receiving a $250 prize for his study of the epidemiology of high school cheerleading injuries.

2015 **Lauren Pierpoint**, Colorado School of Public Health, University of Colorado Anschutz, Department of Epidemiology PhD student, had her oral presentation on the epidemiology of severe injuries among US high school athletes nominated as a finalist for the American Public Health Association, Injury Control and Emergency Health Services (ICEHS) 2015 Student Oral Presentation Award.

2014 **Zachary Y.Kerr**, University of North Carolina, Chapel Hill, PhD student, had his abstract, "Descriptive Epidemiology of Injury in US Women's High School and NCAA Soccer: 2004/05-2012/13"selected as a Doctoral Poster Award Finalist at the 2014 NATA Clinical Symposia & AT Expo in Indianapolis, IN.

2012 **David Swenson**, Ohio State University, College of Medicine and College of Public Health, Clinical MPH student, received a Medical Alumni Society Student Grant of $225 in support of his American College of Sports Medicine Poster Presentation project. His award notice stated, "Congratulations on your funding and please know our Board of Governors was extremely impressed with your application."

2012 **Zack Kerr**, PhD student, University of North Carolina, College of Public Health, Department of Epidemiology, Chapel Hill, NC, received an $800 EIS Alumni Association (EISAA) Scholarship to attend and participate in the 2012 Annual Epidemic Intelligence Service Conference.

2012 **Andrew Stacey**, Riverside Methodist Hospital, Columbus, OH, Medical Resident received a Trainee Travel Grant to present a poster at the 2012 Association of Research in Vision and Ophthalmology (ARVO) Conference.

2011 **David Swenson**, Ohio State University, College of Medicine and College of Public Health student received an NIH training grant (TL1 award) to complete an independent research project on fractures and knee and ankle joint injuries among US high school athletes as part of a clinical MPH program.

2010 **Mallika Marrar**, Columbus Academy High School student won a $2,000 scholarship as one of 60 Regional finalists in the 2010 Young Epidemiology Scholars Competition.

2009 **Julie Rechel**, University of Richmand student received an undergraduate research scholarship to conduct an epidemiologic study of injuries requiring surgical repair among US high school athletes.

2009 **Ellen Yard**, Ohio State University, College of Public Health student, selected as a member of the CDC EIS (Epidemic Intelligence Service) class of 2009, Atlanta, GA.

2009 **Allan Joseph**, St. Charles Preparatory School high school student, won a $35,000 scholarship as second place winner in the 2009 Young Epidemiology Scholars Competition.

2009 **David Swenson**, Ohio State University, College of Medicine student, was awarded $1,500 with the Dr. Robert L. Barnes Fellowship of Medicine Scholarship for the 2008-09 school year based on "Excellence in Scientific Presentation of Biomedical Research at the OSUMC Research Day."

2008 **Anthony D'Ippolito,** Grove City High School student won a $2,000 scholarship as one of 60 Regional finalists in the 2008 Young Epidemiology Scholars Competition.

2008 **Ellen Yard**, Ohio State University, College of Public Health student, selected as a recipient of an $800 EISAA (Epidemic Intelligence Service Alumni Association) Scholarship to attend and participate in the Annual Epidemic Intelligence Service Conference, April 14-18, 2008, Atlanta, GA.

2008 **Luke Gessel**, Ohio State University, College of Medicine student, first author of manuscript which was selected as the first runner-up of the 2007 *Journal of Athletic Training* Kenneth L. Knight Award for the Outstanding Research Manuscript.

2007 **Julie Rechel**, Thomas Worthington High School student, won a $35,000 scholarship as second place winner in the 2007 Young Epidemiology Scholars Competition.

2007 **Ellen Yard**, Ohio State University, College of Public Health student, won an $800 award for the Injury Control and Emergency Health Services (ICEHS) Section of the American Public Health Association (APHA) 2007 Best paper Award for the Student Paper Competition.

2007 **Ellen Yard**, Ohio State University, College of Public Health student, won a $1,000 award for the Health Policy Institute of Ohio, 2007 Ohio Awards, Health Policy Student Research Award.

2007 **Alex Nelson**, Ohio State University, College of Medicine student, won a $600 Scientific Travel Award from the 2007 Ohio State University College of Medicine Student Research Day Poster Competition.

EXHIBIT “2”

Aubry M, Cantu R, Dvorak J, Graf-Baumann T, Johnson K, Kelly J, Lovell M, McCrory P, Meeuwisse W, and Schamasch P. Summary and agreement statement of the first International Conference on Concussion in Sport, Vienna 2001. *Clin J Sport Med*. 2002; 12(1):6-11.

Bailes JE and Cantu RC. Head injury in Athletes. *Neurosurgery*. 2001; 48(1):26-45.

Baillargeon A, Lassonde M, Leclerc S, and Ellemberg D. Neuropsychological and neurophysiological assessment of sport concussion in children, adolescents and adults. *Brain Inj*. 2012; 26(3):211-220.

Benson BW, Meeuwisse WH, Rizos J, Kang J, and Burke CJ. A prospective study of concussions among National Hockey League players during regular season games: the NHL-NHLPA Concussion Program. *CMAJ*. 2011; 183(8):905-911.

Bethune A, da Costa L, van Niftrik CH, and Feinstein A. Suicidal ideation after mild traumatic brain injury: A consecutive Canadian sample. *Arch Suicide Res*. 2016; [Epub ahead of print].

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