

ANNUAL SURVEY OF CATASTROPHIC FOOTBALL INJURIES

1977 - 2019

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INTRODUCTION

In 1977, the National Collegiate Athletic Association initiated funding for the First Annual Survey of Catastrophic Football Injuries. Frederick O. Mueller, Ph.D., and Carl S. Blyth, Ph.D., both professors in the Department of Exercise and Sport Science at the University of North Carolina at Chapel Hill were selected to conduct the research. The Annual Survey of Catastrophic Football Injuries was part of a concerted effort put forth by many individuals and research organizations to reduce the steady increase of football head and neck injuries taking place during the 1960's and 1970's. The primary purpose of the research was and is to make the game of football a safer sport.

An early investigation into serious head and neck football injuries conducted by Schneider et al. reported 30 permanent cervical spinal cord injuries in high school and college football during the period from 1959 to 1963 (Schneider 1973). A later study by Torg et al. reported a total of 99 permanent cervical spinal cord injuries occurring in high school and college football from 1971 to 1975 (Torg, Truex et al. 1979). A study published in 1976 reported the incidence of neck injuries based on roentgenographic evidence was as high as 32% in a sample of 104 high school students and 75 college freshmen in Iowa (Albright, Moses et al. 1976). In order to help alleviate this problem the National Collegiate Athletic Association (NCAA) and the National Federation of State High School Associations (AFCA) implemented rule changes in 1976 to prohibit using the head as the initial contact point when blocking and tackling. Furthermore, the American Football Coaches Association (AFCA) Ethics Committee went on record opposing this type of blocking and tackling. A reduction of these events occurred following these rule changes. Torg has since discontinued his research, however his

work demonstrated a decline in permanent cervical cord injuries in high school and college from 34 cases in 1976 to 5 cases in 1984 (Torg, Vegso et al. 1985).

Recent Rule Changes and Safety Recommendations

Both the NCAA and the NFHS have further defined illegal helmet contact and have established return to play rules if a concussion is suspected. The NFHS 2013 Football Rules Book (page 31 Rule 2-20-1) defined illegal helmet contact as “an act of initiating contact with the helmet against an opponent” (Gardner and Colgate 2013). The rule book further defines the three types of illegal helmet contact:

- a) Butt blocking is an act by an offensive or defensive player who initiates contact against an opponent who is not a runner with the front of his helmet.
- b) Face tackling is an act by a defensive player who initiates contact with a runner with the front of his helmet.
- c) Spearing is an act by an offensive or defensive player who initiates contact against any opponent with the top of his helmet. (NFHS 2013 Football Rules Book, page 31, Rule 2-20-1)

All three of these illegal techniques can cause catastrophic head and neck injuries to the athlete. In 2014, NFHS rules committee added a definition of targeting (page 31, rule 2-20-2) as “an act of taking aim and initiating contact to an opponent above the shoulders with the helmet, forearm, hand, fist, elbow, or shoulder” and made it a separate personal foul (page 71, rule 9-4-3m) (Gardner and Colgate 2014). They also added a definition of a defenseless player to reduce the risk of injury: “A defenseless player is a player who, because of his physical position and focus of concentration, is especially vulnerable to injury.” In 2015, NFHS rules committee

changed the spearing rule: “Spearing is an act by any player who initiates contact against an opponent at the shoulders or below with the crown (top portion) of his/her helmet” (Gardner and Colgate 2015). In 2017 a definition of the blindside block was created: “Unless initiated with open hands, it is a foul for excessive and unnecessary contact when the block is forceful and outside of the free-blocking zone” (Gardner and Colgate 2017).

The concussion rule (3-5-10b) was revised in 2013 as follows: “any player who exhibits signs, symptoms, or behavior consistent with a concussion (such as loss of consciousness, headache, dizziness, confusion or balance problems) shall be immediately removed from the game and shall not return to play until cleared by an appropriate health-care professional.” This time-out, if not charged, is an official’s time-out. Appendix B, page 95, guidelines are provided for management of concussion injuries.

The Second Safety in College Football Summit held by the NCAA in 2016 resulted in an interassociation consensus document that addressed athlete safety and head impact exposure in football. This summit focused on both concussion prevention and catastrophic injury prevention. Consensus outcomes included, but not limited to:

- Head accelerometers are currently unable to function as concussion detectors.
- Tackling and blocking should be performed with technique emphasizing hands and shoulder contact and elimination of head contact.
- Preseason, Inseason, and Postseason practice guidelines.
- Definitions for football contact and equipment.
- A set of six best practice recommendations were published in 2019 (NCAA 2019) that cover:

1. Sportsmanship

2. Protective Equipment
3. Acclimatization and Conditioning
4. Emergency Action Plan
5. Responsibilities of Athletics Personnel
6. Education and Training

This 2016 interassociation consensus document (NCAA 2016) outlined the following definitions, with the intent of providing a framework on varying intensity levels from non-contact/minimal contact practices to live contact/tackling to the ground practices. This framework is consistent with USA Football as follows (italicized content is from USA Football):

Non-contact/minimal contact practices do not involve tackling, thud, “wrapping up” or full-speed blocking. Non-contact/minimal contact practices are those practices in which drills are not run at a competitive speed, as follows:

- **Air.** *Players run a drill unopposed without contact.*
- **Bags.** *Drill is run against a bag or other soft-contact surface.*
- **Control.** *Drill is run at an assigned speed until the moment of contact.*

One player is designated by the coach ahead of time as the pre-determined winner. Contact remains above the waist and players stay on their feet.

Live contact/thud is any practice in which players are not taken to the ground, including “thud” sessions or drills that involve “wrapping up,” irrespective of uniform worn. *Drill is run at competitive speed through the moment of contact with no predetermined winner. Contact remains above the waist, players stay on their feet and a quick whistle ends the drill.*

Live contact/tackling is any practice that involves tackling to the ground. *Drill is run in game like conditions and is the only time that players are taken to the ground.*

This research has been conducted as part of the National Center for Catastrophic sports Injury Research (NCCSIR), University of North Carolina at Chapel Hill. The NCCSIR was directed by Dr. Frederick Mueller from 1980 to 2013. Dr. Mueller retired Spring of 2013 and the NCCSIR is now directed by Dr. Kristen Kucera. The NCCSIR has expanded to become a consortium (University of North Carolina, Boston University, University of Washington, University of Connecticut, University of Colorado, the University of Maryland, and the Datalys Center) with expertise in head/neck, cardiac, and heat-related sports medicine (these three areas account for the overwhelming majority of catastrophic events). The NCCSIR is supported by the American Football Coaches Association (AFCA), the National Collegiate Athletic Association (NCAA), the National Federation of State High School Associations (NFHS), the National Athletic Trainers' Association (NATA), the American Medical Society for Sports Medicine (AMSSM), the National Operating Committee on Standards for Athletic Equipment (NOCSAE), and The University of North Carolina at Chapel Hill (UNC-CH).

METHODS

Data Collection

Data were compiled with the assistance of coaches, athletic trainers, athletic directors, executive officers of state and national athletic organizations, online news reports, online reports, and professional associates of the researchers. In January of 2015, NCCSIR and the Consortium

for Catastrophic Injury Monitoring in Sport developed an online portal where anyone can report a catastrophic event ([www.https://sportinjuryreport.org](https://sportinjuryreport.org)). Throughout the year (January 1 to December 31), upon notification of a suspected catastrophic football injury, contact by telephone, email, or personal letter questionnaire was made with the appropriate individuals including state high school association official, school or team administrator, coach, athletic trainer, team physician, and/or the family. Individuals are asked to complete a brief survey about the event at online portal ([www.https://sportinjuryreport.org](https://sportinjuryreport.org)). All activities were and currently are approved by the Institutional Review Board (IRB) of the University of North Carolina at Chapel Hill (IRB# 05-0018).

Outcome Definitions

Catastrophic injuries were originally defined as football injuries which resulted in brain or spinal cord injury or skull or spine fracture (Mueller and Arnold 1978). Injuries, which result in death, are not included in this report. It should be noted that brain and spine injuries involved some disability at the time of the injury. Neurological recovery was defined as either complete or incomplete (e.g. quadriplegia or paraplegia). Yearly follow-up was not done, thus neurological status (complete or incomplete recovery) refers to when the athlete was entered into the database. Cases with unknown or uncertain disability status at the time of the capture were updated with information available regarding recovery for this report. Other non-fatal catastrophic injuries such as internal organ injuries, commotio cordis, etc. are also noted in this report (Table VII).

Participation in Football

Reports prior to 2012 showed 1,800,000 participants in all levels of football (Mueller & Colgate 2011). Participation numbers gathered by the National Operating Committee for Standards in Athletic Equipment (NOCSAE), NFHS, and USA Football show the following: NFHS has estimated that there are approximately 1,100,000 high school player's grades 9-12. Research also indicates there are 100,000 post high school players including the National Football League (NFL), NCAA, National Association of Intercollegiate Athletics (NAIA), National Junior College Athletic Association (NJCAA), Arena Football, and Semi-professional football. USA Football estimates there are 3,000,000 youth football players in the United States. Organized Youth is defined as non-school, youth football, but organized and using full protective equipment (e.g., Pop Warner, American Football League). These figures give an estimate of 4,200,000 total football participants in the United States each year (Mueller & Colgate 2012). Note these denominators are consistent with those used by NCCSIR's Annual Football Fatality Reports (<https://nccsir.unc.edu/reports/>).

NCCSIR staff and Consortium compiled the data and the report authors prepared this report. Medical data for the report were reviewed by Dr. Robert C. Cantu, MD – medical director of NCCSIR.

Analysis

Yearly frequencies and incidence rates of catastrophic injuries per 100,000 participants were calculated based on participation estimates as described in the **Participation in Football** section above and stratified by level (organized youth, pro/semi-pro, middle school & high school, and college). **Note: Rates with number of incidents less than 5 should be interpreted with caution.**

It is important to note that information is continually being updated due to the fact that catastrophic injury information may not always reach the NCCSIR in time to be included in the current report. The report includes data that is captured by publicly available media sources and directly reported to the NCCSIR by the NCAA, the NFHS, online reports, colleagues, coaches, and athletic trainers. There may be additional catastrophic football injuries that are not reported to the NCCSIR. The authors acknowledge that not every catastrophic injury is included in this report.

RESULTS

Catastrophic Cervical (Neck) Injuries with Incomplete Recovery

During 2019 there were a total of 4 cervical spine injuries with incomplete neurological recovery and 4 with complete recovery. During the six year period from 2014-2019 there were 42 cervical spine injuries with incomplete neurological recovery (3, 10, 4, 10, 11, and 4, respectively, Table I). 32 of the injuries occurred at the middle and high school level, 8 at the college level, 1 at the organized youth level, and 1 at the professional or semi-professional level. The average number of cervical spine injuries with incomplete neurological recovery has decreased since the late 1970's from 11.0 in 1977-1979 to 7.8 in 2015-2019 (Table I and Figure I).

For the approximately 4,200,000 participants per year, the rate of cervical spine injuries with incomplete neurological recovery during 2014 to 2019 was 1.00 per 100,000 participants (95% CI: 0.70 to 1.30). Annual rates for high school ranged from 0.10 per 100,000 in 2019 to 0.73 per 100,000 in 2017 and 2018 (Table II). The rate at the college level ranged from 0 per 100,000 in 2016 to 4.00 per 100,000 in 2015.

Since 1977, 49.2% of players with cervical spine/cord injuries with incomplete recovery were on the defensive side of the ball and 18.4% were on the offensive side, 10.6% were playing special teams, and 21.8% the position was unknown (Table III). The pattern over this time period has not substantially changed (Figure 2a). However, there were fewer special teams injuries and more offensive side injuries in the most recent 5-year period 2015-2019 compared to the previous 5-year period. During the six-year period from 2014-2019, defensive backs continue to be the most frequent position associated with cervical cord injuries with incomplete recovery (26.2%) followed by linebackers (14.3%), and tight end/wide receiver (9.5%) (Table

IIIb). The overwhelming majority occur during competition (78.6%) followed by practice (14.3%), scrimmage (7.1%). Tackling (47.6%) or being tackled (14.3%) remain the most frequent activity at the time of the injury. Most of the events were cervical spine fractures (54.8%) followed by cervical cord/nerve injuries (14.3%), cervical cord contusions (9.5%), or not specified (19.0%).

Catastrophic Brain Injuries with Incomplete Recovery

During 2019 there were 6 catastrophic brain injuries with incomplete neurological recovery and 1 with complete recovery. During the six-year period from 2014-2019 there were 42 brain injuries which resulted in incomplete recovery (5, 8, 9, 8, 6, and 6 respectively, Table IV). 32 of the injuries occurred at the middle and high school level, 8 at the college level, 1 at the organized youth level, and 1 at the professional or semi-professional level. The five-year average number of brain injuries with incomplete neurological recovery has doubled since 1985-1989 from 3.8 to 7.4 in 2015-2019 (Table IV and Figure I).

For the approximately 4,200,000 participants per year, the rate of brain injuries with incomplete neurological recovery during 2014 to 2019 was 1.00 per 100,000 participants (95% CI: 0.70 to 1.30). Annual rates for high school ranged from 0.14 per 100,000 in 2019 to 0.82 per 100,000 in 2016 (Table V). There was only 1 collegiate event during the 6-year period for a rate of 1.33 per 100,000 in 2018.

Since 1984, most players with catastrophic brain injuries with incomplete recovery were on the defensive side of the ball (34.2%), and 25.1% were on the offensive side, 7.8% were playing special teams, and 32.4% were unknown (Table VI). The pattern over the past 10 years has not changed substantially; there were fewer offensive side and more special teams injuries

during the most recent 5-year period 2015-2019 compared to the previous 5-year period (Figure 2b). Linebacker continues to be the most frequent position associated with brain injuries with incomplete recovery (16.9%) followed by defensive backs (12.1%), and running backs (12.1%) (Table VIb). The overwhelming majority during 2014-2019 occurred during competition (95.2%) followed by practice (4.8%). Tackling (19.0%) or being tackled (11.9%) remain the most frequent activity at the time of the injury. However, for half (53.2%) the activity was not known: general play 33.3% or unknown 14.3%. Unlike cervical spine/cord injuries where the activity is often known, activities associated with catastrophic brain/head injuries are difficult to classify as athlete's often collapse on the sideline or away from the ball in play. Most of the events were subdural and/or epidural hematomas (23.8%) followed by brain hemorrhage (16.7%), second impact syndrome (2.4%), aneurism (2.4%) or not specified (50.0%).

Characteristics of All Catastrophic Traumatic Injuries 2014-2019

During the six-year period 2014-2019, there were a total of 166 nonfatal catastrophic football-related injuries captured by NCCSIR – an average of 28 injuries per year over the 6-year period. Yearly totals were as follows: 17 in 2014, 45 in 2015, 24 in 2016, 33 in 2017, 28 in 2018, and 19 in 2019. Most injuries (56.3%, n=90) had incomplete recovery while 43.8% (n=70) had complete recovery (Table VII). The majority of injuries were cervical spine/cord (52.4%, n=87) followed by head/brain (30.7%, n=51) and other (16.9%, n=28). Other injuries included: internal organ (n=9), thoracic/lumbar spine/cord (n=6), lung (n=3), lower leg amputation (n=3), and eye injury with vision loss (n=1).

The majority over the 6-year period were among middle school and high school athletes (77%); this pattern held across each of the 2-year periods (Table VII). However, a greater

number of collegiate events occurred during 2014-2015 (22.6%) compared to 2016-2017 (10.5%) and 2018-2019 (12.8%). Events occurred during competitions and tackling and being tackled remained the most frequent activity associated with catastrophic injury during this period.

DISCUSSION

For the past 43 years there have been a total of 376 football players with incomplete neurological recovery from cervical spine/cord injuries. The majority of these injuries have been to high school (80.1%) and collegiate (13.0%) players. These data indicate a reduction in the number of cervical cord injuries with incomplete neurological recovery when compared to data published in the early 1970's: 5-year average of 19.8 from 1971-1975 (Torg, Truex et al. 1979) versus 7.8 from 2015-2019. However, the most recent years 2017-2018 indicate 10 and 11 injuries per year with incomplete neurological recovery and continued surveillance of these injuries is critical for monitoring and prevention.

Since 1984, there have been 219 brain injuries with incomplete recovery. If the cervical cord injuries and the brain injuries with incomplete recovery are combined, the number of incomplete recovery cervical and brain injuries from 1984 to 2019 was 520—an average of 14.1 injuries per year with incomplete recovery over the past 36 years. Coaches, players, athletic trainers, physicians and administrators must continue efforts to prevent spinal cord and brain disability injuries among football players at all levels of play.

From 2014-2019, there 39 brain injuries with incomplete neurological recovery at the middle and high school level—an average of 6.5 per year. While the number of football-related catastrophic brain deaths decreased from 1969 to 2008, non-fatal catastrophic brain injuries with incomplete recovery has increased (Figure IIIb – note non-fatal brain injury data collection not started until 1984). This decrease in the number of fatalities along with increase in non-fatalities may be reflective of improvements in equipment, medical care, rule changes and coaching techniques which may result in a less severe outcome. The increase in non-fatal may also be reflective of increased attention and reporting in the football and sports medicine communities.

However, the most recent decade from 2010-2019 indicated an increase in the number of fatal brain injuries (29 versus 34) and a decrease in nonfatal brain injuries with incomplete recovery (129 versus 99) compared to 2000-2009. We observed similar patterns in cervical spine fatalities and non-fatalities with incomplete recovery (Figure IIIa).

As indicated in past reports, a majority of the cervical spine/cord injuries with incomplete recovery are taking place in games. Table III indicates that when comparing cervical cord injuries between offensive and defensive players, it is safer playing offensive football.

Defensive backs continue to be injured at a higher rate than other positions and a majority of the defensive players were tackling when injured. During this time period over half of the cervical spine/cord injuries with incomplete recovery were related to tackling. Despite efforts to teach players to tackle with the head up and new rules and penalties for targeting, this report indicates that players still lower their heads before making contact—a frequent mechanism of catastrophic brain and cervical spine/cord injuries. This report indicates that in 2017 three players, in 2018 one player, and in 2019 two players suffered cervical cord/spine or brain injuries with incomplete recovery due to head-first/down contact. Head-first/head down contact was identified as contributing to eight of the 28 deaths (29%) captured in high school and college football from 2005-2014 (Kucera et al. 2017). This emphasizes the importance of instruction in proper tackling techniques (both delivery and receipt of tackles) for all players, but particularly for running backs, linebackers, and defensive backs. Football is a collision sport played at high velocity, and players must act and react quickly. In such situations, new techniques might be difficult to deploy, resulting in players possibly reverting to past behaviors and reactions unless coaches routinely intervene to correct their technique (Kucera et al. 2017). These findings

illustrate the importance of keeping the head up when tackling as well as when blocking and ball carrying.

Educational programs that focus on safer tackling techniques are available (e.g., USA Football's Heads Up Football (<http://usafootball.com/headsup>); University of New Hampshire's Helmetless Tackling Training, or HUTT™ Technique (<http://www.unh.edu/unhtoday/2014/11/keeping-their-heads-out-game>)). Recently national and state high school associations have recommended limiting both the frequency and duration of full contact in football practices (NFHS 2014). As of 2016 a total of 44 state high school associations had enacted policies to limit some full-contact football practices (Concussion Legacy Foundation, 2016). In February 2019, New Jersey set more conservative limits decreasing full contact during practices from 90 minutes to 15 minutes per week and a total of 6 hours of full contact practice during the 3 week preseason (Bogage 2019).

In 2016, the kickoff line was moved from the 35-yd to the 40-yd line and the touchback line was moved from the 25-yd to the 20-yd line. The intention was to have more kickoffs land in the end zone and thereby reduce the likelihood the receiving player will advance the ball, thus increasing touchbacks. The kickoff rule change in Ivy League football was associated with a reduction in concussions: 7.51 fewer concussions occurred for every 1000 kickoff plays after versus before the rule change (Wiebe et al. 2018).

STRENGTHS AND LIMITATIONS

The following strengths and limitations should be noted. Annual totals are continually updated as cases are found and/or reported, therefore the numbers in this report may not match those in past reports. All events have been reviewed for inclusion in this report. Research based

on reliable data is essential if progress is to be made. Surveillance of non-fatal catastrophic injuries on a national scale is challenging. Given the heavy reliance on media reports to identify cases, we recognize that these numbers represent an underestimate of the true number of these events, particularly for the events with incomplete or full recovery. These numbers likely represent the “tip of the iceberg” and the true number of non-fatal catastrophic injuries, both incomplete and full recovery injuries, is not known. In January of 2015 **NCCSIR and the Consortium developed a national centralized reporting site where anyone can report a catastrophic injury or illness event: <https://www.sportinjuryreport.org/>**. This site is the result of a collaborative effort between NCCSIR and the Consortium and is a major step towards improving the capture of the catastrophic sport injury and illness events and increasing our understanding about how they can be prevented.

Given these limitations, the NCCSIR has been collecting catastrophic football injury data at the University of North Carolina at Chapel Hill for fatalities since 1966 and for nonfatal disabling and serious injuries since 1977. Data collection efforts revealed a reduction of football fatalities from 35 in 1968 to zero in 1990 and a reduction of cervical cord injuries from 30 per year in the late 1960s to less than 15 per year since 1991. Football catastrophic injuries may never be totally eliminated, but ongoing surveillance and research efforts has resulted in rule changes, equipment standards, improved medical care both on and off the playing field, and changes in teaching the fundamental techniques of the game. These changes were the result of a united effort by coaches, administrators, researchers, equipment manufacturers, physicians, athletic trainers and players. NCCSIR will continue to collect this data and to make safety recommendations to the NFHS, the NCAA, and youth football programs.

RECOMMENDATIONS

Specific recommendations resulting from the current report are as follows:

1. **Preseason physical exams:** Mandatory medical examinations and medical history should be passed before allowing an athlete to participate in football. The NCAA requires a thorough medical examination when the athlete first enters the college athletic program and an annual health history update with use of referral exams when warranted. If the physician or coach has any questions about the athlete's readiness to participate, the athlete should not be allowed to play. High school coaches should follow the recommendations set by their State High School Association. Most state associations require the use of their own medical examination form.
2. **Conditioning:** All personnel involved with training football athletes should emphasize proper, gradual, and sport-specific physical conditioning. Athletes must be given proper conditioning exercises that will strengthen bodies to withstand the workloads and energy expenditure throughout the game given their positions and time played. Strengthening their necks in order to hold their heads in proper position when tackling and to absorb impact energy to control head movement is important. Players should also have appropriate flexibility and range of motion of the shoulder and neck complex. These preparatory activities can provide the athlete with the ability sustain good tackling and athletic skills throughout the game situations.
3. **Skills:** Coaches should teach and drill the athletes in the proper execution of the fundamental skills, particularly blocking and tackling. Players should keep their head up while tackling and running with the ball. Contact should never be initiated with the top or crown of the head/helmet. Initial contact should never be made with the head/helmet or

face mask. Research is needed to analyze the mechanisms of impacts during competitions and practices that lead to fatal and catastrophic events.

4. **Rules:** Rules are in place to protect defenseless players, the tackler initiating contact, and the ball carrier. Coaches and game officials should discourage the players from using their helmets in initiating contact when blocking and tackling. The rules prohibiting spearing and targeting should be enforced in practice and in games. The players should be taught and held accountable through the rules of play, film sessions, and on the practice field to respect the helmet as a protective device and that the helmet should not be used to initiate contact or as a weapon.
5. **Equipment:** All coaches, equipment managers, athletic trainers, and physicians should take special care to see that players equipment is properly fitted, particularly the helmet. Players should be educated about the use and care of the helmet and other protective equipment and adhere to proper fit guidelines and proper use as outlined by the manufacturer.
6. **Medical care and emergency preparedness:** Emergency measures must be in place for all games and practice sessions. Whenever possible certified athletic trainers should be present for all football practices and games. Physicians should be onsite or accessible for all practices and onsite for all games. Have a written emergency action plan and ensure all personnel have copies and have reviewed the plan. The CDC has guidelines and templates for these plans (<http://www.cdc.gov/niosh/docs/2004-101/emrgact/emrgact1.html>). NCAA and the NFHS have guidelines for these plans at the following websites: www.nfhs.org and www.ncaa.org.

7. **Brain Injury and Concussion:** A brain injury, including concussions, can be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head. This sudden impact or movement of the brain can cause stretching and tearing of brain cells, damaging the cells and create chemical changes in the brain.
- a. Signs & Symptoms: When a player has experienced or shown signs and symptoms of head trauma (such as a change in the athlete’s behavior, thinking, or physical functioning), they should receive immediate medical attention from an appropriate medical provider and should not be allowed to return to practice or game without an evaluation by an appropriate medical provider and permission from a physician if diagnosed with a brain injury.
 - b. Reporting & Care: Some cases associated with brain trauma reported that players complained of symptoms or had a previous concussion prior to their catastrophic injury. The team physician, athletic trainer, or coach should ensure players understand signs and symptoms of concussion and brain trauma. Players should also be encouraged to inform the team physician, athletic trainer, or coach if they are experiencing any of the signs or symptoms of brain trauma outlined by the CDC. Heads Up on Concussion in Sports: *Information for Parents, Coaches, and School & Sports Professionals*. Available at:
<http://www.cdc.gov/headsup/index.html>
 - c. Management & Return to Play: Medical staff must have the unchallengeable authority to assess and make medical decisions for head injuries. Coaches should never make the decision whether a player has a concussion or return the player

back to a game or active participation in a practice if that player is experiencing signs or symptoms of brain trauma. In rare cases, an athlete who has not recovered from a concussion and returned to play and receives another severe hit can experience second impact syndrome.

- d. Policies: All athletes and athletic personnel should follow the state, NFHS, NCAA, or NFL policies related to concussion prevention, identification, management, and return to play depending on their level of play. See the following CDC resource for a list of states with concussion policies: Get a Heads Up on Concussion in Sports Policies: *Information for Parents, Coaches, and School & Sports Professionals*. Available at:

<http://www.cdc.gov/headsup/policy/index.html>

For the most up to date information on concussion management please refer to the updated Consensus Statement on Concussion in Sport: the 5th International Conference on Concussion in Sport held in Berlin, October of 2016 (McCrory et al. 2017 available at: <http://bjsm.bmj.com/content/51/11>).

Over the last decade, sport governing bodies have adopted new or modified playing rules for football to protect defenseless players, remove targeting from the game, eliminate dangerous play, stoppage of play for injured players to ensure medical care can be accessed for injuries, and limits on full contact during preseason and inseason practices. In addition, these same governing bodies have published best practices for prevention, recognition, management and return to

play for athletes with suspected concussion, spine and brain injuries. Member institutions of these organizations should implement these best practices.

NFHS rules changes affecting risk, (1982-2019). Available at:

<https://www.nfhs.org/media/1020416/1982-2019-nfhs-risk-minimization-rules-8-28-19.pdf>

NCAA rules for football and all sports are available at:

<http://www.ncaa.org/championships/playing-rules>

NCAA Football Practice Guidelines: Year-Round Football Practice Contact Guidelines (<http://www.ncaa.org/health-and-safety/football-practice-guidelines>).

The Safety in College Football Summit. Inter-association consensus guidelines for three paramount safety issues in collegiate athletics:

1. Independent medical care in the collegiate setting
2. Concussion diagnosis and management
3. Football practice contact.

NFL timeline of rule changes related to health and safety. Available at:

<http://static.nfl.com/static/content/public/photo/2015/11/12/0ap3000000578872.pdf>

8. **Cervical Cord and Spine Injuries:** Early recognition, prompt medical evaluation and management of cervical cord and spine injuries is critical for preventing permanent disability and death. Certified athletic trainers are trained to recognize and manage these

injuries and whenever possible should be present for all football practices and games. For the most up to date information on management and prevention of these injuries see the following websites:

National Athletic Trainers Association (NATA): <https://www.nata.org/practice-patient-care/health-issues/spine-injury>

The Spine Injury in Sport Group is comprised of 25 medical bodies and sport organizations and published best practice guidelines for prehospital care and management of football players with suspected spine injuries:

<https://meridian.allenpress.com/jat/article/55/6/545/438481/Best-Practices-and-Current-Care-Concepts-in>.

Kory Stringer Institute: <https://ksi.uconn.edu/emergency-conditions/cervical-spine-injury/>

9. **Internal Organ Injuries:** Like cervical cord and spinal injuries, early recognition and prompt medical evaluation and treatment of internal organ injuries is critical for ensuring the best possible outcome. Emergency action plans, access to certified athletic trainers, and on-site medical services for competitions constitute best practices for these injuries. A better understanding of the activities and mechanisms associated with these injuries and use of protective gear worn is needed for prevention. Wearing protective gear (e.g., padded belt or shirt) that extends beyond the bottom of the shoulder pads to cover the torso may protect internal organs from direct contact.

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CASE SUMMARIES 2019

Summaries compiled for 19 cases from publicly available media sources.

CERVICAL SPINE

Collegiate/University

Complete recovery

A male college senior football defensive player suffered a spine fracture during the summer before his senior year. He kept playing and during the fall training camp, he developed spinal stenosis. He played through the season, despite having severe pain. While practicing for the final bowl game, he felt a pop in his back with a tingling sensation in his legs. The athlete was rushed to a nearby hospital. The physician recommended that he not continue playing football.

Incomplete recovery

A male college football linebacker suffered a neck injury during a game. The injury occurred when the athlete went across the middle and hit the opposing tight end. Athletic training staff attended to him for several minutes until he was taken off the field on a stretcher by EMS. He had surgery to repair a fractured cervical vertebrae the next day. He is expected to make a full recovery.

High School Sponsored

Incomplete recovery

A male 15 year old high school football player was left paralyzed from the shoulders down after tackling a quarterback during a junior varsity football game. He was rushed to the emergency room by EMS. The athlete is undergoing rehabilitation. He is paralyzed from the shoulders down but has feeling in his arms and legs.

A male high school football safety was injured while making a tackle in a game. The athlete was attended to by EMS and taken off the field on a stretcher. He was air lifted to a nearby hospital. He is in intensive rehabilitation therapy making physical improvements but is not yet able to walk.

A 15-year old male high school football player suffered a spinal injury late in the third quarter of a game. He was transported via helicopter to the hospital where he regained movement in his extremities. According to the coach, the injury occurred on an "unlucky" hit. He continues to have left-sided weakness as well as problems with regulating his blood pressure.

Complete recovery

A male 14 year old football player suffered a severe spinal injury after colliding with another player during a game. The athlete was taken to a hospital. The current prognosis is unknown.

A sophomore football player was backing up to block for a kickoff when his helmet collided with an opposing player's helmet. After that hit, his head endured another hit to the thigh pad of a

teammate who was also blocking. The player immediately fell to the ground and did not have feeling below his neck. He also experienced a sharp pain through his spine and skull. The athletic trainer stabilized his cervical spine while waiting for paramedics to take the athlete to the hospital. He was able to move his fingers and toes in the ambulance. He was transferred to a trauma hospital before being sent home in a neck brace the next day. He has been cleared to start practicing with the school basketball team.

A high school football player went to a chiropractor for back pain and was told that he had a dislocated vertebrae that would heal on its own. A few weeks later he played in a football game and was injured, causing more severe spine pain. The next day, he was seen by a physician who diagnosed him with two fractured cervical vertebrae. He was told that he would not play contact sports again, however, he is training to return next season and is hopeful.

Professional Level

Complete recovery

A male professional football player fell to the ground after a helmet-to-helmet collision with a teammate which occurred while trying to tackle an opposing running back. He went completely limp after falling and was carted off the field. He was paralyzed for 30 minutes, after which he could wiggle his toes. After 2 hours he regained full mobility. The athlete has fully recovered and plans to return to play.

HEAD/BRAIN

High School Sponsored

Incomplete recovery

A male high school freshman football player sustained a head injury during a 7-on-7 football scrimmage. The athlete lost his footing going in for a tackle, causing his head to collide directly with the opposing player's knee. He was not wearing protective headgear at the time of the injury. He was transported by EMS to a hospital and underwent emergency surgery. The injury caused a compressed skull fracture, life-threatening swelling, and a brain clot. The surgery was successful but long term prognosis is unknown.

A male high school football quarterback collapsed in the locker room about 20 minutes after the end of a football game. The event that is suspected to have caused the injury was a collision with another player after scoring a touchdown. The athlete's head hit the ground. Prior to his collapse, he complained of feeling ill in the locker room and was attended to by a coach and an athletic trainer. EMS, who was at the game and had not left yet, transported that athlete to the hospital where he underwent surgery to relieve a brain bleed. The athlete is expected to make a full recovery.

A male high school football player collapsed on the sideline after suffering a head injury during a game. He was transported by ambulance to a hospital and underwent emergency surgery. He was

later airlifted to another hospital. After being in a coma for four days, the athlete awoke and began showing improvements through in-patient rehab by responding to some commands. The athlete underwent extensive rehabilitation and regained the ability to feed himself but is unable to speak without an alternative communication method.

A male high school football quarterback was injured during a game. During the game, the athlete complained of a headache before collapsing on the sideline. In the play prior to his collapse, he handed the ball off to a running back, was bumped by a defender, then walked the length of the field to hand the ball off for a 2-point conversion. He was rushed to the hospital where he underwent surgery to drain the bleeding from his skull and to relieve pressure. He was then placed in a medically-induced coma and spent 5 months in the hospital. The athlete has returned home to continue therapies and has made some progress, able to now stand up on his own.

A male 17-year old high school football player suffered a traumatic brain injury after a helmet-to-helmet hit during a game. He lay motionless on the football field until paramedics rushed to help him. He was transported to the hospital and had surgery due to brain hemorrhage. Current prognosis is unknown.

A male high school football player was injured during a pre-season scrimmage when he leaped up to catch a pass and fell, hitting his back then his head on the ground. He felt dizzy, sat out on the sideline, where he passed out and hit his head on the ground again. The coach and athletic trainer applied ice to the athlete, believing he had a heat stroke. The athlete's sister called EMS who took him to the hospital. He underwent emergency surgery to address brain hemorrhaging. The athlete woke up the next day and has made a full recovery.

Complete recovery

A male high school sophomore football player was going through a routine hitting drill at practice when he started walking toward the team's athletic trainer and vomiting. The athletic trainer called his mother as soon as this happened and asked her to take him to the hospital. About 10 minutes later, EMS was at the field and the athlete was comatose and seizing on the ground. Paramedics cut off his clothes on the field before transporting him to a hospital. An MRI showed that he had a brain bleed that started a day earlier. At practice the day before, he had a headache after practice that was gone by the next morning. At the hospital, the athlete received emergency surgery to remove part of his skull and fix the brain bleed. He woke up from his medically-induced coma after 2 days and remained in the hospital for 30 days. He had a second surgery to reattach the skull a few days later. He has since returned to school, can fully speak, and has full function of his basic motor skills, including running.

OTHER INJURY

High School Sponsored

Complete recovery

A male high school football player was injured during practice and complained of losing feeling in his arm as well as spinal discomfort. He was transported to a trauma hospital by EMS. He is expected to make a full recovery.

A male high school football wide receiver was injured in a playoff game. After catching a pass, he collided with a defender while crashing his helmet into the turf. He lay motionless for several minutes surrounded by his coaches, the athletic trainers, and other players until an ambulance drove onto the field and transported him to a hospital. He eventually became unresponsive in the hospital. He was diagnosed with a concussion and spinal cord contusion that caused temporary paralysis and a body shutdown. The doctors theorized that the severity stemmed from his spinal cord being too narrow in relation to his body. He was able to walk with assistance after 5 days in the hospital and was discharged after 7 days. He began playing basketball for the high school a few months later. He has also committed to playing college football next year.

A high school senior football player was injured during a 7-on-7 drill at practice. The athlete went up for a ball when another player ran into him with his knee, rupturing his liver. The athlete returned to play about four months later.

Table I. Catastrophic Football Cervical Cord Injuries with Incomplete Recovery, 1977-2019*

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
1977	0	0	10	2	12	
1978	0	0	12	0	12	
1979	0	0	6	3	9	11.0
1980	0	0	10	2	12	
1981	1	0	5	2	8	
1982	0	1	7	2	10	
1983	0	0	11	1	12	
1984	1	0	6	0	7	9.8
1985	0	0	8	3	11	
1986	0	1	4	0	5	
1987	0	0	11	0	11	
1988	0	0	10	1	11	
1989	0	0	13	2	15	10.6
1990	0	0	11	2	13	
1991	0	1	1	0	2	
1992	0	1	7	0	8	
1993	1	1	5	0	7	
1994	0	0	1	1	2	6.4
1995	0	0	8	1	9	
1996	0	0	6	3	9	
1997	1	0	9	1	11	
1998	0	0	4	0	4	
1999	1	0	8	1	10	8.6
2000	0	0	6	2	8	
2001	0	0	8	0	8	
2002	0	0	6	1	7	
2003	0	1	9	1	11	
2004	1	1	10	1	13	9.4
2005	0	0	4	0	4	
2006	0	0	9	2	11	
2007	1	2	5	0	8	
2008	0	3	11	0	14	
2009	0	1	8	1	10	9.4
2010	0	0	5	4	9	

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
2011	1	1	5	0	7	
2012	0	0	2	2	4	
2013	2	0	8	0	10	
2014	0	0	2	1	3	6.6
2015	0	0	7	3	10	
2016	0	0	4	0	4	
2017	1	0	8	1	10	
2018	0	1	8	2	11	
2019	0	0	3	1	4	7.8
Total	11	15	301	49	376	
Percent	2.9%	4.0%	80.1%	13.0%	100.0%	

*Figures are updated annually due to new cases investigated after publication. *Note: 1977-1979 represents a 3-year period.*

Table II. Incidence of Catastrophic Football Cervical Cord Injuries with Incomplete Recovery per 100,000 Participants, 1977-2019

Year	Middle & high school¹	College²
1977	1.00	2.67
1978	1.20	0.00
1979	0.60	4.00
1980	1.00	2.67
1981	0.50	2.67
1982	0.70	2.67
1983	1.10	1.33
1984	0.60	0.00
1985	0.62	4.00
1986	0.31	0.00
1987	0.85	0.00
1988	0.77	1.33
1989	1.00	2.67
1990	0.85	2.67
1991	0.08	0.00
1992	0.54	0.00
1993	0.38	0.00
1994	0.08	1.33
1995	0.62	1.33
1996	0.46	4.00
1997	0.69	1.33
1998	0.31	0.00
1999	0.62	1.33
2000	0.46	2.67
2001	0.62	0.00
2002	0.46	1.33
2003	0.69	1.33
2004	0.77	1.33
2005	0.31	0.00
2006	0.69	2.67
2007	0.38	0.00
2008	0.85	0.00
2009	0.62	1.33
2010	0.38	5.33
2011	0.33	0.00
2012	0.18	2.67
2013	0.73	0.00
2014	0.18	1.33

Year	Middle & high school¹	College²
2015	0.64	4.00
2016	0.36	0.00
2017	0.73	1.33
2018	0.73	2.67
2019	0.27	1.33

¹Rates based on 1, 1.3, 1.5 and 1.1 million in 1968-1984, 1985-2010, 2011 and 2012-2019, respectively, for players grades 9-12.

²Rates based on 75,000 in all years for college players.

Note: Rates with number of incidents less than 5 should be interpreted with caution.

Note: 1977-1979 represents a 3-year period.

Table III. Characteristics of Catastrophic Football Cervical Cord Injuries with Incomplete Recovery, 1977-2019

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being blocked	0	0.0%	0	0.0%	3	1.0%	1	2.0%	4	1.1%
Being tackled	1	9.1%	3	20.0%	36	12.0%	4	8.2%	44	11.7%
Blocking	1	9.1%	1	6.7%	16	5.3%	5	10.2%	23	6.1%
General play	3	27.3%	0	0.0%	15	5.0%	3	6.1%	21	5.6%
Loose ball	0	0.0%	0	0.0%	1	0.3%	1	2.0%	2	0.5%
Receiving pass	0	0.0%	0	0.0%	2	0.7%	1	2.0%	3	0.8%
Tackling	4	36.4%	10	66.7%	195	64.8%	32	65.3%	241	64.1%
Unknown	2	18.2%	1	6.7%	33	11.0%	2	4.1%	38	10.1%
Type of Session										
Competition/Game	8	72.7%	13	86.7%	226	75.1%	36	73.5%	283	75.3%
Practice	3	27.3%	2	13.3%	50	16.6%	12	24.5%	67	17.8%
Scrimmage	0	0.0%	0	0.0%	10	3.3%	0	0.0%	10	2.7%
Unknown	0	0.0%	0	0.0%	15	5.0%	1	2.0%	16	4.3%
Suspected Cause										
Contusion (Hematoma)	1	9.1%	0	0.0%	11	3.7%	2	4.1%	14	3.7%
Fracture	8	72.7%	14	93.3%	254	84.4%	41	83.7%	317	84.3%
Other	1	9.1%	1	6.7%	27	9.0%	4	8.2%	33	8.8%
Nervous System	1	9.1%	0	0.0%	8	2.7%	2	4.1%	11	2.9%
Strain/Tear	0	0.0%	0	0.0%	1	0.3%	0	0.0%	1	0.3%
Position										
Defensive Lineman	1	9.1%	3	20.0%	16	5.3%	3	6.1%	23	6.1%
Defensive back	1	9.1%	2	13.3%	92	30.6%	22	44.9%	117	31.1%
Kicker/punter	0	0.0%	0	0.0%	1	0.3%	0	0.0%	1	0.3%
Kickoff/punt coverage	0	0.0%	4	26.7%	19	6.3%	5	10.2%	28	7.4%
Kickoff/punt return	0	0.0%	0	0.0%	10	3.3%	1	2.0%	11	2.9%
Linebacker	0	0.0%	0	0.0%	36	12.0%	7	14.3%	43	11.4%
Offensive Lineman	0	0.0%	2	13.3%	4	1.3%	2	4.1%	8	2.1%
Quarterback	0	0.0%	1	6.7%	11	3.7%	1	2.0%	13	3.5%
Running back	1	9.1%	2	13.3%	23	7.6%	1	2.0%	27	7.2%
Tight end/Wide receiver	0	0.0%	1	6.7%	15	5.0%	5	10.2%	21	5.6%
Other	1	9.1%	0	0.0%	2	0.7%	0	0.0%	3	0.8%
Unknown	7	63.6%	0	0.0%	72	23.9%	2	4.1%	81	21.5%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Offense or Defense										
Defense	3	27.3%	5	33.3%	145	48.2%	32	65.3%	185	49.2%
Offense	1	9.1%	6	40.0%	53	17.6%	9	18.4%	69	18.4%
Special Teams	0	0.0%	4	26.7%	30	10.0%	6	12.2%	40	10.6%
Other	0	0.0%	0	0.0%	1	0.3%	0	0.0%	1	0.3%
Unknown	7	63.6%	0	0.0%	72	23.9%	2	4.1%	81	21.5%
Location of Injury										
Competitive Venue	3	27.3%	3	20.0%	84	27.9%	21	42.9%	111	29.5%
School Athletic Facility	0	0.0%	0	0.0%	4	1.3%	1	2.0%	5	1.3%
Unknown	8	72.7%	12	80.0%	213	70.8%	27	55.1%	260	69.1%
Total	11	100.0%	15	100.0%	301	100.0%	49	100.0%	376	100.0%

**Table IIIb. Characteristics of Catastrophic Football Cervical Cord Injuries with
Incomplete Recovery, 2014-2019**

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being tackled	0	0.0%	0	0.0%	5	15.6%	1	12.5%	6	14.3%
Blocking	0	0.0%	0	0.0%	2	6.3%	2	25.0%	4	9.5%
General play	0	0.0%	0	0.0%	2	6.3%	1	12.5%	3	7.1%
Receiving pass	0	0.0%	0	0.0%	2	6.3%	0	0.0%	2	4.8%
Tackling	0	0.0%	0	0.0%	16	50.0%	4	50.0%	20	47.6%
Unknown	1	100.0%	1	100.0%	5	15.6%	0	0.0%	7	16.7%
Type of Session										
Competition/Game	1	100.0%	1	100.0%	24	75.0%	7	87.5%	33	78.6%
Practice	0	0.0%	0	0.0%	5	15.6%	1	12.5%	6	14.3%
Scrimmage	0	0.0%	0	0.0%	3	9.4%	0	0.0%	3	7.1%
Suspected Cause										
Contusion (Hematoma)	0	0.0%	0	0.0%	4	12.5%	0	0.0%	4	9.5%
Fracture	0	0.0%	1	100.0%	17	53.1%	5	62.5%	23	54.8%
Other	1	100.0%	0	0.0%	6	18.8%	2	25.0%	9	21.4%
Nervous System	0	0.0%	0	0.0%	5	15.6%	1	12.5%	6	14.3%
Diagnosis										
Cervical Spinal Cord Contusion	0	0.0%	0	0.0%	4	12.5%	0	0.0%	4	9.5%
Cervical Spinal Cord/Nerve Injury	0	0.0%	0	0.0%	5	15.6%	1	12.5%	6	14.3%
Cervical Spine Fracture	0	0.0%	1	100.0%	17	53.1%	5	62.5%	23	54.8%
Cervical Spine Injury, n.s.	1	100.0%	0	0.0%	5	15.6%	2	25.0%	8	19.0%
Other Neck Injury	0	0.0%	0	0.0%	1	3.1%	0	0.0%	1	2.4%
Position										
Defensive Lineman	0	0.0%	0	0.0%	1	3.1%	1	12.5%	2	4.8%
Defensive back	0	0.0%	0	0.0%	9	28.1%	2	25.0%	11	26.2%
Kickoff/punt coverage	0	0.0%	0	0.0%	1	3.1%	0	0.0%	1	2.4%
Kickoff/punt return	0	0.0%	0	0.0%	2	6.3%	0	0.0%	2	4.8%
Linebacker	0	0.0%	0	0.0%	4	12.5%	2	25.0%	6	14.3%
Offensive Lineman	0	0.0%	1	100.0%	0	0.0%	2	25.0%	3	7.1%
Quarterback	0	0.0%	0	0.0%	1	3.1%	0	0.0%	1	2.4%
Running back	0	0.0%	0	0.0%	3	9.4%	0	0.0%	3	7.1%
Tight end/Wide receiver	0	0.0%	0	0.0%	3	9.4%	1	12.5%	4	9.5%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Other	0	0.0%	0	0.0%	1	3.1%	0	0.0%	1	2.4%
Unknown	1	100.0%	0	0.0%	7	21.9%	0	0.0%	8	19.0%
Offense or Defense										
Defense	0	0.0%	0	0.0%	14	43.8%	5	62.5%	19	45.2%
Offense	0	0.0%	1	100.0%	7	21.9%	3	37.5%	11	26.2%
Special Teams	0	0.0%	0	0.0%	3	9.4%	0	0.0%	3	7.1%
Other	0	0.0%	0	0.0%	1	3.1%	0	0.0%	1	2.4%
Unknown	1	100.0%	0	0.0%	7	21.9%	0	0.0%	8	19.0%
Location										
Competitive Venue	1	100.0%	1	100.0%	28	87.5%	7	87.5%	37	88.1%
School Athletic Facility	0	0.0%	0	0.0%	4	12.5%	1	12.5%	5	11.9%
Total	1	100.0%	1	100.0%	32	100.0%	8	100.0%	42	100.0%

Table IV. Catastrophic Football Brain Injuries with Incomplete Recovery, 1984-2019*

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
1984	0	0	5	2	7	--
1985	0	0	4	1	5	
1986	0	0	2	0	2	
1987	0	0	5	0	5	
1988	0	0	2	0	2	
1989	0	0	5	0	5	3.8
1990	0	0	1	0	1	
1991	0	0	3	1	4	
1992	0	0	4	0	4	
1993	0	0	5	0	5	
1994	0	0	4	1	5	3.8
1995	0	0	5	0	5	
1996	0	0	5	0	5	
1997	0	0	8	1	9	
1998	0	0	4	0	4	
1999	0	0	5	0	5	5.6
2000	0	0	6	1	7	
2001	0	0	2	0	2	
2002	0	0	2	1	3	
2003	0	0	8	1	9	
2004	0	0	3	1	4	5.0
2005	1	0	7	1	9	
2006	0	0	9	0	9	
2007	0	0	6	0	6	
2008	1	1	9	0	11	
2009	0	0	12	0	12	9.4
2010	0	0	6	0	6	
2011	1	0	14	0	15	
2012	0	0	2	0	2	
2013	0	1	8	0	9	
2014	1	0	4	0	5	7.4
2015	0	0	8	0	8	
2016	0	0	9	0	9	
2017	1	0	7	0	8	
2018	0	0	5	1	6	
2019	0	0	6	0	6	7.4

Year	Organized youth	Pro & Semi-pro	Middle & High School	College	Total	5-year average
Total	5	2	200	12	219	
Percent	2.3%	0.9%	91.3%	5.5%	100.0%	

*Figures are updated annually due to new cases investigated after publication.

Table V. Incidence of Catastrophic Football Brain Injuries with Incomplete recovery per 100,000 Participants, 1984-2019

Year	Middle & high school¹	College²
1985	0.31	1.33
1986	0.15	0.00
1987	0.38	0.00
1988	0.15	0.00
1989	0.38	0.00
1990	0.08	0.00
1991	0.23	1.33
1992	0.31	0.00
1993	0.38	0.00
1994	0.31	1.33
1995	0.38	0.00
1996	0.38	0.00
1997	0.62	1.33
1998	0.31	0.00
1999	0.38	0.00
2000	0.46	1.33
2001	0.15	0.00
2002	0.15	1.33
2003	0.62	1.33
2004	0.23	1.33
2005	0.54	1.33
2006	0.69	0.00
2007	0.46	0.00
2008	0.69	0.00
2009	0.92	0.00
2010	0.46	0.00
2011	0.93	0.00
2012	0.18	0.00
2013	0.73	0.00
2014	0.36	0.00
2015	0.73	0.00
2016	0.82	0.00
2017	0.64	0.00
2018	0.45	1.33

Year	Middle & high school¹	College²
2019	0.55	0.00

¹Rates based on 1.3, 1.5 and 1.1 million in 1985-2010, 2011 and 2012-2019, respectively, for players grades 9-12.

²Rates based on 75,000 in all years for college players.

Note: Rates with number of incidents less than 5 should be interpreted with caution.

Table VI. Characteristics of Catastrophic Brain Injuries with Incomplete Recovery, 1984-2019

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being blocked	0	0.0%	0	0.0%	9	4.5%	3	25.0%	12	5.5%
Being tackled	0	0.0%	0	0.0%	27	13.5%	3	25.0%	30	13.7%
Blocking	0	0.0%	0	0.0%	10	5.0%	2	16.7%	12	5.5%
General play	2	40.0%	1	50.0%	58	29.0%	0	0.0%	61	27.9%
Receiving pass	0	0.0%	0	0.0%	4	2.0%	0	0.0%	4	1.8%
Running	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Tackling	2	40.0%	0	0.0%	49	24.5%	2	16.7%	53	24.2%
Other	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Unknown	1	20.0%	1	50.0%	39	19.5%	2	16.7%	43	19.6%
Type of Session										
Competition/Game	4	80.0%	2	100.0%	157	78.5%	7	58.3%	170	77.6%
Practice	1	20.0%	0	0.0%	39	19.5%	5	41.7%	45	20.5%
Scrimmage	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Other	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Suspected Cause										
Cardiovascular	0	0.0%	0	0.0%	4	2.0%	0	0.0%	4	1.8%
Contusion (Hematoma)	4	80.0%	0	0.0%	127	63.5%	8	66.7%	139	63.5%
Fracture	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Hemorrhage/Bleed	0	0.0%	0	0.0%	8	4.0%	0	0.0%	8	3.7%
Miscellaneous	0	0.0%	0	0.0%	4	2.0%	0	0.0%	4	1.8%
Traumatic Brain Injury, nec	1	20.0%	2	100.0%	55	27.5%	4	33.3%	62	28.3%
Position										
Defensive Lineman	0	0.0%	0	0.0%	11	5.5%	1	8.3%	12	5.5%
Defensive back	0	0.0%	0	0.0%	25	12.5%	1	8.3%	26	11.9%
Kicker/punter	0	0.0%	0	0.0%	1	0.5%	1	8.3%	2	0.9%
Kickoff/punt coverage	0	0.0%	0	0.0%	10	5.0%	2	16.7%	12	5.5%
Kickoff/punt return	0	0.0%	0	0.0%	3	1.5%	0	0.0%	3	1.4%
Linebacker	0	0.0%	1	50.0%	34	17.0%	1	8.3%	36	16.4%
Offensive Lineman	0	0.0%	0	0.0%	8	4.0%	1	8.3%	9	4.1%
Quarterback	0	0.0%	0	0.0%	8	4.0%	1	8.3%	9	4.1%
Running back	2	40.0%	0	0.0%	22	11.0%	2	16.7%	26	11.9%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Tight end/Wide receiver	0	0.0%	0	0.0%	9	4.5%	2	16.7%	11	5.0%
Other	0	0.0%	0	0.0%	2	1.0%	0	0.0%	2	0.9%
Unknown	3	60.0%	1	50.0%	67	33.5%	0	0.0%	71	32.4%
Offense or Defense										
Defense	0	0.0%	1	50.0%	71	35.5%	3	25.0%	75	34.2%
Offense	2	40.0%	0	0.0%	47	23.5%	6	50.0%	55	25.1%
Special Teams	0	0.0%	0	0.0%	14	7.0%	3	25.0%	17	7.8%
Other	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	3	60.0%	1	50.0%	67	33.5%	0	0.0%	71	32.4%
Location of Injury										
Competitive Venue	2	40.0%	1	50.0%	58	29.0%	4	33.3%	65	29.7%
School Athletic Facility	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1	0.5%
Unknown	3	60.0%	1	50.0%	141	70.5%	8	66.7%	153	69.9%
Total	5	100.0%	2	100.0%	200	100.0%	12	100.0%	219	100.0%

Table VIIb. Characteristics of Catastrophic Brain Injuries with Incomplete Recovery, 2014-2019

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Type of Activity										
Being blocked	0	0.0%	0	0.0%	2	5.1%	1	100.0%	3	7.1%
Being tackled	0	0.0%	0	0.0%	5	12.8%	0	0.0%	5	11.9%
Blocking	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
General play	1	50.0%	0	0.0%	13	33.3%	0	0.0%	14	33.3%
Receiving pass	0	0.0%	0	0.0%	2	5.1%	0	0.0%	2	4.8%
Running	0	0.0%	0	0.0%	2	5.1%	0	0.0%	2	4.8%
Tackling	1	50.0%	0	0.0%	7	17.9%	0	0.0%	8	19.0%
Other	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Unknown	0	0.0%	0	0.0%	6	15.4%	0	0.0%	6	14.3%
Type of Session										
Competition/Game	2	100.0%	0	0.0%	37	94.9%	1	100.0%	40	95.2%
Practice	0	0.0%	0	0.0%	2	5.1%	0	0.0%	2	4.8%
Suspected Cause										
Contusion (Hematoma)	1	50.0%	0	0.0%	9	23.1%	0	0.0%	10	23.8%
Fracture	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Hemorrhage/Bleed	0	0.0%	0	0.0%	7	17.9%	0	0.0%	7	16.7%
Miscellaneous	0	0.0%	0	0.0%	2	5.1%	0	0.0%	2	4.8%
Traumatic Brain Injury, nec	1	50.0%	0	0.0%	20	51.3%	1	100.0%	22	52.4%
Diagnosis										
Brain Aneurysm	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Brain Hemorrhage/Bleed	0	0.0%	0	0.0%	7	17.9%	0	0.0%	7	16.7%
Epidural Hematoma	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Other Injury To Head	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Second Impact Syndrome	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Skull Fracture	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Subdural Hematoma	1	50.0%	0	0.0%	7	17.9%	0	0.0%	8	19.0%
Subdural/Epidural Hematoma	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Traumatic Brain Injury, nec or n.s.	1	50.0%	0	0.0%	19	48.7%	1	100.0%	21	50.0%
Position										
Defensive Lineman	0	0.0%	0	0.0%	3	7.7%	0	0.0%	3	7.1%
Defensive back	0	0.0%	0	0.0%	4	10.3%	0	0.0%	4	9.5%
Kicker/punter	0	0.0%	0	0.0%	0	0.0%	1	100.0%	1	2.4%

Characteristics	Organized youth		Pro & Semi-Pro		Middle & High school		College		All	
	N	%	N	%	N	%	N	%	N	%
Kickoff/punt return	0	0.0%	0	0.0%	1	2.6%	0	0.0%	1	2.4%
Linebacker	0	0.0%	0	0.0%	5	12.8%	0	0.0%	5	11.9%
Offensive Lineman	0	0.0%	0	0.0%	2	5.1%	0	0.0%	2	4.8%
Quarterback	0	0.0%	0	0.0%	4	10.3%	0	0.0%	4	9.5%
Running back	1	50.0%	0	0.0%	2	5.1%	0	0.0%	3	7.1%
Tight end/Wide receiver	0	0.0%	0	0.0%	2	5.1%	0	0.0%	2	4.8%
Unknown	1	50.0%	0	0.0%	16	41.0%	0	0.0%	17	40.5%
Offense or Defense										
Defense	0	0.0%	0	0.0%	12	30.8%	0	0.0%	12	28.6%
Offense	1	50.0%	0	0.0%	10	25.6%	0	0.0%	11	26.2%
Special Teams	0	0.0%	0	0.0%	1	2.6%	1	100.0%	2	4.8%
Unknown	1	50.0%	0	0.0%	16	41.0%	0	0.0%	17	40.5%
Location										
Competitive Venue	2	100.0%	0	0.0%	39	100.0%	1	100.0%	42	100.0%
Total	2	100.0%	0	0.0%	39	100.0%	1	100.0%	42	100.0%

Table VII. Characteristics of All Catastrophic Football Traumatic Injuries, 2014-2019

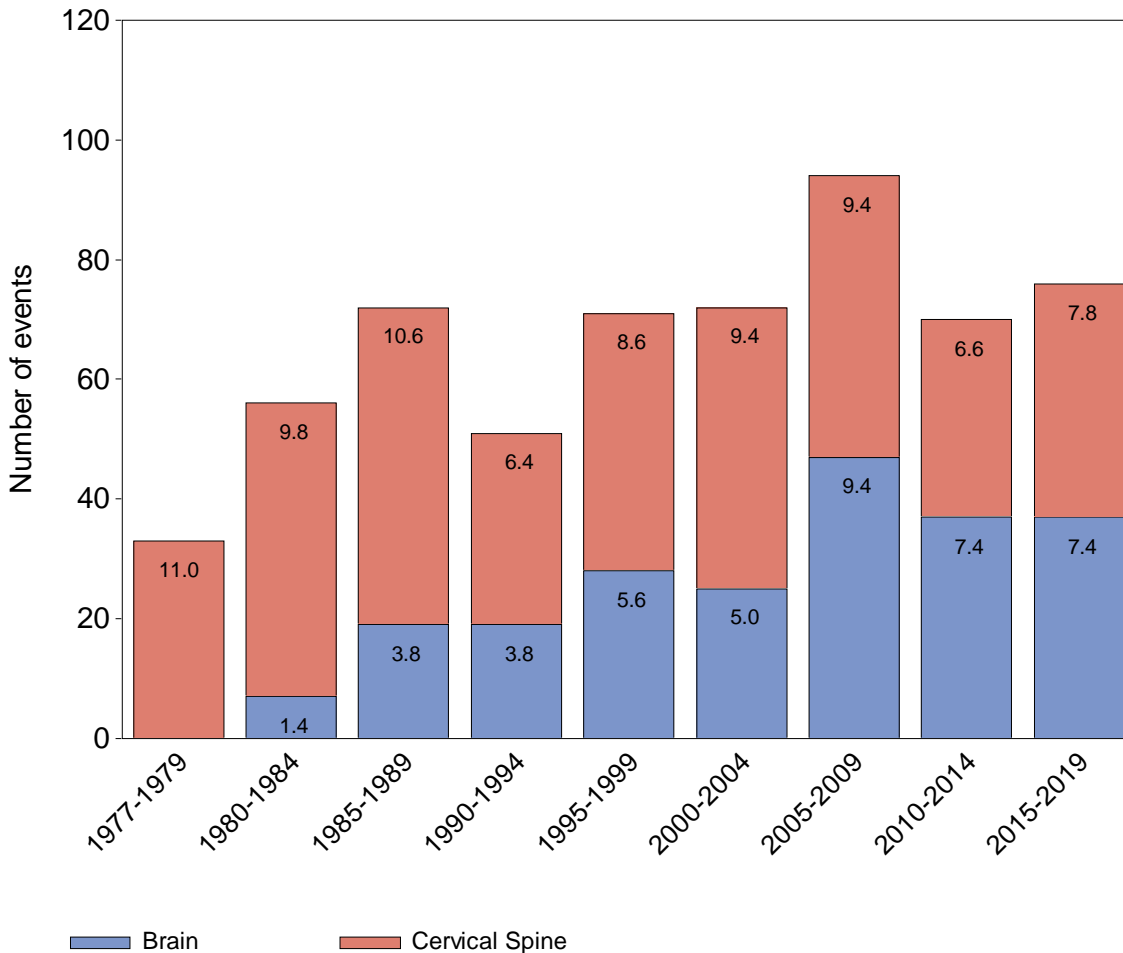
Characteristics	2014-2015		2016-2017		2018-2019		All	
	N	%	N	%	N	%	N	%
Player Level								
College	14	22.6%	6	10.5%	6	12.8%	26	15.7%
Middle & high school	44	71.0%	45	78.9%	39	83.0%	128	77.1%
Organized youth	1	1.6%	2	3.5%	0	0.0%	3	1.8%
Pro & Semi-pro	3	4.8%	4	7.0%	2	4.3%	9	5.4%
Type of Activity								
Being blocked	0	0.0%	2	3.5%	1	2.1%	3	1.8%
Being tackled	11	17.7%	15	26.3%	11	23.4%	37	22.3%
Blocking	6	9.7%	2	3.5%	3	6.4%	11	6.6%
Conditioning (land)	0	0.0%	1	1.8%	0	0.0%	1	0.6%
General play	14	22.6%	6	10.5%	3	6.4%	23	13.9%
Receiving pass	2	3.2%	3	5.3%	2	4.3%	7	4.2%
Running	2	3.2%	1	1.8%	1	2.1%	4	2.4%
Tackling	24	38.7%	17	29.8%	12	25.5%	53	31.9%
Other	0	0.0%	0	0.0%	2	4.3%	2	1.2%
Unknown	3	4.8%	10	17.5%	12	25.5%	25	15.1%
Type of Session								
Competition/Game	54	87.1%	48	84.2%	38	80.9%	140	84.3%
Conditioning Session	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Practice	7	11.3%	6	10.5%	6	12.8%	19	11.4%
Scrimmage	1	1.6%	2	3.5%	3	6.4%	6	3.6%
Suspected Cause								
Contusion (Hematoma)	6	9.7%	13	22.8%	4	8.5%	23	13.9%
Dislocation	0	0.0%	1	1.8%	1	2.1%	2	1.2%
Fracture	24	38.7%	13	22.8%	17	36.2%	54	32.5%
Hemorrhage/Bleed	1	1.6%	2	3.5%	6	12.8%	9	5.4%
Internal Organ	1	1.6%	3	5.3%	3	6.4%	7	4.2%
Nervous System	6	9.7%	3	5.3%	7	14.9%	16	9.6%
Strain/Tear	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Traumatic Brain Injury, nec	12	19.4%	12	21.1%	3	6.4%	27	16.3%
Other	11	17.7%	10	17.5%	4	8.5%	25	15.1%
Unknown	0	0.0%	0	0.0%	2	4.3%	2	1.2%
Diagnosis								
Brain Aneurysm	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Brain Hemorrhage/Bleed	1	1.6%	2	3.5%	6	13.3%	9	5.5%
Cervical Spinal Cord Contusion	3	4.8%	5	8.8%	1	2.2%	9	5.5%
Cervical Spinal Cord/Nerve Injury	3	4.8%	2	3.5%	6	13.3%	11	6.7%
Cervical Spinal Stenosis	0	0.0%	0	0.0%	1	2.2%	1	0.6%

Characteristics	2014-2015		2016-2017		2018-2019		All	
	N	%	N	%	N	%	N	%
Cervical Spine Fracture	24	38.7%	10	17.5%	14	31.1%	48	29.3%
Cervical Spine Injury, n.s.	7	11.3%	7	12.3%	2	4.4%	16	9.8%
Cervical Strain/Whiplash	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Epidural Hematoma	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Intestinal Injury	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Knee Dislocation	0	0.0%	0	0.0%	1	2.2%	1	0.6%
Liver Injury	0	0.0%	1	1.8%	1	2.2%	2	1.2%
Lumbar Spine Fracture	0	0.0%	0	0.0%	1	2.2%	1	0.6%
Lumbosacral Spine Contusion	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Lung Contusion	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Other Abdominal Injury	1	1.6%	1	1.8%	0	0.0%	2	1.2%
Other Eye Injury	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Other Injury To Head	0	0.0%	0	0.0%	1	2.2%	1	0.6%
Other Lower Leg Injury	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Other Neck Injury	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Proximal Tibio-Fibular Dislocation	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Punctured lung	0	0.0%	2	3.5%	0	0.0%	2	1.2%
Second Impact Syndrome	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Skull Fracture	0	0.0%	0	0.0%	1	2.2%	1	0.6%
Spleen Injury	0	0.0%	2	3.5%	2	4.4%	4	2.4%
Subdural Hematoma	3	4.8%	5	8.8%	2	4.4%	10	6.1%
Subdural/Epidural Hematoma	0	0.0%	0	0.0%	1	2.2%	1	0.6%
Thoracic Spinal Cord/Nerve Injury	1	1.6%	0	0.0%	0	0.0%	1	0.6%
Thoracic Spine Fracture	0	0.0%	1	1.8%	1	2.2%	2	1.2%
Thoracic Spine Injury, n.s.	0	0.0%	1	1.8%	0	0.0%	1	0.6%
Transient Para/Quadriplegia	2	3.2%	1	1.8%	1	2.2%	4	2.4%
Traumatic Brain Injury, nec or n.s.	12	19.4%	11	19.3%	3	6.7%	26	15.9%
Recovery								
No	27	46.6%	34	61.8%	29	61.7%	90	56.3%
Yes	31	53.4%	21	38.2%	18	38.3%	70	43.8%
Position								
Defensive Lineman	6	9.7%	3	5.3%	1	2.1%	10	6.0%
Defensive back	13	21.0%	8	14.0%	8	17.0%	29	17.5%
Kicker/punter	0	0.0%	0	0.0%	1	2.1%	1	0.6%
Kickoff/punt coverage	5	8.1%	1	1.8%	0	0.0%	6	3.6%
Kickoff/punt return	3	4.8%	1	1.8%	3	6.4%	7	4.2%
Linebacker	10	16.1%	6	10.5%	3	6.4%	19	11.4%
Offensive Lineman	2	3.2%	3	5.3%	3	6.4%	8	4.8%
Quarterback	4	6.5%	6	10.5%	3	6.4%	13	7.8%

Characteristics	2014-2015		2016-2017		2018-2019		All	
	N	%	N	%	N	%	N	%
Running back	5	8.1%	5	8.8%	3	6.4%	13	7.8%
Tight end/Wide receiver	4	6.5%	5	8.8%	4	8.5%	13	7.8%
Other	0	0.0%	0	0.0%	1	2.1%	1	0.6%
Unknown	10	16.1%	19	33.3%	17	36.2%	46	27.7%
Offense or Defensive Position								
Defense	29	46.8%	17	29.8%	12	25.5%	58	34.9%
Offense	15	24.2%	19	33.3%	13	27.7%	47	28.3%
Special Teams	8	12.9%	2	3.5%	4	8.5%	14	8.4%
Other	0	0.0%	0	0.0%	1	2.1%	1	0.6%
Unknown	10	16.1%	19	33.3%	17	36.2%	46	27.7%
Location of Injury								
Competitive Venue	55	88.7%	52	91.2%	44	93.6%	151	91.0%
School Athletic Facility	7	11.3%	5	8.8%	2	4.3%	14	8.4%
School Campus	0	0.0%	0	0.0%	1	2.1%	1	0.6%
Total	62	100.0%	57	100.0%	47	100.0%	166	100.0%

*Note: lower extremity injuries resulted in amputation of the lower leg (n=3)

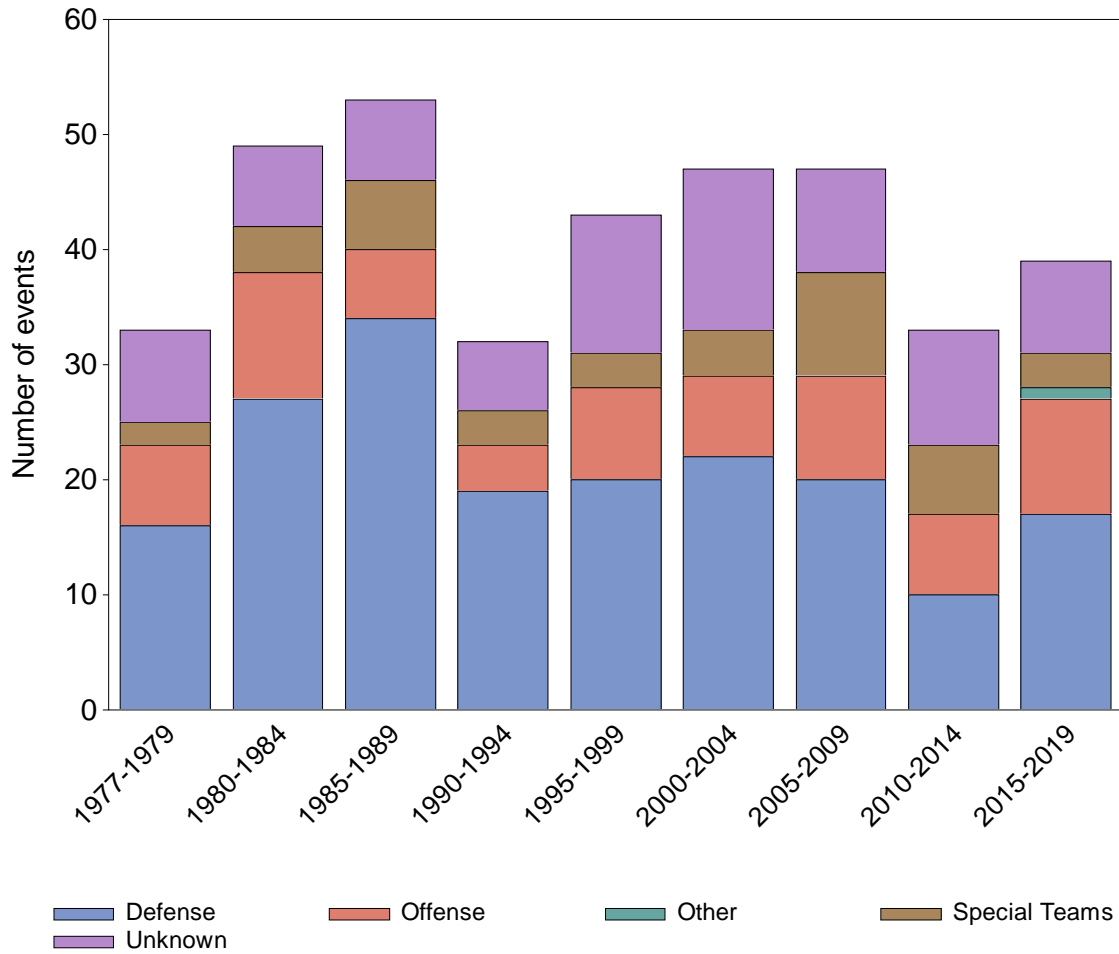
Figure 1. Catastrophic Neck/Cervical Spine (n=376) and Head/Brain (n=219) Injuries with Incomplete Recovery by 5-year periods, 1977-2019



Note 1. Numbers in bars are yearly averages.

Note 2. Data collection for non-fatal head/brain injuries began in 1984, and 1977 for neck/cervical spine injuries; 1977-1979 represents a 3-year period.

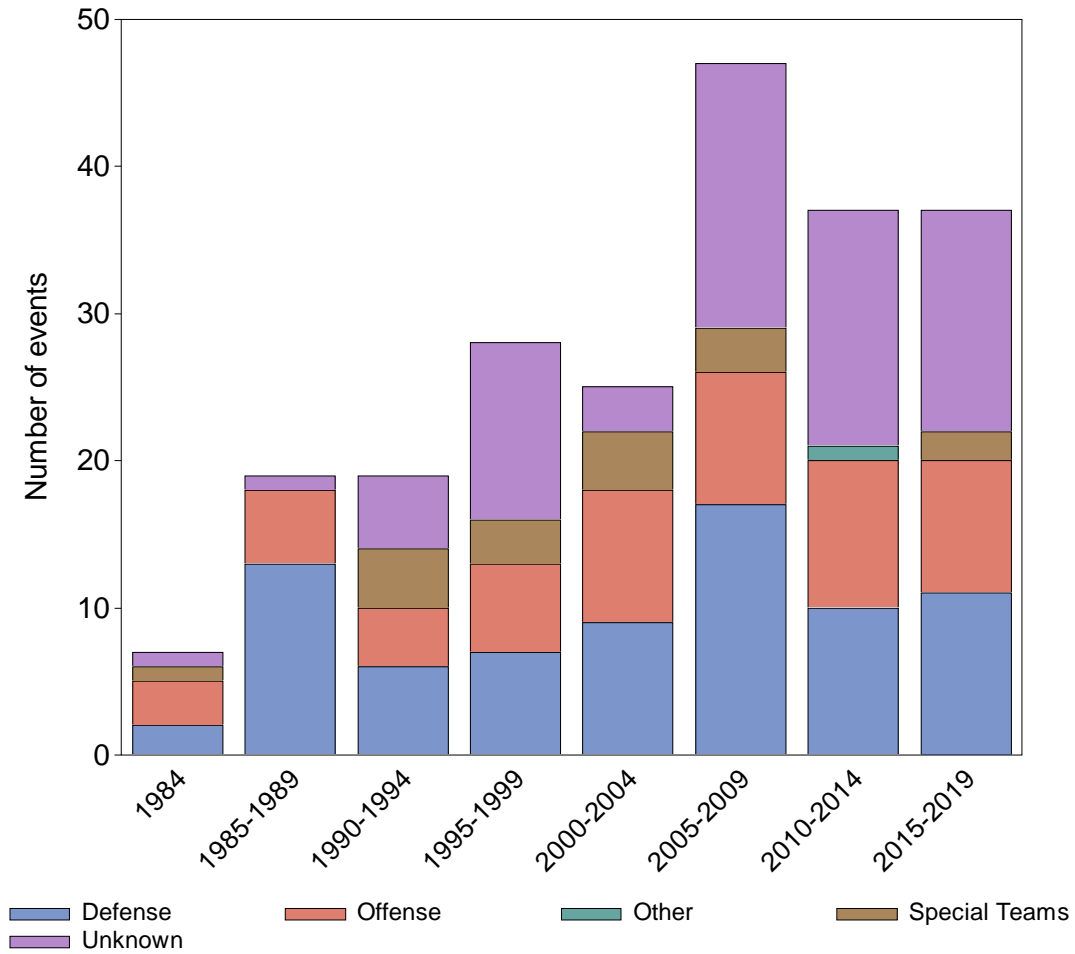
Figure 2a. Catastrophic Neck/Cervical Spine Injuries with Incomplete Recovery by Offensive or Defensive Category by 5-year periods, 1977-2019



*Note: 1977-1979 represents a 3-year period.

*Defense (n=185), Offense (n=69), Special Teams (n=40), and Other/unknown (n=82)

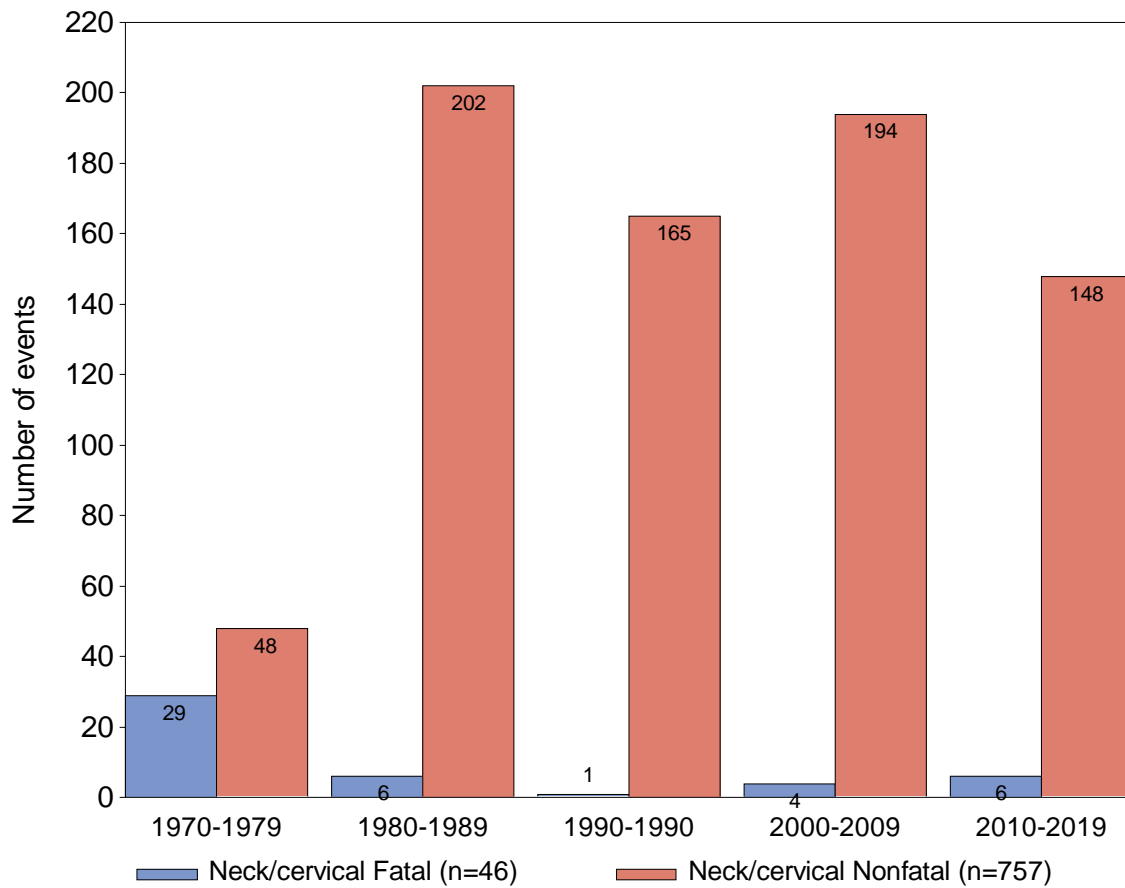
Figure 2b. Catastrophic Brain Injuries with Incomplete Recovery by Offensive or Defensive Category by 5-year periods, 1984-2019



*Note: 1984 represents a 1-year period.

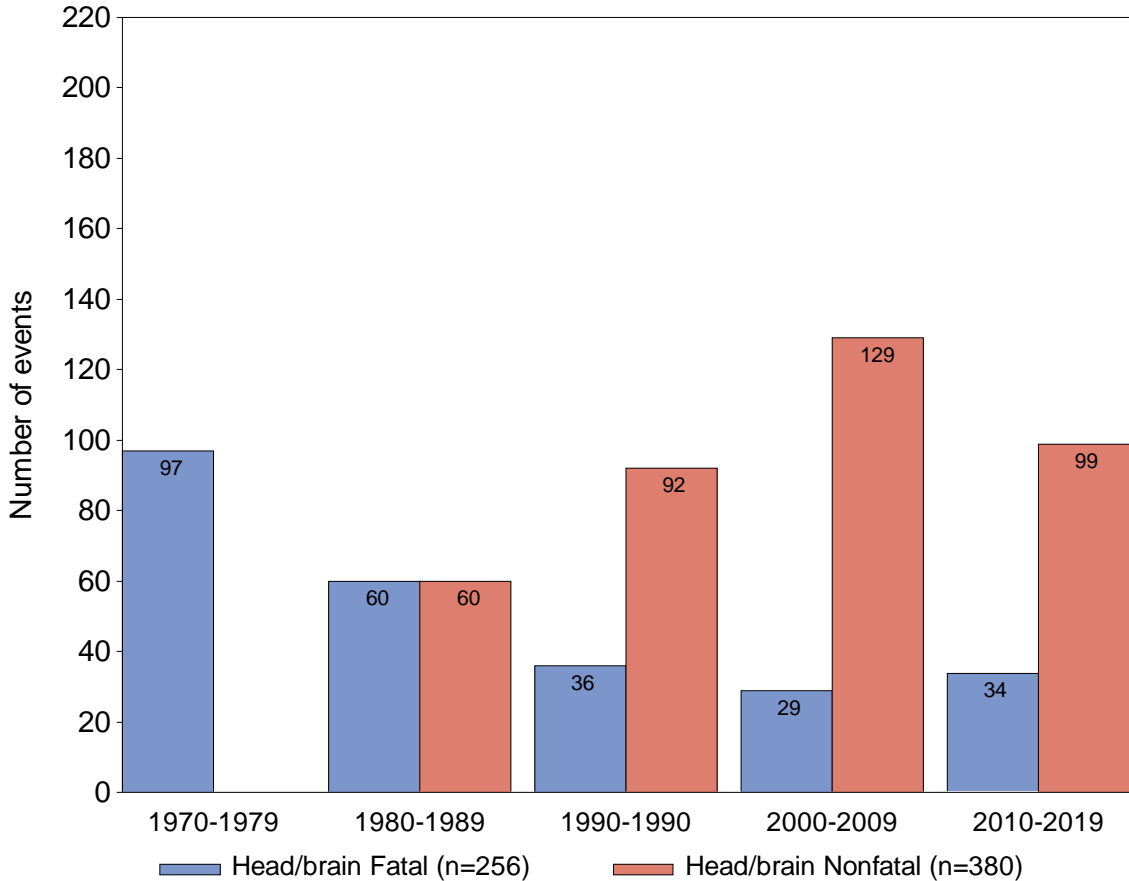
*Defense (n=75), Offense (n=55), Special Teams (n=17), and Other/unknown (n=72)

Figure 3a. Catastrophic Cervical Spine Fatalities and Injuries by Severity and Decade, 1970-2019



*Note: data collection for non-fatal neck injuries began in 1977

Figure 3b. Catastrophic Head/Brain Fatalities and Injuries by Severity and Decade, 1970-2019



*Note: data collection for non-fatal brain injuries began in 1984