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Examination of Emergency Medical Services Activations for Sport- Related Injuries

Rebecca Marie Hirschhorn

EXAMINATION OF EMERGENCY MEDICAL SERVICES ACTIVATIONS FOR SPORT-RELATED INJURIES

by

Rebecca Marie Hirschhorn

Bachelor of Science
James Madison University, 2012

Master of Science
University of South Carolina, 2014

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Accepted by:

Susan Yeargin, Major Professor

James Mensch, Committee Member

Zachary Kerr, Committee Member

Caroline Rudisill, Committee Member

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

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ABSTRACT

Research examining emergency medical services (EMS) activations for sport-related injuries has been limited regarding the populations examined, inclusion criteria, and location. The management of sport-related injuries by EMS providers has also not been examined. The purpose of this study was to describe EMS activations for sport-related injuries from a national sample and describe their management by EMS. Data was obtained from the National EMS Information System Database for the years 2017 and 2018. Sport-related injuries were identified using specific ICD-10-CM codes for the incident location type and cause of injury. Cases were limited to 9-1-1 responses for patients aged 3-99. Descriptive variables included patient characteristics (e.g. age, gender), incident location, complaint reported by dispatch, chief complaint organ system and anatomic location, primary symptom, provider's primary impression, service level, and procedures performed. Frequencies and proportions were calculated for all descriptive variables. There were 71,322 sport-related injuries identified, accounting for 0.2% of all EMS activations from 2017-2018. The average patient age was 36.6±22.9 years and most were male (n=41132, 57.7%). The most common incident location was general sports and athletics areas (n=46017, 64.5%). Traumatic injury was the most common complaint reported by dispatch (n=16064, 22.5%). The most common chief complaint was "global/general" for anatomic location (n=24075, 33.8%) and organ system (n=20543, 28.8%) affected, with unspecified pain selected as the most common primary symptom (n=9642, 14.6%). On average, 1.5 procedures were performed by

EMS, with the most frequent procedure being catheterization of the vein (n=25449). Most EMS activations for sport-related injuries received an advanced level of care (n=25885, 85.5%). Overall, sport-related injuries account for a low percentage of all EMS activations. Individuals of all ages were represented, indicating sport-related injuries affect a wide variety of people in formal and informal sport settings. Most sport-related injuries receive an advanced level of care and have procedures performed, indicating EMS activation was likely necessary. Coaches and administrators hosting athletic events should develop an emergency action plan for their venues and consider having trained on-site medical providers to provide immediate care for an injury and coordinate the EMS response. (347/350)

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LIST OF ABBREVIATIONS

AE ..... Athlete-Exposure

AED ..... Automated External Defibrillator

AHCT ..... Athletic Health Care Team

ALS ..... Advanced Life Support

AMCAT ..... Appropriate Medical Care Assessment Tool

AMCIA ..... Appropriate Medical Care of Intercollegiate Athletics

AT ..... Athletic Trainer

ATLAS ..... Athletic Trainer Location and Services

BLS ..... Basic Life Support

CMS ..... Centers for Medicare and Medicaid Services

CPR ..... Cardiopulmonary Resuscitation

ECG ..... Electrocardiogram

EAP ..... Emergency Action Plan

ED ..... Emergency Department

EMT ..... Emergency Medical Technician

EMS ..... Emergency Medical Services

ICD-9-CM ..... International Classification of Diseases, 9th Revision, Clinical Modification

ICD-10-CM . International Classification of Diseases, 10th Revision, Clinical Modification

IPR ..... Injury Proportion Ratio

NATA ..... National Athletic Trainers' Association

NCAA ..... National Collegiate Athletic Association

NEMSIS ..... National Emergency Medical Services Information System

RVU ..... Relative Value Unit

SCA ..... Sudden Cardiac Arrest

SRI ..... Sport-Related Injuries

U.S. ..... United States

CHAPTER 1

INTRODUCTION

Participation in sports activities includes an inherent risk of injury, potentially requiring immediate care and transportation to an Emergency Department (ED). Epidemiological studies of sport-related injuries have frequently been examined in the ED setting,[1-4] but only recently have sport-related injuries needing transport by emergency medical services (EMS) been examined specifically.[5] Hirschhorn et al.,[5] described injuries in both collegiate and high school student-athletes resulted in EMS transportation rates at 0.70 and 0.29 per 10,000 athlete-exposures, respectively. However, this study was limited to academic institutions with athletic trainers (ATs) and did not include athletes outside the high school and collegiate settings (e.g. middle school, recreational club).

The National Emergency Medical Services Information System (NEMSIS) provides a standardized database for national EMS activations across the United States (US).[6] Data from the NEMSIS have been used to examine EMS activations for pediatric patients;[7,8] however, each study was limited to a single state, and only one examined places of recreation, and sport.[7] Places of recreation and sport accounted for 22.1% of EMS activations with the most common dispatch complaints of traumatic injury, fall victim, unconscious/fainting, sick person, and breathing problems.[7] No studies have examined multifactorial aspects including: sport-related injuries, EMS activations

originating from places of recreation or sport in the adult population. While not all sport-related injuries result in EMS transport, EMS are a critical link between on-field responders, such as ATs, and the ED.

Among U.S. children aged 14 to 18 years, the highest proportion of EMS transports were due to "trauma/environmental" diagnoses, and the majority received advanced life support (ALS) care.[9] This study was limited to those with private insurance coverage and was not specific to sport-related injuries. Literature has found fractures and concussions are reported as the most frequently diagnosed EMS transports of high school student-athletes.[5] Many schools and recreation leagues do not have access to ATs and must rely on another on-field responder (i.e., coach, parent, or other bystanders) to recognize potentially emergent injuries or illnesses and call for EMS. Dependence on untrained personnel to appropriately recognize and triage sport-related injuries has the potential to result in inappropriate use of EMS resources with associated economic costs and the use of alternative transportation methods.

Athletic trainers are health care providers for athletes who participate in organized sports and are trained in the prevention, recognition, and management of athletic injuries. In the event of life and limb-threatening injuries, ATs can provide immediate care, determine the need for emergency EMS activation, and refer appropriately. However, access to AT services varies widely across the US,[10] and access to an AT in unorganized and recreational sports is largely unknown. The aims of this study are as follows:

Aim #1: Describe EMS activations for sport-related injuries from a national sample during the 2017 to 2018 years. The following research questions will specifically

be examined: What proportion of EMS activations are due to sport-related injuries? How do sport-related injuries differ between pediatric (<18 years) and adult (≥18 years) patients in regard to chief complaint anatomic location and organ system affected? We hypothesize that adults will have higher proportions of abdomen, chest and general/global injuries than the pediatric population and that the pediatric population will have higher proportions of musculoskeletal/skin injuries than the adult population. We also hypothesize there will not be difference between adult and pediatric populations with regards to other anatomic locations and organ systems.

Aim #2: Describe EMS management (i.e., incident/patient disposition, primary impression, procedures performed) of sport-related injuries during the 2017 to 2018 years. The following research questions will be specifically examined: 1) What types of injuries are more likely to result in transportation by EMS?, 2) What types of sport-related injuries transported by EMS are more likely to receive an advanced life support level of care?, and 3) What is the estimated cost for of EMS activations due to sport-related injuries? We hypothesize that sport-related injuries to the abdomen, chest, head or neck; or affecting the cardiovascular, neurological, or pulmonary systems will most likely result in ALS level of care as opposed to BLS.

Aim #3 Compare the incidence of EMS activations for sport-related injuries among high school-aged patients (i.e., 13-18 years old) between zip-codes by athletic training service level (i.e., full-time, part-time, none) and employment type from 2017 to 2018. The following research questions will be specifically examined: 1) How will the incidence of EMS activations differ between zip-codes with differing athletic training services levels? How will the incidence of EMS activations differ between zip-codes with

differing athletic training employment models? We hypothesize that zip-codes categorized as having an AT will have a lower incidence of EMS activations for sport-related injuries than those without an AT. We also hypothesize that there will be no difference in the incidence of EMS activations between zip-codes categorized as having a full-time AT compared to those with a part-time AT.

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

Sport-related injuries are an inherent risk of sport participation. Injuries may range from being minor and not result in time lost from sports participation to be life-threatening and require immediate care and emergency transportation to the emergency department (ED). Emergency medical services are a critical link between ATs and the ED. The purpose of this literature review is to describe sport-related injuries from the perspective of ATs, EMS and the ED; best practices and appropriate medical care for athletics; EMS utilization; medical necessity, and the economic burden of sport-related injuries.

SEARCH STRATEGY

Databases used for this literature review were PubMed, Web of Science, EBSCOhost, SPORTDiscus, Google Scholar, and hand searching. The "multi-search" function provided by the university's library was also utilized to identify articles for this review. The following search terms were used singularly and combined: ambulance, use, utilization, medical necessity, sport*, sport-related, injury, emergency, room, department, medical services, EMS, athlete*, athletic trainer, service*, coverage, high, secondary, school, pediatric, college*. Articles were included if they were peer-reviewed, in the U.S.

and published in English. Peer-reviewed abstracts were included if the findings were not presented elsewhere in manuscript form. All others were excluded.

EPIDEMIOLOGY OF SPORT-RELATING INJURIES PRESENTING TO U.S. EMERGENCY DEPARTMENTS

Numerous studies have examined sport-related injuries presenting to EDs, particularly for pediatric patients.[1,2,4,11-13] Epidemiological studies examining sport-related injuries reporting to EDs in the adult population are less common.[3,12] Males have consistently accounted for a more substantial proportion of ED visits than females, ranging from 67% to 78% of ED visits for pediatric patients.[1-4] The rate of ED visits is also higher for males than females.[12] Children aged 10 to 17 most commonly report to EDs for sport-related injuries.[1,4,13] These ages align with children and adolescents in middle and high school. When including adults up to age 24, children aged five to 14 accounted for the highest proportion of sport-related injuries, followed by 15 to 24-year-olds.[12] Five to 24-year-olds have accounted for 68% of ED visits due to sport-related injuries by all ages.[12] The age groups used in studies for comparisons has varied considerably in the literature.

Prevalence of Sport-Related Injuries

Over 4.6 million ED visits occurred in 2003 in children under the age of 17, with 3.9 million being due to injury; however, injuries were not limited to those resulting from sports participation.[13] Sport-related injuries have been identified in epidemiological studies using a variety of definitions and methodologies.[2-4,11,12] A comparison of definitions used to identify sport-related injuries is shown in Table 2.1.

In North Carolina, data from the North Carolina Disease Event Tracking and Epidemiological Collection Tool was used to examine unintentional injuries presenting to EDs, approximately 27% of which were due to sport and recreation activities.[1] The prevalence of sport-related injuries have also been examined nationally using the Nationwide Emergency Department Sample,[2,4] the National Electronic Injury Surveillance System,[11], and the National Hospital Ambulatory Medical Care Survey.[12] From 1997 to 1998, ED visits for sport-related injuries occurred at a rate of 33.9 ED visits per 1,000 persons for individuals aged five to 24 years.[12] Between 2006 and 2011, over 3.3 million ED visits were due to sports activities with a rate of 76.1 ED visits per 100,000 population.[2] In 2008, over 430,000 ED visits due to sports activities were identified; however, this sample was limited to individuals aged 13 to 19 years.[4] From 2001 to 2013, over 15.9 million sport-related injuries were estimated to have presented to EDs across the US, with an average annual increase of 10,010 sport-related injuries.[11] While the prevalence and rates of sport-related injuries presenting to EDs among children has varied in the literature, it is clear that sport-related injuries place a considerable burden on EDs across the US. Emergency department visits for sport-related injuries are also frequent among young adults; however, little literature is available on how these trends may change over the lifespan.

Sport and Mechanism of Injury

Injuries presenting to EDs vary by sport and mechanism of injury. Sports played as a group, or team sport accounted for over 34% of sport-related ED visits, with American tackle football and basketball cited as the most common causes.[1,3,12] Together, football, basketball, soccer, and baseball accounted for over 70% of sport-related injuries

presenting to national EDs.[11] Increasing annual trends in sport-related injuries due to football, soccer, cheerleading, lacrosse, swimming, softball, dancing, wrestling, track and field, volleyball, martial arts, and rugby have been reported.[11] The most common mechanism of injury reported was being struck against during sports without subsequent fall.[4] Sport-related injuries reporting to EDs are not limited to organized sports, and likely also include recreational activities with little to no administrative oversight or access to medical care other than EMS or the ED. None of the studies described above examined if patients had received any type of medical care before coming to the ED. Sport-related injuries that resulted from organized or interscholastic sports may have had a medical provider present to assess the injury and determine the need for ED services, such as an athletic trainer. However, this likely was not the case for injuries sustained during unorganized or recreational sports activities.

Injury Type, Severity, and Emergency Department Care Provided

Sport-related injuries presenting to EDs vary from minor, non-life threatening injuries to potentially life-threatening injuries, requiring varying levels of care upon arrival to the ED. Sprains, strains, and contusions are the most commonly reported diagnoses, accounting for 22% to 33% and 18% to 27% of injuries, respectively.[4,11,12] Fractures have also been commonly reported, accounting for approximately 20% of injuries.[11,12] Together, the upper and lower extremities accounted for over 50% of sport-related injuries.[12] Concussions have also been reported to account for 2.0% to 6.8% of ED visits.[4,11] In the ED, 50.5% of patients with sport-related injuries had extremity radiographs performed, 25.0% received wound care, 43.3% received orthopedic care, and 13.3% received a mental status test.[12] Less than one-third of patients did not receive any

therapeutic services, and 5.8% had no diagnostic services provided. Most sport-related injuries do not require emergent and advanced medical care beyond services available in the ED. The proportion of children subsequently discharged from the ED has ranged from 96% to over 98%,[1,2,13] indicating decreased injury severity and that these sport-related injuries may have been manageable elsewhere, such as urgent care or physician's office. Thus, few of the sport-related injuries reporting to EDs likely necessitated transportation to the ED via EMS.

Nearly 7% of children arriving at the ED for a sport-related injury arrive via ambulance.[1] The proportion of children admitted to the hospital for further care has ranged from 1.2% to 2.5%,[1,2,4] indicating increased injury severity and the need for emergent and advanced care. In an examination of hospital admissions for pediatric sports-related injuries, approximately 73% were admitted from the ED.[14] Increasing trends have been seen in internal organ injuries (2.5% to 5.9%) presenting to EDs as a result of sport participation.[11] Systemic injuries, injuries to the abdomen, chest, leg, hip, head, and back were at an increased relative risk of being admitted to the hospital while injuries to the ankle/foot, wrist/hand, and knee had decreased relative risk of hospital admission.[3] Sport-related injuries necessitating emergent and advanced medical care account for a small proportion of sport-related injuries reporting to EDs; however, the risk of severe injury resulting from sports participation exists. Prompt recognition of severe injury and transportation by EMS is critical in these situations.

One study specifically examined the incidence of life-threatening injuries presenting to EDs as a result of sport participation.[15] Data was obtained from the National Hospital Ambulatory Medical Care Survey database from 1999 to 2008. Life-threatening

injuries were defined using ICD-9 codes for skull fracture, cervical spine fracture, intracranial hemorrhage, traumatic pneumothorax/hemothorax, liver lacerations, spleen lacerations, traumatic aortic aneurysm or rupture, gastric/duodenal rupture, heat stroke, and commotio cordis/heart contusion. External cause of injury codes related to sports was also used to identify sport-related life-threatening injuries. An estimated 0.5% of ED visits were considered life-threatening, with 14% of those being sport-related. During the 10-year study period, an estimated 926,805 life-threatening sport-related injuries presented to US EDs. The highest proportions of life-threatening sport-related injuries were among children less than 18 years old, with the 6 to 12 and 13 to 18 age groups, each accounting for 39% of life-threatening sport-related injuries. Fourteen percent of head/neck injuries were considered life-threatening, and 17% of torso/abdomen injuries were considered life-threatening. This study, however, did not present which sports resulted in these life-threatening sport-related injuries. It is also unknown if these injuries were a result of organized or recreational sports activities.

Large proportions of ED visits are attributable to sport participation in children and adults. While numerous studies have been conducted using nationally representative samples,[2-4,11-13] database methodologies, and the inclusion criteria for defining a sport-related injury have varied between studies, making direct comparisons difficult. Sprains, strains, contusions, and fractures are the most commonly reported sport-related injuries presenting to EDs;[4,11,12] however, these are not typically considered emergent conditions and may have been safely evaluated elsewhere (e.g., a sports medicine physician's office, urgent care, athletic training room). Only one study was identified that specifically examined life-threatening sport-related injuries.[15] Sport-related injuries resulting in

transportation by emergency medical services (EMS) will be specifically discussed later in this review.

EPIDEMIOLOGY OF SPORT-RELATED INJURIES PRESENTING TO ATHLETIC TRAINERS

Overall Injury Prevalence, Sport, and Injury Type

Athletic trainers (ATs) in high school and collegiate institutions are in a unique position to track sport-related injuries as they are often the initial medical contact for student-athletes seeking care for injuries and illnesses. Among collegiate athletes, an estimated 1 million sport-related injuries occurred over five years across 25 NCAA sports.[16] Emergency transportation by EMS was reported in 0.9% of cases. Student-athletes participating in sports at Division I institutions have consistently demonstrated higher injury rates compared to those at Division II and III institutions regardless of the time of the season (e.g., pre-season, in-season, post-season).[17] Participation in men's football, men's wrestling, and women's gymnastics frequently resulted in injuries among collegiate athletes.[16] In high school, an estimated 1.4 million sport-related injuries occurred across nine sports over one year.[18] Participation in football, wrestling, boys' and girls' soccer and girls' basketball frequently resulted in injuries. Sprains/strains accounted for the majority of injuries sustained, followed by contusions and fractures,[18] which are also commonly seen in the athletic training and ED settings.[4,11,12,18] Most injuries result in less than seven days lost from participation; however, the proportion of high school student-athletes requiring more than seven days to return to participation is higher than those in college.[16,18] Sport-related injuries are common across competition

levels, but most are minor and do not typically necessitate emergency transportation. However, it is unknown what proportion of sport-related injuries may have been referred to the ED for further evaluation via an alternate method of transportation.

Severe and Rare Injuries

Severe injuries have been studied in both high school and collegiate athletes.[19,20] Severe injuries were defined as any injury that resulted in a loss of greater than 21 days of participation in sports.[19,20] In high school, severe injuries represented 14.9% of all sport-related injuries, an estimated 446,715 severe injuries nationally, and occurred at a rate of 0.39 severe injuries per 1,000 AE.[19] Collegiate athletes had a severe injury rate of 0.66 per 1,000 AE with severe injuries representing 9.5% of all injuries reported.[20] In high school, football, wrestling, and girls' basketball had the highest rates of severe injuries.[19] Men's wrestling, women's gymnastics, and men's football had the highest severe injury rates in college.[20] Boys had a higher severe injury rate than girls; however, among sex- comparable sports, girls had a higher severe injury rate. No difference in injury rate was found between men and women among sex comparable sports in college.[20] The knee was the most commonly severely injured body part in both high school and college settings.[19,20] Sprains, strains, and fractures were the most common severe injury types.[19,20] Over 50% of severe injuries resulted in medical disqualification for the season, and 0.3% resulted in medical disqualification for the athlete's career. The proportion of severe injuries that involved care and transportation by EMS or referral to the ED was not examined in either of these studies.

Rare injuries and conditions have been examined in high school athletes.[21] A rare injury was defined as eye injuries, dental injuries, neck and cervical injuries, dehydration, and heat illness. Data for this study was obtained over two academic years and included nine sports. Rare injuries occurred at a rate of 9.04 per 100,000 AE, accounted for 3.5% of all reported injuries, and most commonly occurred in football, wrestling, and baseball. Boys had over a four-fold higher injury rate than girls. Most athletes who sustained rare injuries returned to sport participation within a week, while 4.9% resulted in medical disqualification for the season, and 0.6% resulted in medical disqualification for their sports career. Just over five percent of rare injuries and conditions required surgical intervention. While not explicitly examined in this study, the rare injury and condition types included in this study would have necessitated emergency care and transportation by EMS. This triage decision is vital to fully understand sport-related injuries requiring transportation and leaves a gap in the literature.

Catastrophic Injuries and Fatalities

The National Center for Catastrophic Sport Injury Research collects data on catastrophic injuries resulting from sports participation, directly or indirectly. The capture of catastrophic injuries in this database relies on reports by coaches, athletic trainers, athletic directors, state and national organization officers, news reports, and research associates.[22] In the most recent report, from July 1, 2016, to June 30, 2017, there were 86 catastrophic injuries or illnesses reported among high school and collegiate athletes, of which 75 were due to or occurred during organized sport-related activities.[22] Approximately 30% of reported cases were fatal. Most catastrophic events occurred due to participation in football, accounting for over 45% of catastrophic injuries, followed by

basketball, track and field, wrestling, baseball, ice hockey, and soccer. The most common diagnoses were sudden cardiac arrest (SCA), cardiac conditions, and brain trauma. Due to the nature of these injuries, emergency care and transportation by EMS was likely; however, the proportion of which EMS was involved in the care and transportation of the patient has not been examined.

Fatalities have been examined at the youth, high school, and collegiate levels. [23-25] Commonly cited causes of death have been atraumatic SCA, brain injuries, exercise-related death associated with sickle cell trait, exertional heat stroke, commotio cortis, anaphylactic shock, lightning, and drowning.[23-25] In a review of football fatalities reported in the National Center for Catastrophic Sports Injury Research, 243 deaths were reported between July 1990 to June 2010, an average of 12 per year.[24] Deaths were categorized as indirect (systemic) or direct (traumatic), of which there were 164 (131 in high school and 33 in college) and 79 (72 in high school and 7 in college), respectively. High school football players had an increased odds of death than their collegiate counterparts for all categories. Most deaths occurred during practices (62.2%) and games (37.8%). In youth athletes aged six to 17 years-old, 45 deaths occurred across 12 sports activities between 2007 and 2015, averaging five per year.[25] Sudden death was considered a death that occurred during sports participation or as a result of sport participation. Organized youth sports included organized youth leagues, middle school athletics, and organized recreational youth sports. The majority (73%, n=33/45) of deaths occurred in 12 to 14-year-olds and males (80%, n=36/45). The most substantial proportion of deaths occurred as a result of basketball, followed by baseball, American

football, and soccer. Overall, the authors reported an annual estimated incidence of 1.83 million sudden deaths per 10 million athlete years.

Millions of sport-related injuries occur each year in high school and collegiate athletics. However, little to no literature exists examining sport-related injuries due to participation in youth or recreational sports. High school athletes, typically aged 13 to 18, and collegiate athletes, typically aged 19 to 24, also represent a rather narrow age range within the overall physically active population. While severe, rare, catastrophic injuries and fatalities have been studied,[19-25] it is unknown what role EMS played in the immediate care and transportation of the injured or ill athlete, which likely would have been warranted. Participation in football, basketball, soccer, track and field, wrestling, baseball, ice hockey, and gymnastics has frequently resulted in severe, rare, and catastrophic injuries, including fatalities.[19-22,25] These findings have important implications for the determination of appropriate medical care, particularly by ATs and EMS, for these high-risk sporting activities.

MANAGEMENT OF SPORT-RELATED EMERGENCIES

Examination of Sudden Cardiac Arrests and Emergency Action Plan Activations

One study examined previous incidents of sudden cardiac arrest (SCA).[26] Approximately two percent of schools surveyed reported having an incident of SCA during the previous six months. Most incidents occurred in older non-students and during organized sports activity. Locations in which SCA occurred were basketball facility, classroom building, football facility, baseball facility, theater, official's locker room, cafeteria, main office, and hallway near an athletic facility. The AT was the first

responder in 47% of cases. In 14% of cases arriving EMS providers provided the AED despite there being one on school grounds. The median EMS response time was eight minutes. Local EMS had not been on-site before the SCA in any cases where it occurred during sporting activity for a student-athlete. For older, non-student athletes, EMS was on site before SCA in four of 22 cases. These findings, together with a previous In another study, the most commonly reported sport-related emergencies were extremity sprain/strain (92%) and musculoskeletal injury (86%).[27] Other sport-related emergencies included lacerations, obvious or open fractures, head injury/concussion, dehydration/shock, respiratory distress, heat-related condition, and chest/abdominal blunt injury. Fifty-four percent of ATs reported having activated their EAP in response to a sport-related emergency in the past year.[27] Emergencies can occur anywhere, in athletic and non-athletic facilities, and ATs are not always available to be the first responder.[28] These findings support the need for a comprehensive EAP that addresses a variety of emergent conditions, access to emergency equipment, and coordination with local EMS. Therefore, administrators, coaches, and other necessary individuals must be able to recognize potentially emergent situations, be able to follow the EAP, and provide necessary immediate care until EMS arrives.

Incidence of Emergency Medical Services Activations and Injury Types

Few studies have directly examined sport-related injuries that result in EMS transportation to the ED.[5,16,29] One study compared basketball injuries presenting to ATs and EDs;[30] however, the proportion of injuries requiring emergency transport was not examined. Decoster, et al.,[29] specifically examined EMS activations resulting from football participation at the high school and collegiate levels. Approximately 39% of high

schools reported an average of one to two EMS activations per year compared to 44.5% in collegiate institutions. However, 6.1% of high schools and 2.3% of collegiate institutions reported averaging over six EMS activations each year. Emergency transport was required for a more substantial proportion of injuries sustained during competition (1.4%) than during practice (0.6%) among NCAA collegiate athletes.[16] Sprains and strains accounted for 29.4% of practice injuries that resulted in emergency transport. During competitions, fractures, stress fractures, dislocations, and subluxations accounted for more emergency transports. Hirschhorn et al.,[5] compared emergency transports among high school and collegiate athletes from the 2011/12 to 2014/15 academic years. Emergency transport accounted for 1% of collegiate and 0.3% of high school reported injuries. The highest incidence rate in college was in women's ice hockey, men's wrestling, and men's ice hockey. In high school, the highest incidence rates were in football, girls' gymnastics, and boys' wrestling. The head/face was the most commonly injured in both levels, followed by the neck. The leading mechanism of injury resulting in emergency transport was player contact in both competition levels. Strains were the most commonly cited diagnosis in college, most frequently involving the neck. However, fractures were the most common diagnosis in high school. There were no SCAs reported in this sample. In this study, the diagnosis provided was that of the hospital, not the impression of the AT or EMS provider involved in the care of the patient. Examination of the impression of ATs and EMS would provide insight into the decision-making process to activate EMS as well as assess the appropriateness of care delivered.

Coverage of athletics events by EMS has been predominantly for football home games at the secondary school level;[31-34] however, these findings indicate other sports

more frequently require EMS transportation at both the secondary school and collegiate level. The frequency of EMS activations resulting from sports participation in other settings, such as youth or recreation sports, has not been examined. Appropriate medical coverage for athletic events should include the consideration of on-site EMS coverage for sports that frequently necessitate EMS transportation. Emergency medical services are a critical link between ATs and the EDs. Other gaps in the literature include what factors may have contributed to the decision to call for EMS, the medical necessity of the EMS transports, and how EMS managed the patient during their transport.

RELATIONSHIPS BETWEEN ATHLETIC TRAINERS AND EMERGENCY MEDICAL SERVICES

Disagreements Between Athletic Trainers and Emergency Medical Services

In addition to the frequency of EMS transports, Decoster et al.,[29] examined perceived inappropriate healthcare and on-field disagreements between ATs and EMS. Athletic trainers in the high school setting reported more AT-perceived inappropriate health care and on-field disagreements with responding EMS than those in the college setting. Up to 72% of college and 57% of high school ATs reported having preseason planning meetings, but the reporting of a pre-season planning meeting was not associated with episodes of AT-perceived inappropriate care or on-field disagreements in Fall 2008. Emergency medical services providers were surveyed regarding their perceived roles during an emergency at an athletic event, their knowledge of ATs, and if they trust an AT during an emergency.[35] All levels of EMS providers were represented in the sample and were from 18 states. Three overall themes emerged: 1) EMS response to emergencies

during athletic events are determined by their protocols, 2) EMS provider lack knowledge of ATs' emergency training, and 3) previous experiences with ATs guide EMS provider's' trust of ATs. Athletic trainers must be knowledgeable of local EMS protocols, thus emphasizing the importance of creating EAPs together. The familiarity of local ATs and EMS providers should occur beyond the field at the time of an emergency and more often than pre-season.

Perceptions of Emergency Management

Biddington et al.,[36] conducted a study of 1) EMS directors' perceptions of AT's management of emergencies, and 2) ATs' comfort level with managing emergencies. Emergency medical services directors and AT in Pennsylvania were each asked to complete a survey. For EMS directors, the survey asked their perceptions of how ATs managed emergencies. For the ATs, the survey asked participants to report their comfort level in managing emergencies. Eleven items in both surveys asked questions regarding the same emergencies. Emergency medical service directors who reported having a preseason meeting with ATs scored higher on the survey than those who did not, indicating agreement that ATs were able to manage emergencies.[36] A positive correlation existed between athletic trainers' age and comfort level handling emergencies. Athletic trainers were ranked higher in their abilities to manage splinting and bandaging, dislocations, lacerations, and concussions and lowest in their abilities to operate an AED and manage diabetic and respiratory emergencies by EMS directors. Athletic trainers were least comfortable managing diabetic emergencies, traction splinting, use of airway adjuncts, and oxygen administration. While this study was limited to one state, these findings suggest preseason meetings between ATs and EMS are associated with more

favorable perceptions of an AT's ability to manage medical emergencies. Athletic trainers were less comfortable with the management of diabetic and respiratory emergencies and were similarly perceived as being less capable of managing by EMS directors.[36] Collaboration with EMS in the development of EAPs as well as skill training can ensure appropriate management of sport-related emergencies

While sport-related emergencies do not frequently occur, proper recognition, management, and transportation to a higher level of care are essential to reduce morbidity and mortality. Thus far, the examination of sport-related emergencies and the involvement of EMS has been limited to the high school and collegiate settings and has primarily focused on the incidence of EMS activations.[5,29]. The management of sport-related emergencies has focused on the perceptions ATs and EMS providers regarding the appropriateness of care,[29] roles and responsibilities,[35] and ability to perform skills,[36] rather than an objective evaluation of the care provided to the patient.

EMERGENCY MEDICAL SERVICES UTILIZATION

As of 2017, the National Emergency Medical Services Information System (NEMSIS) collected over 7.9 million records of EMS activations from 4,016 agencies in 35 states and territories.[37] In 2014, over 17.5 million 911 responses were recorded in the NEMSIS, with approximately 1.4 million in response to individual less than 18 years old and over 16.1 million in response to individuals over the age of 18.[38] Because not all states are required to report their EMS data, it is unknown how many EMS activations occur each year nationally. Most of the literature available of EMS utilization has focused

on the pediatric population,[7-9,39-41] and none have made direct comparisons between the adult and pediatric populations.

Incident Location for Pediatric Patients

Several studies have examined EMS utilization among the pediatric populations.[7-9,39-41] Males account for the majority of pediatric patients utilizing EMS.[7,9,39-41] Most EMS transports for pediatric patients originate from the residence.[9] In Pennsylvania, less than 1% of EMS activations originated from places of recreation and sport in 2011.[7] However, 11% of EMS activations were considered serious incident calls, 14.1% of which were from places of recreation or sport.[7] In a multi-state study, a recreational or public area was the incident location in 11.8% of cases.[40] In a comparison of school-based and non-school based EMS incidents in South Dakota, 6% of EMS incidents were for school-aged children, 6% of which were to schools.[41] Other public areas accounted for 9.6% of EMS incidents.

Dispatch Complaints of Pediatric Patients

When examining dispatch complaints among pediatric EMS transports, traumatic injury accounted for 35% of EMS activations originating from places of recreation and sport and was the most frequent dispatch complaint for patients aged 5 to 18 year-olds in Pennsylvania.[7] In the same study, serious incident calls were most commonly for respiratory distress, seizure, or altered level of consciousness.[7] Another study, over ten years, examined diagnoses by age group; however, incidents were not limited to a specific location.[9] Neurologic, respiratory, trauma/environmental, and mental disorders were the most common diagnoses in children. Over the study period, the rate of

trauma/environmental diagnoses decreased across all age groups, with an absolute relative reduction of -6.8 per 10,000 children.[9] Being struck by an object and blunt injury were the most common mechanisms of injury reported and were specific to traumatic injuries.[7,40] However, the activity at the time of injury was not examined in either study. In Wisconsin, "Other" was the most common primary working assessment, followed by respiratory distress, seizure, and blunt trauma; however, this study was limited to a single EMS agency.[8] Dispatch complaints of pediatric patients vary and have been related to sport based on the scene (e.g., places of recreation or sport); however, dispatch complaints directly attributable to sport participation have not been examined.

Emergency Medical Services Response and Incident Disposition

Over ten years, 5.7% to 7.5% of children arrived at the ED by ambulance each year.[42] Few studies reported EMS response and transportation mode for pediatric patients.[8,39,40] In a multi-state analysis of pediatric emergency transports, an emergent response to the scene was recorded in 84% of cases.[40] However, an emergency response to a rendezvous location or ED occurred in 39% of cases, indicating the response level was decreased in a large proportion of cases. In this study, the average EMS response time was 9±16 minutes.[40] Within a single EMS agency, 43.9% of transports were by an advanced life support (ALS) unit.[8] In another study, an ALS unit responded in 62.1% of cases.[40] However, the level of response (i.e., BLS or ALS) is dependent on how each agency is staffed, their protocols, and available units at the time of dispatch. When examining the outcome of all EMS activations, transportation occurred in 89% of calls, and care was refused in 7.7% of calls. Two percent of calls were considered treat and release, and the child was transported in a private vehicle in 0.8% of cases.[40] The reasons

for call refusal or for utilizing an alternative means of transportation were not discussed in these studies. Transportation by EMS has also been examined in adult populations.[43,44] From 2004 to 2006, approximately 70 million ED visits occurred for adults aged 19 to 65 occurred in the US.[43] Of these, only 14% arrived by ambulance. In a retrospective study of ED patients arriving at a large urban academic hospital in Missouri in 2001, 6% of patients arrived by bus, 70% arrived by car, 2% of patients walked in, 0.4% arrived by air medical, and 22% arrived by ambulance.[44] A small proportion of patients presenting to the ED arrive by ambulance; however, these studies did not examine the appropriateness of ambulance utilization in these cases. Thus, it is unknown if EMS was over or underutilized by patients presenting to the ED.

One study specifically examined the transportation mode of injured children under the age of 15 arriving at US Trauma Centers.[39] The patients found most likely to use ground ambulance were trauma patients aged 11 to 15 years old, those transported to adult trauma centers, and EDs with an average pediatric inpatient volume of 1 to 126. Patients who used non-EMS transportation (i.e., privately-owned vehicle) were more likely to be transferred to another facility, suggesting an inappropriate choice of destination facility on the part of whoever brought the patient to the ED. In-hospital mortality was higher among patients who arrived via ground or air ambulance compared to those who arrived via non-EMS mode. Similarly, patients who arrived via ground or air ambulance typically had a longer length of stay in the hospital. This study was not specific to children who participated in sports at the time of injury; however, it demonstrates a possible lack of knowledge among the general public when EMS transportation may be appropriate and what the most appropriate facility for care is.

Procedures Performed by Emergency Medical Services for Pediatric Patients

Emergency medical services not only provide transportation to the ED, but they can perform specific diagnostic procedures and interventions en route to the ED. Procedures performed by EMS providers are classified as BLS or ALS. Procedures performed by EMS have been examined in both children[8,9,40] and adults.[45,46] Children have been reported to receive an advanced level of care (i.e., by an ALS unit) 14.2% to 15.6% of transports.[9,40] The most common BLS level procedures performed for children are spinal immobilization, oxygen administration, bandaging and bleeding control, airway maneuvers and devices, ventilatory support, and CPR.[9,40] The most common ALS procedures for children were establishing peripheral intravenous access, endotracheal intubation, established intraosseous access, and needle thoracotomy.[40] Medications are given in less than five percent of transports.[9,40] Drayna et al.,[8] reported less than two percent of pediatric patients required critical interventions including cardiopulmonary resuscitation, bag-valve-mask, advanced airway, intraosseous access attempt, oral airway, defibrillation, or thoracentesis. Interventions were not classified as ALS or BLS, but the most common routine interventions were reported to be checking blood glucose, drug/medication administration, and intravenous access.[8]

Emergency Medical Services Use by Adults

In 2014, 40.76% of EMS responses involved older adults (i.e., ≥65 years old), and 59.24% involved younger adults (i.e., 18 to 64 years old).[46] The most common EMS response was to a home/residence. Places of sport or recreation were not examined specifically; however, “recreation facilities/ bodies of water” accounted for 0.9% and

1.4% of EMS responses for older and younger adults, respectively.[46] Seventy-seven percent of younger and 81% of older adults were treated and transported by EMS.[46] Carlson et al.,[45] determined an average of 1.5 procedures were performed per EMS response for adults 18 years and older. Additionally, therapeutic procedures were performed at a rate of 713.7 per 1000 EMS responses, and monitoring procedures were performed at a rate of 735.5 per 1000 EMS responses. Advanced life support level procedures were infrequent at 713.7 per 1000 EMS responses. The most common procedures performed were peripheral venous access, cardiac monitoring, pulse oximetry, blood glucose analysis, and 12-lead ECG monitoring. Duong et al.,[46] reported older adults were more likely to require care for critical illnesses, including respiratory distress or arrest, syncope, cardiac arrest or disturbance, stroke, shock, hyper- or hypoglycemia, airway obstruction, and diabetic symptoms than younger adults. However, traumatic injury has also been reported as a common complaint among adults.[45]

Factors Associated with Emergency Medical Services Use

Clinical factors associated with EMS use have been examined in adult and pediatric populations.[42-44] In a nationally representative sample of adult ED patients, those who arrived by ambulance were more likely to have chief complaints of chest pain and shortness of breath.[43] Patients arriving by other means of transportation were more likely to have chief complaints of headache, back pain, and upper extremity laceration.[43] The average age of patients who arrived by ambulance to a single urban hospital was older than patients who arrived by any other type of arrival.[44] Patients arriving by ambulance patients also had a higher triage acuity level upon arrival. When examining specific mechanisms of injury, victims of motor vehicle collisions, those who had

suffered a gun or stab would or who fell zero to ten feet were more likely to arrive by ambulance compared to those without those injuries.[44] Of these mechanisms of injury, it is possible a fall from zero to ten feet could have occurred during sports participation. However, the other common mechanisms of injury are unlikely to have been directly or indirectly related to sports participation. Among children, ambulance arrival was more common in children of black race, aged 12 to 18, who sustained an injury or poisoning, lived in a metropolitan statistical area, had a critical care status, and who arrived overnight.[42] Additionally, children who arrived by ambulance underwent more diagnostic tests and procedures in the ED and were more likely to require hospital admission.[42] Understanding the clinical factors associated with EMS and the subsequent ED care received can be used to assess medical necessity and improve the determination of the appropriate mode of transportation.

HEALTHCARE COSTS AND UTILIZATION ASSOCIATED WITH SPORT-RELATED INJURIES AND AMBULANCE USE

Healthcare Costs and Insurance Status

Median ED charges for children reported for sport-related injuries was $1013, with an inter-quartile range of $637 to $1630.[2] However, a study examining cost of injury among North Carolina high school athletes reported a mean cost of $14,343 for injuries seen in the ED and mean cost of $166,960 for those that resulted in hospital admission.[47] Among pediatric hospital admissions for sports-related injuries from 2000-2003, total hospital charges were $485,352,952, with a median charge of $12,777 and mean charge of $9,299 per discharge.[14] Charges due to sport-related injury were more than those

resulting from motor-vehicle crashes, but less than those resulting from all-terrain vehicle crashes.[2] Insurance status has been reported in multiple studies.[2,4,12-14] The majority of children and adults presenting to EDs with sport-related injuries are insurance by private insurance, ranging from 63% to 79% of patients.[2,4,12,14] The proportion of children and adults with public insurance (e.g., Medicaid) ranged from 13% to 29%, and anywhere from 4% to 15% were uninsured or self-pay. Owens et al.,[13] reported expected approximate payor estimates of 37% to 71% billed to private insurance, 17% to 47% to Medicaid, and 2% to 10% to uninsured patients. However, this study was not specific to sport-related injuries. Studies have not yet been done examining the cost of sport-related injuries presenting to EDs among the adult population. Nor have any estimated the cost of EMS transportation to the ED for a sport-related injury.

Economic factors, particularly insurance status, have been examined in association with medically unnecessary ambulance use.[43,44,48] The association between EMS use and insurance status is independent of patient age, race, ethnicity, sex, transport to a hospital in a metropolitan service area, triage acuity, the region of the country, and chief complaint.[43] In the same study, patients with Medicaid or no insurance had an increased odds of arrival by ambulance than those with private insurance.[43] Ruger et al.,[44] also found that patients with Medicare, Medicaid, or "self-pay or uninsured" are more likely to arrive by ambulance even after controlling for age, acuity, and severity of the injury. Emergency department patients with private insurance arrived by ambulance in 11.5% of cases, whereas patients without insurance arrived by ambulance in 13.4% of cases, and those with Medicaid arrived by ambulance in 15.8% of cases. An analysis of medically unnecessary ambulance transports found that patient insurance type was a

significant predictor of unnecessary ambulance transport.[48] In this study, 59% of unnecessary ambulance transports were by Medicaid recipients. However, this study was limited to five EDs in New York.

MEDICAL COVERAGE PROVIDED TO ATHLETES

Types of Medical Professionals Providing Medical Coverage

Several states have examined medical coverage of interscholastic sporting events in the US by surveying school administrators, primarily athletic directors.[31-34,49,50] In most of these studies, the type of medical coverage for football was of primary concern.[32-34,49,51] States represented included North Carolina,[31] South Carolina,[32,50] Wisconsin,[33] and California.[34,49] However, the studies in California were not state-wide and limited to the school district level. In North Carolina, 48% of schools denied having access to a nationally certified AT, and only 20% reported having a state-certified AT.[31] In South Carolina, 78% of responding schools reported having an AT, with 10% reporting having two or more at their school.[50] Between 24% and 87% of schools reported having an AT present for football coverage to some degree (e.g., routinely, practices, scrimmages, games), but more often for games than practices or routine coverage.[32-34,49] In the study by Rutherford et al.,[33] 87% of respondents reported having a "designated trainer" for football; however, only 85.5% were certified ATs. At the time this study was conducted, coaches, teachers, and students were also considered to be "trainers" at some responding schools. It is also to essential to consider the lack of certification or licensure in California at the time these studies were conducted,[34,49] so it is unknown what the certification levels, if any, were held by the individuals reportedly providing athletic

training coverage at those schools. Additionally, in the study by Salzman et al.,[49] responses categorized as “rarely”, “often”, and “always” were combined together in their analysis, so it is possible the combined proportion overestimates the presence of medical care at the responding schools.

In addition to examining the prevalence of sports coverage by ATs, coverage by physicians, EMS and others were included.[31-34,49] Physicians were present for 36% to 73% of home football games, and zero to 10% of schools reported a physician present for practices.[32-34,49] Medical coverage by physicians for sports other than football appears to be lacking. For football practices and scrimmages, between 14% and 80% of schools reported having an ambulance on-call or standby.[32-34] For home football games, an ambulance was on-site at 37% to 78% of schools.[31-33,49] In 47% to 78% of schools, an emergency medical technician (EMT) or Paramedic was present to provide medical coverage, but sans ambulance.[33,49] Medical coverage by EMS for sporting events varies. Similar to physician coverage, EMS coverage for football home games appears to be prioritized over other sporting events. Other medical professionals providing care to athletics included nurses, chiropractors, and physicians assistants.[32-34,49] Each of these studies reported how often various medical professionals provided medical coverage for sporting events; however, it is not clear if or when multiple medical professionals were present for the same events types. Additionally, some studies only examined medical coverage for football events,[32-34] making a comparison of medical coverage across sports and events types challenging. In North Carolina, 51% of responding schools reported reliance on non-licensed, non-certified sports medicine personnel for coverage of athletic events.[31] The majority of these studies were published between 1994 and 2006,[31-34]

making these findings out-dated. Within the last five years, the literature examining medical coverage of interscholastic athletics programs is limited and does not provide a comprehensive assessment of who is providing medical care to athletes in addition to ATs.[49,52]

A quintessential study examined what types of medical care providers, if any, provided care to secondary school athletes when an AT was not employed.[52] Principals and athletic directors from public and private secondary schools across the US were surveyed regarding the type of medical coverage available for their athletics teams, particularly for home game events. Nationally, 25% (n=552/2180) of public and 63% (n=425/668) of private schools reported having no medical caregiver for their sports competitions. Of the public schools that reported having a medical care provider other than an AT, 80% (n=1309) had EMS present, 17% (n=272) had a physician present, and 10% (n=156) had a first responder present. Of the private schools that reported having another medical provider present, 49% (n=120) had EMS present, 22% (n=53) had a nurse, and 21% (n=51) had a physician. Athletic trainers are the preferred on-site medical provider for secondary school-aged athletes.[53,54] A qualified medical person, other than an AT, may still be appropriate depending on the type of event and services being provided;[54] however, this study focused on medical coverage for home competitions. These recent findings provide a nationally representative snapshot of the medical coverage provided by schools instead of ATs.

A retrospective study of sudden deaths in secondary schools examined the presence of ATs and EAPs at the time of sudden death.[28] Athletic trainers were not present during 62% (n=47) of the sudden death events, and no medical professional was

present in 42% (n=32) of cases. An AT was employed in 61% (n=46) of the schools but was not present at the time of death in 37% (n=17) of cases. An EAP was in place at 66% (n=50) of schools and was followed 100% of the time. Thirty-eight percent of survey respondents did not have an EAP in place at the time and still did not at the time of the survey, a concerning finding. Seventy-eight percent of survey respondents reported their coaches had received emergency training, which was applied in 58% (n=34) of sudden death events. Sudden death events are unpredictable at it may not be realistic or feasible to have an AT immediately available during all athletic activities, particularly when multiple athletic events are happening at the same time. Coaches who had received emergency training applied their skills in the majority of sudden death events. The findings from this study support providing emergency training for coaches and establishing an EAP.

Factors Associated with Type of Medical Care Provided

Perceived adequacy of medical care by school administrators was only assessed in one study.[31] When asked if respondents felt their school had adequate medical coverage, 51% (n=70) reported at least adequate coverage, while the other 49% (n=67) felt their coverage was inadequate. Other studies assessed factors associated with the type of medical coverage provided by secondary schools.[33,50,51] Specific to the Appropriate Medical Care Assessment Tool, variables significantly associated with the Appropriate Care Index were the presence of a certified AT, the source of the certified AT, number of certified ATs, school size, school's public or private status, sports medicine supply budget, and school setting.[50] Variables not found to be associated with the Appropriate Care Index were distance to the nearest medical center, varsity football regional

championships, region of the state, and free or reduced lunch qualifiers. Similarly, school size has been associated with the type of medical coverage provided.[33] Larger schools more frequently reporting coverage by a physician or certified AT, whereas smaller schools more frequently reported medical coverage by EMTs or Paramedics. Lack of funding and lack of certified personnel, particularly in rural areas, has been identified as a barrier to meeting appropriate medical care standards.[51] All institutions sponsoring athletics should strive to meet best-practice recommendations for appropriate medical coverage; however, barriers exist. These findings are also limited to the secondary school setting, and likely differ from barriers existing at other competition levels or recreational leagues.

Medical Coverage Outside the Secondary School Setting

Medical coverage of youth and collegiate sporting events has been less frequently studied than in the secondary school setting. However, some researchers have examined medical coverage provided for specific events, including club sports,[55] and youth Olympics.[56] Post et al.,[55] examined and compared medical coverage of high school and club sport coaches in three sports: basketball, volleyball, and soccer. Thirty-one percent of high school coaches and 8.8% of club sport coaches reported that an AT was responsible for medical care during practices. For competitions, 57.9% of high school coaches and 31.2% of coaches reported that an AT was responsible for medical care. However, this study abstract did not describe where the study sample was derived from.

In multiple studies, the “trainer” athletes had access to was not a certified AT.[31,33,34] Many institutions also rely on EMS to provide medical care, sometimes instead

of an AT.[31-34,52] Other medical professionals providing medical care to athletes included physicians, nurses, coaches, teachers and students.[31-34,52,55] Medical coverage of sporting events varies considerably between states in the secondary school setting and has not been well examined in other athletic settings (e.g., collegiate, youth, recreation). A recent study of sudden death in youth sports shows that deaths have occurred in middle school, youth sports league and recreational settings during games and practices.[25] Ensuring access to qualified, trained personnel during athletics activities is a key component to providing comprehensive, appropriate medical care at all competition levels.[53,54,57,58]

ATHLETIC TRAINING SERVICES IN SECONDARY SCHOOLS

Prevalence of Athletic Training Services

Numerous studies within the last ten years have investigated athletic training services in secondary schools across the US.[10,59-64] The National Athletic Treatment, Injury and Outcomes Network,[59] Athletic Training Location And Services (ATLAS),[10,61-63] and Athletic Training Practice-Based Research Network[64] databases have each been used to characterize athletic training services. Services were characterized by the proportion of high schools with access to athletic training services,[10,61-63,65] level of athletic training services provided (e.g., full-time, part-time),[10,61-63] athletic training coverage provided,[60,65] and types of services provided.[60,64,66] Studies examining athletic training services provided at the youth, or collegiate level were not found.

From 2013-2016 the availability of athletic training services was examined nationally in US public and private secondary schools.[10,61-63] Among a sample of 8509 public secondary schools, 70% (n=5930) reported having athletic training services, and

86% (2394284/2787595) of all student-athletes had access to athletic training services.[63] More specifically, 37% (n=3145) of schools reported having access to full-time athletic training services, 31% (n=2619) to part-time and 2% (n=199) per diem. Among private secondary schools (n=2,044), 58% (n=1176) had athletic training services, and 84% (n=281285/336165) of all student-athletes had access to athletic training services.[61] By service level, 28% (n=574) of schools had full-time athletic training services, 25% (n=501) had part-time athletic training services, and 4% (n=78) had per diem services. More public schools (70%) provided athletic training services than private schools (58%); however, the proportion of student-athletes with access to athletic training services was comparable between the two.[62] Providing any level of access to an AT is a starting point. However, most secondary schools do not provide a full-time AT, thus limiting their student-athletes' access to quality medical care and potentially vulnerable in the event of an emergency for a substantial portion of their athletics activities. These studies did not examine access to alternative medical services when an AT was not available.

In February 2018, the mapping of AT services across the US in the ATLAS Project was completed.[10] The ATLAS database contains data on over 20,000 secondary schools with interscholastic athletics programs that have a least one grade from nine through 12. Fifty-percent of schools that reported having access to athletic training services completed the ATLAS survey (n=6754). Full-time athletic training services were defined as ≥30 hours per week, ≥ five days a week, ≥ ten months per year, and services to only one school. Part-time athletic training services were defined as anything less than full-time. The percentage of schools with access to athletic training services by state

ranged from 14% in Alaska up to 90% in New Jersey (shown in Figure 2.1). Overall, 66% (13473/20272) of secondary schools receive some level of athletic training services, with 53% (n=7119) being considered full-time. States with the highest proportion of schools without AT services were Alaska, Oklahoma, Idaho, Arkansas, and North Dakota. Sixty-nine percent of public schools had access to athletic training services, compared to 70% previously reported by Pryor et al. in 2016.[63] A 14% reduction in athletic training services at private schools was reported. Athletic training services at the per diem level were not examined in this study.

In Wisconsin, athletic training services were examined by calculating AT hours per week and the number of athletes seen per AT hour, as opposed to employment status (i.e., part-time, full-time, PRN).[65] Socioeconomic characteristics of the schools were as examined by determining the proportion of percent free and reduced meals and median household income. Over 94% (n=402/492) of respondents reported providing athletic training services to student-athletes, a higher proportion of schools than was reported in other literature.[10] However, this difference is likely due to the sampling strategy used in this state-level study. Two-thirds reported having an AT available between 3 PM and 6 PM an average of 5 days a week. Other national-level studies that examined athletic training coverage reported between 47% and 55% of school ATs providing practice coverage every afternoon.[60,63] Only 71.2% of ATs always covered games.[60] A median of 12 AT hours were reported per week, ranging from 3 to 20 hours. A median of 15 student-athletes was seen per AT hour, ranging from 10 to 30 student-athletes. Athletic trainers at schools with fewer student-athletes qualifying for free and reduced meals and higher median household income were responsible for providing care to fewer athletes

per hour. These findings provide additional evidence for the association between the proportion of students qualifying for free and reduced lunch and the level of medical care available.[50]

Types of Athletic Training Services Provided

In addition to determining the prevalence of athletic training services across the US, researchers have also sought to describe the types of services athletic trainers provide.[60,64,66] Over three years, ~ 210,000 athletic training room visits were recorded in the National Athletic Treatment, Injury, and Outcomes Network, 70% of which were for non-time loss injuries.[59] Therapeutic activities were the most common service rendered (45.4%). In contrast, Lam et al.,[64] reported the most common services provided were taping (38.2%), followed by ice or hot pack (25.8%). In this study, 48% of patient encounters were considered preventive services. Evaluations accounted for approximately 10% of patient encounters. In a survey of ATs working in the secondary school setting, 72% of ATs reported they performed on-site evaluations daily; however, only 60.3% provided treatments, and 39.0% provided rehabilitation services.[60] Kerr et al.,[66] also surveyed a subset of ATs regarding their employment status and examined athletic training services specifically for football. Of the respondents, only 31.8% were full-time. Full-time ATs reported higher overall injury rates than outreach ATs; however, injury rates did not differ between the two employment statuses when restricted to non-time loss injuries. Athletic trainers provide a variety of services to their patients, with nearly half being considered preventive. Most ATs provide on-site evaluations daily; however, evaluations accounted for a small proportion of overall patient services

provided. It is unknown what proportion of athletic training services is considered for acute injury care and management.

The model of employment varies for ATs. Employment model is a variable collected in the ATLAS survey for schools have access to athletic training services. In the most recent ATLAS Project report,[67] the most prevalent employment model was through a medical or university facility, accounting for 57% overall (public and private secondary schools). Twenty-five percent of ATs were hired as a school district employee, 11% as a school district teacher, 4% as an independent contractor, and 3% were unknown. Similar proportions were seen within public and private secondary schools when examined on their own. The types of AT services provided have been examined by the athletic training service level, but not yet by the employment model. It is possible the employment model may affect the relationships ATs have with their administrative staff, coaches, and student-athletes as well as the resources they may have available to them to provide care at their school. Relationships with key stakeholders (e.g., athletic director, school resource office, local EMS) and available resources (e.g., AED, emergency equipment) can directly impact the ability to provide care in an emergency and is therefore worth examining in relation to the occurrence of EMS activations.

Barriers to Providing Athletic Training Services

Barriers to hiring ATs in the secondary school setting were identified by interviewing athletic directors using a semi-structured interview.[68] Athletic directors were asked about their views on ATs, medical care provided for student-athletes, and risk of catastrophic injury or death for student-athletes. The budget was identified as a limiting

factor for hiring ATs according to the majority of athletic directors interviewed. Other barriers identified were a lack of support from supervisors and misconceptions about the role of an AT. In rural areas, a heavy reliance on EMS was reported instead of an AT. Some interscholastic leagues were reported to only mandate medical personnel for football games, and therefore athletic directors rely on coaches and EMS for emergencies. Similarly, Pryor et al.,[63] identified budgetary constraints, school size, and lack of awareness of the athletic trainer's role as barriers to providing athletic training services.

In the US, 66% of secondary schools have access to athletic training services; however, only 35% of schools have full-time athletic training services.[10] Less than half of secondary schools have practice coverage by an athletic trainer every afternoon, and approximately 71% of ATs report always covering games.[60,63] Thus, secondary school athletes remain without access to an AT during a substantial portion of their sport participation time. Recall, at the time of a sudden death event, ATs were only employed in 61% of the schools and not present for 37% of the deaths.[28] In schools with limited access to AT services, student-athletes likely remain vulnerable during a potential sport-related emergency. When available, ATs have been reported to see 10 to 30 athletes per hour;[65] however, the number of athletes seen has been shown to vary based on school socioeconomic status. Most athletic training services provided are for non-time loss injuries and commonly include therapeutic activities.[59] Examination of athletic training services provided for time-loss or severe injuries that may have warranted immediate and emergency care has not been examined. The characterization of athletic training services

provided at other competition levels (e.g., youth, collegiate, professional) has yet to be done.

Athletic trainers are typically responsible for emergency planning, EAP development;[69,70] AED maintenance, storage, and use.[71,72] Medical coverage and emergency preparedness in less common settings (e.g., recreational leagues, non-interscholastic tournaments or competitions, non-organized sporting activities) are largely unknown. The presence of an AT is associated with the presence of EAPs and AEDs.[73,74] Therefore, it is unlikely that proper steps have been put in place to provide appropriate medical care and plan for sport-related injuries, especially those that may require EMS transport to the ED. A gap in the literature currently exists examining the association between access to athletic training services, emergency preparedness, and the management of sport-related emergencies.

Impact of Athletic Trainers on Healthcare Costs

The cost of hiring an AT has been identified as a barrier to employing ATs in the secondary school setting.[63,68] In Oregon, a team of researchers conducted a microsimulation analysis to assess the impact of athletic training services provided in high schools on medical payments and utilization (e.g., emergency visits and total visits for AT relevant claims).[75] Medical claims for patients aged 14 to 18 years were obtained from the Oregon All Payer All Claims dataset. Zip-codes were used from medical claims to link patients with Oregon high schools, which were classified as having an AT or not having an AT, and the probability of access to athletic training services was then determined for each patient. Among patients with Medicaid, 14% of medical visits were

to the ED compared to 4% of visits among commercially insured patients. Those with commercial insurance had higher payments, more overall visits, and fewer emergency department visits compared to those with Medicaid. Probable access to athletic training services was associated with significantly fewer ED visits among both insurance groups.[75] A preliminary study conducted using Maine All Claims data compared ED utilization for ankle sprains, concussions, and fractures between high schools with and without ATs.[76] Aggregated counts of ED visits for each diagnosis were determined for each zip-code, and each zip-code was related to a high school. Their results demonstrated significantly decreased ED utilization rates for sprains; however, a significant difference in the rates was not seen for fractures nor concussions. The benefits of access to athletic training services related to ED visits may also extend to the utilization of EMS as a means of transportation to the ED; however, this has yet to be examined.

CONCLUSION

Sport-related emergencies represent a small proportion of all sport-related injuries sustained; however, when they do occur, prompt recognition, management, and transportation to the ED are key. Until now, studies examining sport-related injuries resulting in EMS activations have been limited to the high school and collegiate populations,[5,29] although we know deaths have occurred in youth recreation populations as well.[25] Several studies have examined severe, rare, catastrophic injuries and fatalities in the youth, high school, and collegiate populations, [19-25] but the involvement of EMS in the transportation or management of these injuries was not examined. The management of sport-related emergencies has been limited to the perceptions of ATs and EMS providers as opposed to objectively and quantitatively examining the actual care provided

to the patients.[29,35,36] Data collected from EMS agencies that have been used to examine sport-related injuries has been limited in scope.[7] The NEMSIS database presents an opportunity to examine EMS activations due to sport participation across a diverse patient population, including those less represented in the current literature.

The most recent report from the ATLAS project found that only 66% of secondary schools in the U.S. have access to athletic training services, ranging from 13% to 90% within states.[67] Athletic training services vary greatly across the U.S. by service level and employment model. Athletic trainers are typically the individuals responsible for emergency planning, EAP development, and AED maintenance, storage, and use.[69-72] Further, having an AT is associated with the presence of EAPS, venue-specific EAPs, and AEDs in secondary schools.[73,74] Therefore, in schools with limited or no access to an AT, it is unlikely that proper procedures have been put into place for responding to a sport-related emergency. Additionally, it has been estimated that access to an AT results in fewer ED visits for student-athletes compared those without access to an AT.[75] It is unknown if there is an association between access to athletic training services and the management of sport-related emergencies, specifically the incidence of EMS activations.

Therefore, the aims of this study are to 1) describe EMS activations for sport-related injuries from a national sample during the 2017 to 2018 years, 2) describe EMS management (i.e., incident/patient disposition, primary impression, procedures performed) of sport-related injuries during the 2017 to 2018 years, 3) compare the incidence of EMS activations for sport-related injuries among high school-aged patients (i.e., 13-18 years old) between zip-codes by athletic training service level (i.e., full-time, part-time, none) and employment type from 2017 to 2018.

Table 2.1a Comparison of Codes and Search Terms Used for Sport-Related Injury Case Selection

Study (Author, Year)	Sport-Related Injury Case Selection
Harmon, 2018[1]	E007 (.0-.7, .9) Sports/athletics played as a group or team E006 (.2, .3, .6, .9), E008 (.0-.2, .4) Sport/activities played individually E886.0, E917 (.0, .5) Fall, or struck by/striking against, in sports E008.9 Other specified sports/athletic activity E005 (.0, .2, .4, .9) Dancing and other rhythmic movement E005.1, E001 (.0-.1), E009 (.0-.9), E010 (.0-.9) Cardiorespiratory and muscle strengthening activities, not elsewhere specified E005.3, E006.5, E007.8, E008.3, E884.0 Activities involving play and other activities usually unstructured E006.4, E800-E807 (.3), E810-E819 (.6), E820-E825 (.6), E826 (.1, .9), E827-E829 (.1) Pedal cycle E002 (.0-.9), E830-E838 (.0, .1, .3, .4, .5, .8. ,9), E883.0, E902.2, E910 (.0, .1, .8, .9) Recreational activities involving bodies of water E003 (.0-.9), E004 (.0-.9), E006 (.0, .1), E820-E821 (.0, .1, .5, .8, .9), E822-E825 (.5), E826-E829 (.2), E885 (.0-.2), E922 (.4, .5) Other outdoor recreational activities E849.4 Injury occurred at a place of recreation or sport, no further detail
Nalliah, 2014[4]	E886.0 Falls due to tackles in sports E917.0 Struck against during sports without fall E917.5 Struck against during sports with subsequent fall Type of Injury (CCS codes 225-236, 239, 240) E850 (.0, .11, .12, .2, .3, .4, .5, .9) Types of concussion
Nabaweesi, 2018[2]	E866.0 E917.0 E917.2 E917.5
Abbreviations: CCS (clinical classification software) code	

Table 2.1b Comparison of Codes and Search Terms Used for Sport-Related Injury Case Selection

Study (Author, Year)	Sport-Related Injury Case Selection
Bayt, 2016[11]	NEISS product codes with descriptions for football, basketball, soccer, baseball, softball, swimming, wrestling, volleyball, cheerleading, gymnastics, track and field, dancing, lacrosse, ice skating, ice hockey, martial arts, and golf
Padegimas, 2016[3]	Terms searched for: athlete, athletics, all-terrain vehicle, baseball, basketball, catch, cycle, cycling, dance, fencing, football, game, golf, hockey, horse, judo, jump, kick, kickball, lacrosse, lift, martial arts, motocross, rock climbing, skate, skateboard, skating, ski, snowboard, soccer, softball, stretch, swim, tag, tennis, throw, ultimate frisbee, volleyball, weight lifting, weight training, wrestle, wrestling
Burt, 2001[12]	Group sports activities: basketball, football, baseball-softball, soccer, or other group Individual sports activities: pedal cycling, snow sport, water sport, gymnastics-cheerleading, ice or roller skating, skateboarding, exercise-track, playground, recreational sport, combative, other sport Non-sport: all other specified activities Unspecified cause: 000, E928.9, E988.9, or "unknown"

Abbreviations: NEISS (National Electronic Injury Surveillance System)

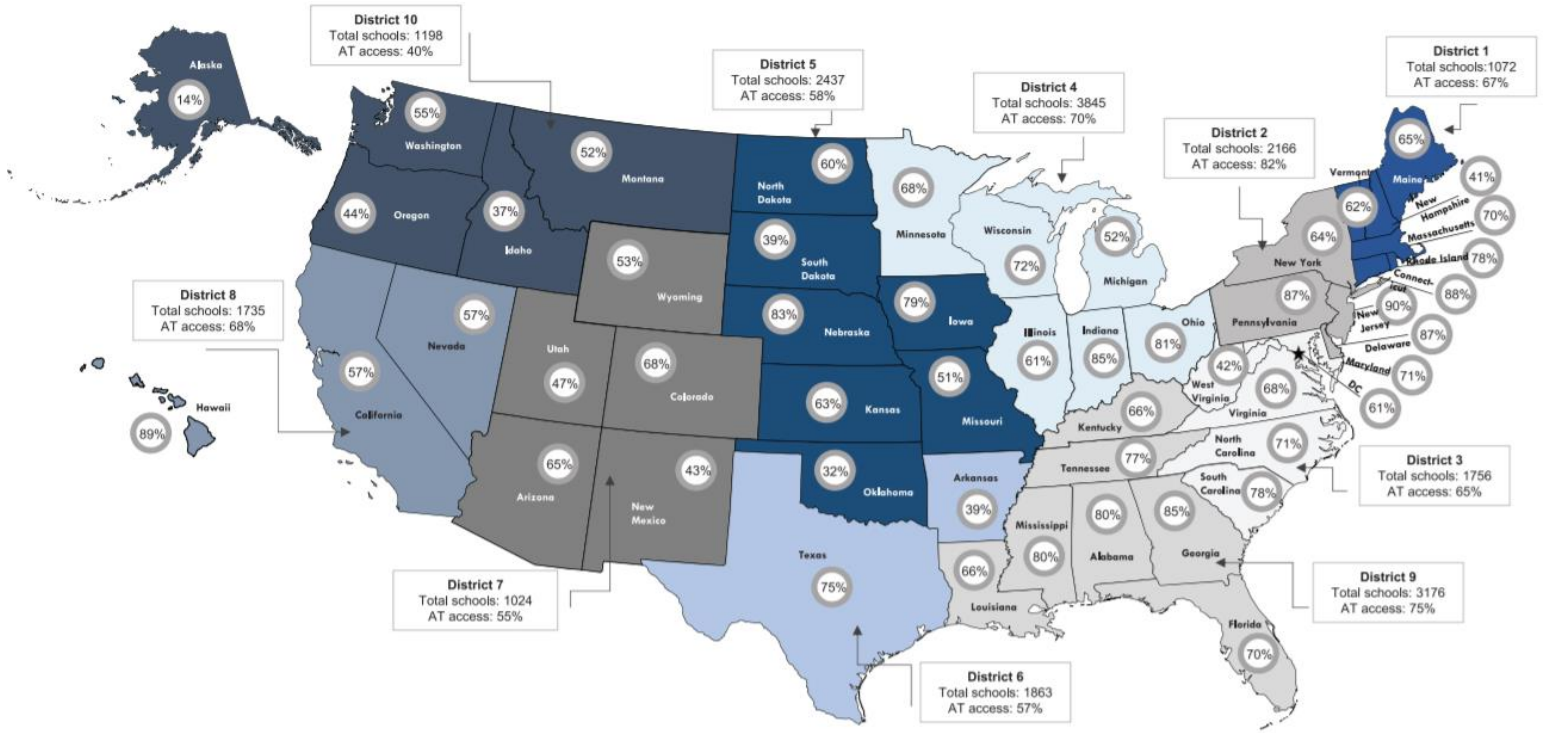

Figure 2.1 Percentage of Schools by State and NATA District with Athletic Trainer Services[10]

CHAPTER 3

METHODS

STUDY DESIGN

Aims 1 and 2 utilized a descriptive epidemiological design. Data was obtained from the NEMSIS for the years 2017-2018. Emergency medical services activations included in this study were limited to 9-1-1 responses for a sport-related injury for individuals aged 3 to 99. This range was selected due to 3 being the typical age at which children begin to participate in formal sporting activities, and 99 being the highest defined upper age limit for the world master's athletics.[77] Aim 3 utilized a retrospective cohort design with selected NEMSIS data from the years 2017-2018, limited to EMS activations for high school-aged patients (i.e. 13-18 years), and ATLAS data from the same years. The year span 2017-2018 was chosen because the NEMSIS upgraded to Version 3 utilizing ICD-10-CM codes on January 1st, 2017 and the mapping phase of the ATLAS Project began on June 30th, 2016.[10,37]

DATA SOURCES

The NEMSIS collects data voluntarily reported by participating EMS agencies across the United States using compatible documentation software. For each EMS activation, a patient care report is completed by the EMS provider. Emergency medical services agencies determine which elements to include in their documentation but must include required national and state-level elements. Starting in 2017, the NEMSIS utilized

ICD-10-CM codes. The 2017 Public-Release Research Dataset included over 7.9 million EMS activations from 4,016 EMS agencies across 35 states and territories.[37] The 2018 Public-Release Research Dataset from the NEMSIS included over 22.5 million EMS activations from 9,599 EMS agencies across 43 states and territories.[78] Each public release dataset contained all required national-level variables. Data received from participating agencies was checked by the NEMSIS Technical Assistance Center for completeness, logical consistency and formatting, and quality assurance. All data was de-identified. In addition, the Centers for Medicare and Medicaid Services (CMS) ambulance fee schedule public use files for the 2017 and 2018 calendar years were obtained from online.[79]

The ATLAS Project includes information on 16,076 public secondary schools and 4,196 private schools across all 50 states and the District of Columbia; however, only schools with an interscholastic athletics program for grades between 9-12 were included in their analyses.[10] Athletic trainers at these schools were then contacted and asked to provide information regarding the level of AT services they provide at their school (i.e., full-time or part-time) and their employment type (i.e., school district, school district with teaching responsibilities, or medical/university facility). The ATLAS database has combined data from the National Center for Education Statistics Database, US Census Database, and the ATLAS online survey. The survey distributed to secondary school ATs for the ATLAS Project underwent a process of content validity prior to distribution.[10] As of December 2018, the ATLAS Project successfully mapped 100% of public and private secondary schools in the US and surveys completed by approximately 58% of schools who reported having AT services.

STUDY PROCEDURES

For this study, data requests were submitted to the principal investigator of the NEMSIS for the 2017 and 2018 Public-Release Datasets and to the Korey Stringer Institute for the most recent data from the ATLAS Project, including the years 2017 and 2018. The variables collected from each database are outlined in Table 3.1. The ATLAS mapping data requested for this study was presence of an AT (yes/no), AT service level (full-time, part-time, none), and school zip-code. The ATLAS survey data requested was presence of an AT (yes/no), level of AT services the school receives (full-time or part-time), employment provider type (i.e., school district, school district with teaching responsibilities, medical/university facility), and if other medical services were present at home games for football and all other sports. Additionally, American Community Survey data collected by the ATLAS Project including median household income, median family income, number of households, number of families, and socioeconomic status was requested. Once received, a file was created to code the existence of an AT and their employment level by zip-code. Zip-code is considered a state-level variable by the NEMSIS and could not be included in the requested data. Therefore, the zip-code coding scheme was sent to the NEMSIS Technical Assistance Center who created a new blinded variable for zip-code which was then included within the requested data.

A sport-related injury was operationally defined as an EMS activation within the NEMSIS based on incident location type and cause of injury. The ICD-10-CM codes were selected within the patient care report as determined by the EMS provider. *Incident location type* is defined as the kind of location where the incident happened.[80] *Cause of injury* is the category of the reported/suspected external cause of the injury.[80] Reports

were narrowed initially from the dataset by any cause of injury documented as being directly due to sports activity and/or the incident location type documented as occurring at a sports and athletic area. Second, the resulting cases in which the cause of injury *or* incident location type were met, were then reviewed by a panel of sports injury experts to determine if they were likely due to sports participation. Those determined to be a sport-related injury were kept in the dataset. This process, with the corresponding ICD-10-CM codes, are presented in Figure 3.1.

NEMSIS VARIABLE DEFINITIONS[80]

Patient age (in years), U.S. census division,[81] U.S. census region,[81] and urbanicity[82] were variables calculated and provided by the NEMSIS within their dataset, but not directly entered by the EMS provider who completed the patient care report.

Chief Complaint Organ System was the primary organ system of the patient injured or medically affected as determined by the EMS provider.

Chief Complaint Anatomic Location was the primary anatomic location of the chief complaint as identified by EMS providers.

Complaint Reported by Dispatch was the complaint dispatch reported to the responding unit.

Primary Symptom was the predominant sign and symptom present in the patient or observed by EMS providers.

Other Associated Symptoms were other symptoms identified by the patient or observed by EMS providers.

CMS service level was based on the level of care and services provided to the patient during transport and was documented by the EMS provider for each encounter. Each service level is reimbursed at a different rate by the CMS and corresponds to a relative value unit accounting for the resources associated with providing care at each level.[79]

Primary role of the unit was the type of EMS unit (e.g., ground transport, non-transport assistance, air-transport) which responded to the specific event.

Level of care of this unit identified the level of care the EMS unit was capable of providing, regardless of patient need, based on the unit's EMS provider staffing and treatment capabilities. For example, if a unit was staffed with a Paramedic, but the unit was licensed or stocked at a basic life support (BLS) level, the appropriate level of care was "BLS-Basic".

Incident/patient disposition was the resulting treatment and/or transport of the EMS event (e.g., call cancelled prior to arrival at scene, patient refused evaluation/care, patient treated and transported by EMS).

Provider's primary impression was the EMS provider's impression of the patient's predominant problem or most significant condition which led to the management procedures (treatments, or medications, or monitoring).

Provider's secondary impression was the EMS provider's impression of the patient's secondary problem, if one existed, which led to additional management procedures.

Procedures were any type of care performed on the patient, not including those documented as a vital sign.

Possible injury indicated whether an injury (e.g., traumatic) mechanism occurred to the patient resulting in the EMS activation.

It is important to note that not all variables were required to be completed for every electronic patient care report.[83] Variables collected by the NEMSIS were designated as either mandatory, required, recommended, or optional. All variables included in this study were either mandatory or required. Mandatory variables were required to be completed by the EMS provider for every report. Required variables had to be completed for every report, but "not values" (i.e., not applicable or not reported) were allowed to be selected.

Additional variables created for the purpose this study were *EMS disposition* (if the EMS activation resulted in treatment and transportation by EMS) and the *level of care provided* to the patient (BLS or ALS). The variable *EMS disposition* was determined using the NEMSIS variable *incident/patient disposition*. Cases treated and transported by EMS included those documented as "patient treated, transferred care to another EMS unit" and "patient treated, transported by this EMS unit". All others were considered not to be transported by EMS. The *level of care provided* to the patient was determined using the NEMSIS variable *CMS service level*. Cases considered BLS were defined as "BLS" or "BLS, Emergency". Cases considered ALS were defined as "ALS, Level 1", "ALS, Level 1 Emergency", "ALS, Level 2", "Paramedic Intercept", "Specialty Care Transport", "Fixed Wing Airplane", and "Rotary Wing (Helicopter)".

STATISTICAL ANALYSIS

Data were analyzed using SAS® software (Version 9.4, SAS Institute Inc., Cary, NC, USA). Frequencies and proportions were calculated for all variables of interest. The mean and standard deviation were calculated for patient age.

Aim 1

The age groups "pediatric" (<18 years old) and "adult" (≥18 years old) were created to allow for comparison of chief complaint anatomic locations and organ systems. Injury proportion ratios with 95% confidence intervals were calculated to compare chief complaint variables by age group. Confidence intervals not including 1.00 were considered statistically significant. Cases in which a required variable was coded as "not applicable" or "not recorded" were considered as not documented and therefore excluded from the analyses.

Aim 2

Research Question #1: How do EMS providers manage sport-related injuries (i.e., incident/patient disposition, primary impression, procedures performed)? Frequencies and proportions were calculated for primary role of the unit, level of care of the unit, possible injury, incident/patient disposition, provider's primary impression, provider's secondary impression, and procedure.

Research Question #2: What types of sport-related injuries are more likely to result in EMS transport? The dependent variable for this analysis was *EMS disposition*. The independent variables included in the initial model were patient age group, patient

gender, urbanicity, U.S. Census Region, possible injury, chief complaint anatomic location, and chief complaint organ system. The variables patient race and CMS Service Level were excluded from the model due to the large proportion of cases where these were not documented. Additionally, the variables primary impression, cause of injury, incident location type, and procedure were not included in the model due to the utilization of ICD-10-CM codes for EMS providers to select in their patient care report, prohibiting meaningful and accurate calculation of odds ratios for these variables. A stepwise multiple logistic regression was performed to determine the odds ratios for which types of EMS activations were more likely to result in treatment and transport by EMS. Odds ratios with 95% confidence intervals excluding 1.00 were considered significant.

Research Question #3: What types of sport-related injuries transported by EMS were more likely to receive an ALS level of care? The dependent variable for this analysis was *level of care provided*. The independent variables included in the initial model were patient age group, patient gender, urbanicity, U.S. Census Region, possible injury, chief complaint anatomic location, and chief complaint organ system. The variables patient race and CMS service level were excluded from the model due to the large proportion of cases where these were not documented. Additionally, the variables primary impression, cause of injury, incident location type, and procedure were not included in the model due to the utilization of ICD-10-CM codes for EMS providers to select in their patient care report, prohibiting meaningful and accurate calculation of odds ratio for these variables. A stepwise multiple logistic regression was performed to determine the odds ratios for which types of EMS activations were more likely to receive an ALS level of care during

transportation to the ED. Odds ratios with 95% confidence intervals excluding 1.00 were considered significant.

Research Question #4: What is the estimated cost of EMS activations for sport-related injuries? To estimate the average cost for EMS activations due to sport-related injuries, the frequency of EMS activations was determined by calendar year for the variable *CMS Service Level*. The average base rate (in dollars) was calculated for each Relative Value Unit.[79] The average base rate was then multiplied by the Relative Value Unit to determine the adjusted base rate for each service level. The adjusted base rate for each service level was then multiplied by the number of EMS activations documented at each service level.

Aim 3

The ATLAS data was used to create a zip-code coding scheme for the NEMSIS to translate into a blinded variable. For AT service level, an aggregate score was created for each zip-code. Schools with full-time AT services received a 1, schools with part-time AT services received and 0.5 and schools with no AT services received a 0. The average score was then calculated for each zip-code. The variable AT employment type was treated as a categorical variable with the following options: medical or university facility (MUF), school district (SD), independent contractor (IC), mixed-employment types (MIX), or none (NONE) where no AT was employed. The number of ATs employed within each zip-code was also calculated. Poisson regressions will be performed to determine if the frequency of EMS activations for sport-related injuries will vary by

athletic training service level, athletic training employment type, and number of ATs employed.

Table 3.1 Variables Collected from Each Database

NEMSIS Database	
Patient Age (years)[a,c]	Chief Complaint Organ System[c]
Patient Gender[c]	Chief Complaint Anatomic Location[c]
Patient Race[c]	Complaint Reported by Dispatch[b]
U.S. Census Division[a]	Incident/Patient Disposition[b]
U.S. Census Region[a]	Cause of Injury[c,d]
Urbanicity[a]	Primary Symptom[c,d]
CMS Service Level[c]	Other Associated Symptoms[c,d]
Primary Role of the Unit[b]	Provider's Primary Impression[c,d]
Level of Care of this Unit[b]	Provider's Secondary Impression[c,d]
Incident Location Type[c,d]	Procedure[c]
Possible Injury[c]	
ATLAS Database	
Presence of an AT	Median household income
AT service level	Median family income
School zip-code	Number of households
Employment provider type	Number of families
Presence of other medical services	Socioeconomic status

[a] Variables not directly entered by the EMS provider in their patient care report, but calculated by the NEMSIS and provided in the dataset
[b] Usage by the NEMSIS was mandatory ("not values" not allowed)
[c] Usage by the NEMSIS was required ("not values" allowed)
[d] Coded using ICD-10-CM

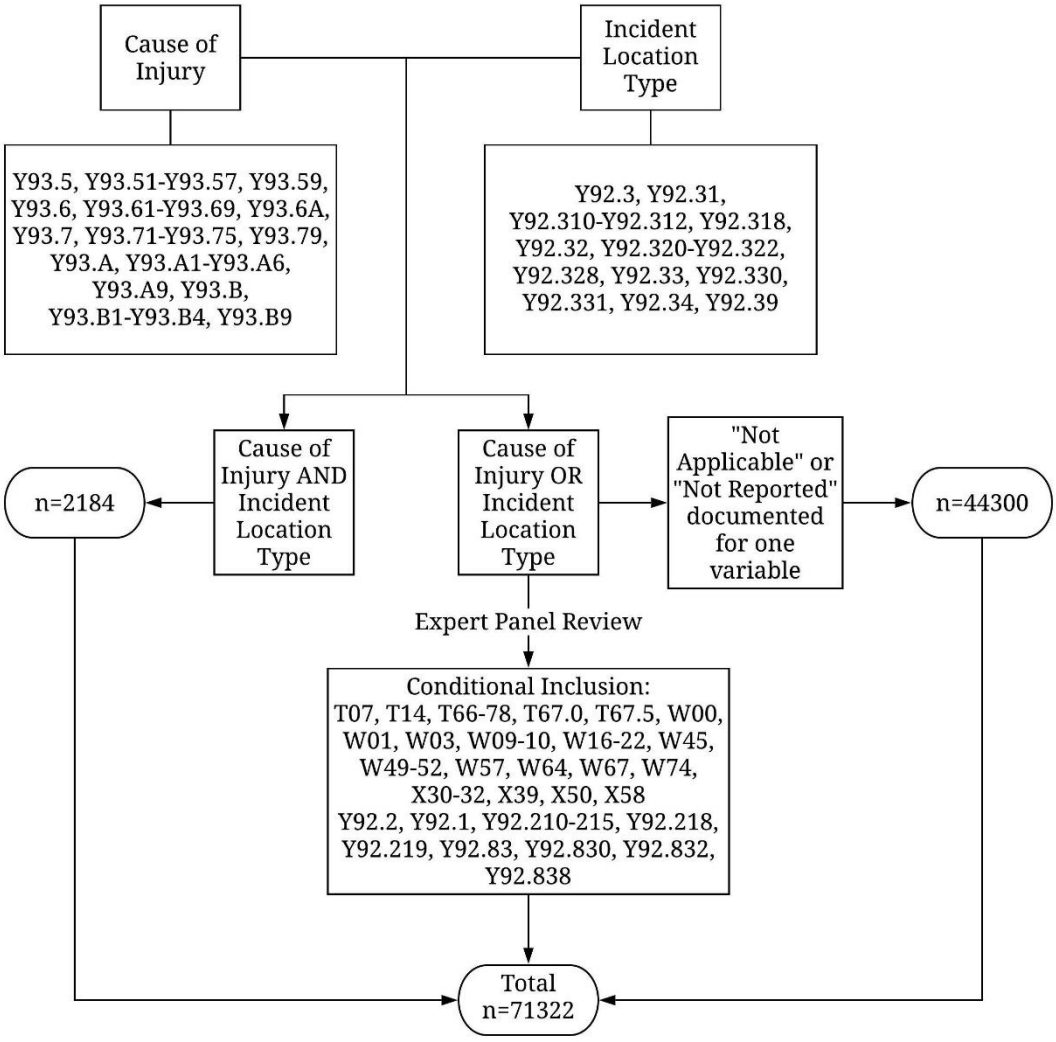

Figure 3.1 Inclusion Criteria for Identifying EMS Activations for Sport-Related Injuries

CHAPTER 4

EPIDEMIOLOGY OF EMERGENCY MEDICAL SERVICE ACTIVATIONS FOR SPORT-RELATED INJURIES[1]

[1] Hirschhorn RM, Kerr ZY, Mensch JM, Huggins RA, Dompier TP, Rudisill C, Yeargin SW. To be submitted to *Prehospital and Disaster Medicine.*

ABSTRACT

Introduction: Literature examining emergency medical services (EMS) activations for sport-related injuries is limited to the pediatric, high school and collegiate student-athlete populations. *Study Objective:* The purpose of this study was to examine EMS activations for sport-related injuries using the National EMS Information System Database from 2017-2018. *Methods:* Sport-related injuries were identified using specific ICD-10-CM codes for cause of injury and incident location type. 9-1-1 responses for patients aged 3-99 were included. Descriptive variables included patient age, gender, complaint reported by dispatch, incident location type, cause of injury, chief complaint organ system and anatomic location, and primary symptom. *Results:* There were 71,322 sport-related injuries identified, accounting for 0.2% of all EMS activations. The average patient age was 36.6±22.9 years and most patients were male (58.1%, n=41132). Traumatic injury was the most common complaint reported by dispatch (22.5%, n=16064), followed by falls (12.4%, n=8850). The most common incident location types were "gymnasium" (36.7%, n=26196) and "sports and athletics area" (27.8%, n=19821). Approximately 22% of injuries were attributed to "unspecified fall" (n=5947); however, no cause of injury was provided in most cases (62.1%, n=44281). "Global/general" was the most commonly documented chief complaint anatomic location (46.9%, n=24075) and organ system (38.9%, n=20543,) affected. Unspecified pain was the most common primary symptom (14.6%, n=9642), followed by syncope and collapse (6.1%, n=3963). *Conclusion:* Sport-related injuries account for a small proportion of all EMS activations. Patients of all ages were represented in this sample, indicating EMS utilization for sport-related injuries affects a wide variety of people in formal and informal sport setting. Coaches and

administrators hosting athletic events should consider having trained on-site medical personnel to develop an emergency action plan, provide immediate care for an injury and facilitate the EMS response (e.g., communication with dispatch, direction to the scene, assistance with care). Emergency medical services providers should more frequently document cause of injury as this data may help inform and assess sporting rule changes. General/global chief complaints are likely indicative of sport-related injuries affecting multiple anatomic locations and organ systems. An age-appropriate pain assessment should be performed during all patient assessments and pharmacological pain management considered. (350/375)

Keywords*:* ambulance, athletics, athlete, recreation

INTRODUCTION

Emergency department (ED) visits resulting from sports participation are estimated to occur at a rate of 76.1 visits per 100,000 population.[2] The number of sport-related injuries presenting to EDs has increased by over 10,000 each year, in the decade leading up to 2013.[11] Approximately 14% of life-threatening injuries among pediatric patients are attributable to sports activities. This equates to over 92,000 life-threatening sport-related injuries presenting to EDs every year.[15] Several studies have examined sport-related injuries among pediatric patients presenting to EDs in the United States (U.S.),[1,2,4,11-13] but research in the adult population is sparse.[3,12] Football, basketball, soccer, and baseball have accounted for significant proportions of sport-related injuries presenting to EDs,[1,3,11,12] with the most common diagnoses of sprains, strains and contusions.[4,11,12]

Sport-related sprains, strains and fractures are also commonly seen in the prehospital setting (i.e. athletic training facilities).[4,11,12,18] A variety of organized sports have reported injuries in epidemiological research across genders, and competition levels.[16,18] Severe and rare injuries, that could necessitate EMS transport, have accounted for approximately 3-15% of sport-related injuries in collegiate and high school athletics.[19-21] In only one year, 75 catastrophic injuries occurred among high school and collegiate athletes that were directly attributed to sports participation, 30% of which were fatal.[22] Atraumatic sudden cardiac arrest, brain injuries, exercise-related death associated with sickle cell trait, exertional heat stroke, commotio cordis, anaphylactic shock, lightning, and drowning are the most common causes of death in athletes.[23-25] Due to the

nature of severe and catastrophic injuries, transportation by EMS is likely warranted in a variety of sport settings; however, the utilization of EMS has not been examined.

Among children, 11-22% of EMS activations originate from places of recreation or sport.[7,40] One study specifically examined EMS activations to places of recreation and sport among children using data collected by EMS agencies;[7] however, only location criteria were used to identify sport-related injuries while mechanism or cause of injury was not examined. Until now, research examining sport-related injuries resulting in EMS activations have been limited to the high school and collegiate populations.[5,29] Of high schools and collegiate institutions surveyed, most indicated they activated EMS one to two times per year, on average, with some activating EMS up to six or more times.[29] This study was also limited to football-specific EMS activations, indicating EMS activations are probably greater per year when considering all organized sports.

Emergency medical services are a critical link between the place of injury (e.g., incident location) and the ED when sport-related emergencies occur. Approximately 7% of pediatric patients presenting to the ED for a sport-related injury arrive via an ambulance.[1] Current literature examining sport-related injuries resulting in transportation by EMS are narrowly focused on the high school and collegiate settings,[5,29] leaving a broader understanding of sport-related emergencies unknown as sports participation occurs in a variety of settings by people of all ages. The National EMS Information System (NEMSIS), a standardized EMS database, presents an opportunity to robustly examine sport-related injuries from the perspective of EMS across the U.S. Therefore, the purpose of this study was to describe EMS activations for sport-related injuries using the NEMSIS. A secondary purpose was to compare pediatric and adult injuries.

METHODS

Study Design

A descriptive epidemiological design was conducted utilizing data from the NEMSIS for the 2017 and 2018 calendar years. These years were chosen because the NEMSIS began using ICD-10-CM codes in 2017. Emergency medical services activations included in this study were limited to 9-1-1 responses for a sport-related injury for individuals aged 3 to 99. This range was selected due to 3 being the typical age at which children begin to participate in formal sporting activities, and 99 being the highest defined upper age limit for the world master's athletics.[77] The current study was conducted as part of a larger examination of sport-related injuries presenting to EMS.

Study Procedures

A data request was submitted to the NEMSIS for the 2017 and 2018 Public-Release Datasets. The NEMSIS collects data voluntarily reported by participating EMS agencies across the U.S. using compatible documentation software. For each EMS activation, a patient care report is completed by the EMS provider. Emergency medical services agencies determine which elements to include in their documentation but must include required national and state-level elements. Starting in 2017, the NEMSIS utilized ICD-10-CM codes. The 2017 Public-Release Research Dataset included over 7.9 million EMS activations from 4,016 EMS agencies across 35 states and territories.[37] The 2018 Public-Release Research Dataset from the NEMSIS included over 22.5 million EMS activations from 9,599 EMS agencies across 43 states and territories.[78] Each public release dataset contained all required national-level variables. Data received from

participating agencies was checked by the NEMSIS Technical Assistance Center for completeness, logical consistency and formatting, and quality assurance. All data were de-identified.

A sport-related injury was operationally defined as an EMS activation within the NEMSIS based on incident location type and cause of injury. The ICD-10-CM codes were selected within the patient care report as determined by the EMS provider. *Incident location type* is defined as the kind of location where the incident happened.[80] *Cause of injury* is the category of the reported/suspected external cause of the injury.[80] Reports were narrowed initially from the dataset by any cause of injury attributed to sports activity and/or the incident location as a sports and athletic area. Second, the resulting cases in which the cause of injury *or* incident location type were met, were then reviewed by a panel of sports injury experts to determine if they were likely due to sports participation. Those determined to be a sport-related injury were kept in the dataset. This process, with the corresponding ICD-10-CM codes, are presented in Figure 4.1.

Variables of Interest

The NEMSIS variables of interest in this study were: patient age (years), patient gender, patient race, U.S. census region, U.S. census division, urbanicity, complaint reported by dispatch, incident location type, cause of injury, chief complaint organ system, chief complaint anatomic location, primary symptom, and other associated symptoms. Patient age (in years), U.S. Census Division,[81] U.S. Census Region,[81] and urbanicity[82] were variables calculated and provided by the NEMSIS, but not directly entered by the EMS provider completing the patient care report. *Complaint reported by*

dispatch was the complaint EMS dispatch reported to the responding unit. *Chief complaint organ system* was the primary organ system of the patient injured or medically affected as determined by the EMS provider. *Chief complaint anatomic location* was the primary anatomic location of the chief complaint as identified by EMS providers. *Primary symptom* was the predominant sign and symptom present in the patient. *Other associated symptoms* were additional symptoms identified by the patient or observed by EMS providers.

Statistical Analysis

Data were analyzed using SAS® software (Version 9.4, SAS Institute Inc., Cary, NC, USA). Frequencies and proportions were calculated for all variables of interest. Mean and standard deviation were calculated for patient age. The age groups "pediatric" (<18 years old) and "adult" (≥18 years old) were created to allow for comparison of chief complaint anatomic locations and organ systems. Injury proportion ratios with 95% confidence intervals were calculated to compare chief complaint variables by age group. Confidence intervals not including 1.00 were considered statistically significant. Cases in which a required variable was coded as "not applicable" or "not recorded" were considered as "not documented" and therefore excluded from the analyses.

RESULTS

Overall, 71,322 EMS activations for sport-related injuries were identified (2017: 0.3%, n=20,903; 2018: 0.2%, n=50,419). The average patient age was 36.6±22.9 years. Most patients were White (70.0%, n=19038) and males (58.1%, n=41132). Other detailed

patient characteristics (age group, gender, race) and geographical variables (U.S. census region, U.S. census division, urbanicity) are provided in Tables 4.1a and 4.1b.

Complaint Reported by Dispatch

Traumatic injury was the most common complaint reported by dispatch, accounting for nearly 23% of EMS activations (n=16064). Other frequently documented complaints included falls (12.4%, n=8850), sick person (11.1%, n=7935), and unconscious/fainting/near-fainting (9.7%, n=6949). Interestingly, "no other appropriate choice" was selected in 9.5% of cases (n=6748) and "unknown problem/person down" was selected in 4.0% of cases (n=2862). The most frequently documented complaints reported by dispatch are presented in Table 4.2.

Incident Location Type

The most frequent incident location types that EMS responded to were "gymnasium" (36.7%, n=26196) and "sports and athletics area" (27.8%, n=19821). Other common locations included "athletic field" (12.7%, 9087), "athletic court" (6.7%, n=4751), and "swimming pool (public)" (5.3%, n=3798). All other locations only accounted for 10.7% of EMS activations (n=7650). Notably, schools were documented as the incident location in 2.7% (n=1950) of EMS activations for sport-related injuries. Sport-specific athletic areas were not commonly documented, but included football field (1.1%, n=765), baseball field (0.4%, n=278), ice skating rink (0.2%, n=152), roller skating rink (0.1%, n=84), basketball court (0.2%, n=136), and tennis court (0.0%, n=34). Incident location type was not documented in 19 cases.

Cause of Injury

The most frequently documented causes of injury were "unspecified fall" (22.0%, n=5947) and "fall on the same level from slipping, tripping, and stumbling" (16.8%, n=5806). Sport activities played individually accounted for 8.7% (n=2346) of EMS activations and those played as a team or group accounted for 6.6% (n=1775). Other activities that accounted for ≥5% of EMS activations included "striking against or struck by sports equipment" (5.3%, n=1444) and "accidental hit, strike, kick, twist, bite, or scratch by another person" (5.0%, n=1356). However, cause of injury was not documented for most EMS activations (62.1% (n=44281).

Chief Complaint Anatomic Location and Organ System

Chief complaints that were "general/global" were the most prevalent for both anatomic location and organ system, accounting for 46.9% (n=24075) and 38.9% (n=20543) of EMS activations, respectively. Figure 4.2 presents chief complaint anatomic location by organ system affected. Adults had higher proportions of sport-related injuries affecting the abdomen (IPR:2.05, 95%CI: 1.83, 2.31), chest (IPR: 1.90, 95%CI: 1.75, 2.05), general/global (IPR: 1.54, 95%CI: 1.50, 1.58), and genitalia (IPR: 2.40, 95%CI: 1.39, 4.15) compared to pediatric patients. Conversely, adults had lower proportions of sport-related injuries affecting the back (IPR: 0.55, 95%CI: 0.50, 0.60), lower extremity (IPR: 0.63, 95%CI: 0.60, 0.65), upper extremity (IPR: 0.50, 95%CI: 0.47, 0.53), head (IPR: 0.73, 95%CI: 0.70, 0.77), and neck (IPR: 0.18, 95%CI: 0.16, 0.20) compared to pediatric patients. Adults had higher proportions of sport-related injuries involving the behavioral/psychiatric (IPR: 2.36, 95%CI: 2.00, 2.79),

cardiovascular (IPR: 5.99, 95%CI: 5.21, 6.88), central nervous system/neurological (IPR: 1.25, 95%CI: 1.19, 1.31), endocrine/metabolic (IPR: 2.13, 95%CI: 1.84, 2.47), gastrointestinal (IPR: 2.45, 95%CI: 2.12, 2.82), global/general (IPR: 1.23, 95%CI: 1.19, 1.26), and reproductive (IPR: 5.01, 95%CI: 2.63, 9.54) systems compared to the pediatric population. Conversely, adults had lower proportions of sport-related injuries affecting the musculoskeletal/skin (IPR: 0.50, 95%CI: 0.49, 0.52) and pulmonary (IPR: 0.81, 95%CI: 0.73, 0.89) systems compared to pediatric patients. Tables 4.3 and 4.4 present chief complaint anatomic location and organ system by age groups.

Primary and Associated Symptoms

The most prevalent primary symptom was "pain, unspecified" (14.9%, n=9642), followed by "syncope and collapse" (6.1%, n=3963), "weakness" (4.4%, n=2815), and "altered mental status, unspecified" (4.0%, n=2578). The most commonly documented primary symptoms are presented in Table 4.5. Other associated symptoms were not documented in most cases (n=41672). Of other associated symptoms documented, "encounter for general adult medical examination without abnormal findings" accounted for 45.9% (n=13597) and "encounter for routine child health exam without abnormal findings" accounted for 12.4% (n=3663).

DISCUSSION

Our study aimed to identify and describe EMS activations for sport-related injuries across the U.S. Overall, sport-related injuries accounted for a small proportion of all EMS activations within the NEMSIS from 2017-2018. Sport-related injuries that result in transportation by EMS typically represent a small percentage of overall sport-

related injuries,[5,84] but account for significant proportions of life-threatening injuries treated in EDs.[15] Previous studies examining EMS utilization related to sports participation have been limited by geographic location or were based solely on incident location.[1,7] Our study is the first to examine EMS activations due to sport-related injuries using a national database. Additionally, we utilized an operational definition for sport-related injuries that used both cause of injury and incident location type variables, providing a more comprehensive examination of these injuries. By using cause of injury criteria, it is less likely that we captured injuries that occurred at an athletic venue, but were not a result of sports participation (e.g., spectator).

Patient Characteristics

Our study included both pediatric and adult patients in contrast to previous literature which has focused on the pediatric population,[7] or was not specific to sport-related injuries.[9,39,40,85-87] The average age of patients in our study was 36, with over two-thirds of EMS activations having been for adults. The utilization of EMS has been shown to increase with age among the general population.[44,88] According to the U.S. Bureau of Labor Statistics,[89] more individuals aged 15 to 24 participate in athletic activities than older age groups. Our findings demonstrate that EMS activations for sport-related injuries are not limited to any specific age group. Males accounted for most EMS activations, which is not surprising considering males have consistently accounted for more ED visits[1-4] and EMS utilization[7,9] than females. Additionally, more men report participating in athletic activities on an average day than women.[89] Planning for sport-related emergencies should not be limited to organized sports, such as in high school or collegiate settings. In secondary schools, the presence of an athletic trainer has been

associated with having an emergency action plan (EAP) in place,[73,74] but only 66% of secondary schools have access to an athletic trainer.[10] Any facilities hosting athletic activities, regardless of participant age, should consider having an on-site medical professional, such as an athletic trainer, in case of an emergency. This includes recreational facilities, fitness gyms, and senior living campuses. Beyond typical emergency procedures (i.e., fire), no research has been conducted on if these facilities have venue specific medical coverage or EAPs to determine when calling EMS is necessary and to facilitate an efficient EMS response.

Complaint Reported by Dispatch

The use of emergency medical dispatch has been shown to decrease inappropriate ALS-level unit assignment by dispatchers and more effectively distribute EMS resources within their service area.[90] When an individual calls 9-1-1, the dispatcher selects the most appropriate choice based on a set list of complaints in their system. The selection "no other appropriate choice" was documented in nearly 10% of our sport-related injuries. This finding may be reflective of the lay responder to an injury, such as a spectator, coach, or teammate, not being sure how to accurately describe what has occurred to the dispatcher to inform the responding EMS unit. Providing dispatch, and therefore the responding EMS unit, with accurate information regarding the patient and scene is an important step in the emergency response after recognizing the need for EMS. Organizations hosting sports should have an on-site trained first responder who is able to recognize a potential emergency that necessitates EMS care and accurately describe the situation upon activation. If it is not possible to have a trained first responder, coaches and staff hosting athletic events should have basic first aid, cardiopulmonary resuscitation

and automated external defibrillator training. Lack of trained personnel may result in unnecessary EMS activations.

Traumatic injury was the most common complaint reported by dispatch in our study which could include injuries such as fractures, dislocations, and other blunt trauma. Such injuries typically require the application of emergency equipment, such as splints and bandaging, an important consideration when developing EAPs and for those providing medical coverage at these events. Other common complaints included falls, sick person, and unconscious/fainting/near-fainting. Altered mental status or loss of consciousness can be indicative of conditions such as hypoglycemia, hyponatremia, exertional heat stroke, or concussion which can commonly occur in sport.[91-94] Emergency medical services providers need to consider these conditions in their differential diagnosis when responding to a potential sport-related injury. Our findings are similar to those reported in a study of EMS activations from places of sport and recreation in which traumatic injury, fall victim, unconscious/fainting, and sick person were most reported.[7] Organizations hosting athletics, regardless of the level of competition, need to be prepared for emergencies and consider access to emergency equipment (e.g., splints, bandaging, automated external defibrillator). For trained personnel, additional emergency equipment should include supplemental oxygen, bleeding control and medications for allergic reactions and overdoses based on the other common dispatch complaints seen in our study.[69]

Incident Location Type

Most EMS activations in our study occurred at sports and athletic areas as opposed to schools or other recreational areas. The utilization of ICD-10-CM codes in the current version of the NEMSIS allowed for more specific locations to be selected by EMS providers than was possible with previous versions. Previous studies were limited to the general category of "places of recreation and sport".[7,40,87] However, the options made available for EMS providers to choose from were dependent on their EMS agency and documentation system design. Interestingly, locations such as schools or colleges/universities were not frequently documented in our study. Sports are a leading contributing factor to school-based EMS activations among the pediatric population.[41] Sports and athletics areas can include athletic fields, recreational areas, public and private swimming pools as well as indoor and outdoor courts, as was the case in our study. Each location comes with its own unique challenges for EMS response (e.g., locked gates, uneven terrain, sand, stairs), thus it is important for organizations overseeing these areas to develop detailed access plans and consider conducting a walk-through with their local EMS agency to ensure easy access for the responding EMS units.[69] In the event of an emergency, an individual familiar with the facility should meet EMS at the best entrance and escort them to the scene to ensure prompt access to the patient.

Cause of Injury

Of the causes of injury documented in our sample, falls resulted in the majority of EMS activations. In sports, falls can occur due to slipping or tripping on a wet or uneven surface, improperly landing from a jump, or from an elevated piece of athletic equipment.

Facilities should take care to inspect playing surfaces for potential safety hazards. Our findings are in agreement with previous literature demonstrating that falls are common cause of injury resulting in EMS use.[7,40,41,87,95] Blunt injuries and falls are the most frequent causes of injury noted among pediatric trauma patients.[39] Falls are also a leading cause of injury in older adults.[96] Changes in stepping and reaching reactions have been shown to occur with age and contribute to fall risk.[97] However, exercise and fall prevention programs are effective in reducing fall rates,[97,98] and should therefore be considered in an effort to reduce sport-related injuries resulting from falls. A cause of injury was not documented in a large proportion of our data. Emergency medical services providers responding to sport-related injuries should include cause or mechanism of injury in their documentation, as this data can provide insight to high-risk activities that may warrant rule changes in sports and evaluate the effectiveness of changes that have been implemented.

Sports played as a team or group and those played individually were also common causes of injury in our study. Participation in group and individual sports has accounted for large proportions of patients seen in EDs;[12] however, ours was the first to examine this within the EMS system. School-based sports may have a on-site medical professional, such as an athletic trainer, who can initiate immediate care and likely has an EAP in place to facilitate EMS response. However, it is unknown whether or not this was the case for any EMS activations in our study. Player contact or being struck against during sports are common mechanisms of injury among sport-related injuries resulting in EMS transportation.[4,5] While the type of sport being played is not specifically known within our sample, previous literature has established participation in football, basketball,

soccer, track and field, wrestling, baseball, ice hockey, and gymnastics have frequently resulted in severe, rare, and catastrophic injuries, including fatalities.[19-22,25] Standby coverage by EMS providers is warranted for the majority of these sports, minimally at high school and college events.[5] Large scale tournaments for younger and older athletes within these sports may also warrant standby coverage in light of our results. Providers responding to EMS activations originating from these sporting events should have a heightened awareness for potentially life-threatening injuries.

Chief Complaint Anatomic Location and Organ System

The most frequently documented chief complaint anatomic locations in our study were general/global, lower extremity, and head. The general/global category may include conditions that are more systemic in nature, affecting the entire body (e.g., exertional heat illness, diabetic emergency, neurological conditions, or psychiatric conditions). The most frequently documented organ systems in our study were general/global, musculoskeletal/skin, and central nervous system/neurological. Emergency medical services providers responding to potential sport-related injuries should have a heightened index of suspicion if the injury has occurred to the head, neck or torso, as these are most likely to be life-threatening.[15,22] Injuries to the head and face have been the most frequently reported among high school and collegiate athletes who sustained sport-related injuries resulting in EMS transportation,[5] and can include life-threatening conditions such as subdural or epidural hematomas. Sport-related injuries that are systemic or involving the pelvis, abdomen, chest, leg, hip, head and back have increased risk of hospital admission,[3] indicating increased injury severity and need for advanced medical care. Expedient transport to the ED with frequent re-assessments in these cases is crucial due

to the inability to rule out potentially life-threatening injuries without diagnostic imaging in the prehospital setting and the potential for rapid deterioration during transportation.

Adults had higher proportions of injuries to the abdomen, chest, general/global, and genitalia compared to children. Adults had lower proportions of injuries affecting the musculoskeletal/skin and pulmonary organ systems. Previous literature comparing sport-related injuries sustained between similar age groups was limited to high school and collegiate athletes, representing a small proportion of the athletic population.[5] Collegiate athletes had increased odds of sustaining systemic and trunk injuries that resulted in EMS transportation than their high school counterparts which are similar to our findings related to the abdomen, chest and genitalia.[5] Age-related declines in muscular, cardiovascular, and pulmonary function may also contribute to the differences seen in adult sport-related injuries.[99] Underlying medical conditions, such as cardiovascular disease or diabetes, may also affect injury risk and clinical presentation in adults. Future research examining sport-related injuries in the adult population, beyond collegiate athletics, is warranted to better understand how aging affects injury risk and subsequent EMS and ED utilization. Additionally, EMS providers should conduct a thorough evaluation, paying special attention to previous medical history, even when responding to a sport-related injury since it is not known if other conditions may have contributed to, or resulted from, the sport-related injury.

Primary and Associated Symptoms

Unspecified pain was the most frequently documented primary symptom in our study, followed by syncope and collapse. Considering traumatic injury and falls were the

most common complaints reported by dispatch it is not surprising that pain was the leading symptom. Pain has also been frequently reported among the general population, thus there does not appear to be a distinct difference in common symptoms reported as a result of sport-related injuries compared to overall EMS activations.[87,100] Both paramedics and emergency physicians have agreed that experiencing severe pain is an appropriate use of EMS.[101] The assessment of pain can be difficult, since it is subjectively reported by the patient. All patients should be assessed for pain as part of general patient care using an age-appropriate pain scale and current guidelines recommend the consideration of narcotic analgesia for patients who have acute traumatic pain,[102] as may be the case in sport-related injuries. An unexpected result was symptoms of alcohol use. It is possible this could be due to alcohol use during team practices or competitions for adult recreation leagues; however, this is speculation.

Strengths and Limitations

A strength of our study was using an operational definition for sport-related injury that included both cause of injury and incident location type variables. Unlike studies that only utilized incident location, this enabled us to rule out emergent events that did not directly result from sport participation, such as for spectators attending an athletic event. Agency participation in the NEMSIS is voluntary, thus the database relies on a convenience sample of EMS agencies across the U.S. and does not include all states and territories. The data collected by the NEMSIS is event-based, thus multiple patient care reports could have been completed for a single incident/patient if there were multiple responders on the scene. It is not possible to link electronic patient care reports for the same patient across responding units or agencies. There were large proportions of "not

applicable" or "not reported" data which we considered as not documented and excluded from analyses. Future research is warranted investigating how access to on-site medical care and appropriate emergency planning may affect EMS utilization and potential reduce unnecessary EMS activations for sport-related injuries.

CONCLUSION

Emergency medical services activations due to sport-related injuries account for a small proportion of overall EMS activations in the U.S; however, considering not all EMS agencies are required to report to the NEMSIS, the actual number of EMS activations for sport-related injuries in the U.S. is likely higher. Our study indicates a need for on-site medical providers and planning with local EMS agencies for athletic venues outside of the traditional high school and collegiate settings. Sport-related injuries resulting in EMS activations differ between the adult and pediatric populations warranting additional research into how sport-related injuries, particularly those emergent in nature, may change across the lifespan. Administrators and organizations hosting athletic events need to be prepared for sport-related emergencies by providing appropriate on-site medical care, developing EAPs for all venues and ensuring life-saving equipment (e.g., automated external defibrillator, splints) is readily available for all events.

Manuscript Word Count: (4273/4000)

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Table 4.1a Patient Demographics of EMS Activations for Sport-Related Injuries from 2017-2018

Variable	n (%)
Patient Age	
Pediatric (<18)	22317 (31.3)
Adult (≥18)	49005 (68.7)
Average±SD (Range)	36.6±22.9 (3-99)
Patient Gender[a]	
Female	29618 (41.8)
Male	41132 (58.1)
Unknown (Unable to Determine)	30 (0.0)
Patient Race[b]	
American Indian or Alaska Native	329 (1.2)
Asian	486 (1.8)
Black or African American	4356 (16.0)
Hispanic or Latino	2837 (10.4)
Native Hawaiian or Other Pacific Islander	158 (0.6)
White	19038 (70.0)

[a] Patient gender was not documented in 542 cases
[b] Patient race was not documented in 44118 cases

Table 4.1b Geographic Distribution of EMS Activations for Sport-Related Injuries from 2017-2018

Variable	n (%)
U.S. Census Division	
East North Central (IL, IN, MI, OH, WI)	5574 (7.8)
East South Central (AL, KY, MS, TN)	4231 (5.9)
Middle Atlantic (NJ, NY, PA)	3546 (5.0)
Mountain (AZ, CO, ID, MT, NM, NV, UT, WY)	13952 (19.6)
New England (CT, ME, MA, NH, RI, VT)	2943 (4.1)
Pacific (AK, CA, HI, OR, WA)	14034 (19.7)
Territories	136 (0.2)
West North Central (IA, KS, MN, MO, NE, ND, SD)	5009 (7.0)
West South Central (AR, LA, OK, TX)	5306 (7.4)
U.S. Census Region[a]	
Island Areas	136 (0.2)
Midwest	10583 (14.8)
Northeast	6489 (9.1)
South	26128 (36.6)
West	27986 (39.2)
Urbanicity[b]	
Rural	5005 (7.3)
Suburban	3146 (4.6)
Urban	59127 (86.2)
Wilderness	1323 (1.9)

[a] The Midwest region includes the West North Central and East North Central Divisions. The Northeast regions includes New England and Middle Atlantic divisions. The South region includes the South Atlantic, East South Central and West South Central divisions. The West regions includes the Pacific and Mountain divisions.
[b] Urbanicity was not reported in 2721 cases

Table 4.2 Complaint Reported by Dispatch for EMS Activations of Sport-Related Injuries

Complaint Reported by Dispatch	n (%)
Traumatic Injury	16064 (22.5)
Falls	8850 (12.4)
Sick Person	7935 (11.1)
Unconscious/ Fainting/ Near-Fainting	6949 (9.7)
No Other Appropriate Choice	6748 (9.5)
Convulsions/ Seizure	3350 (4.7)
Breathing Problem	2973 (4.2)
Unknown Problem/ Person Down	2862 (4.0)
Chest Pain (non-traumatic)	2713 (3.8)
Heat/Cold Exposure	1569 (2.2)
Overdose/ Poisoning/ Ingestion	1040 (1.5)
Abdominal Pain/ Problems	984 (1.4)
Psychiatric Problem/ Abnormal Behavior/ Suicide Attempt	856 (1.2)
Hemorrhage/ Laceration	846 (1.2)
Allergic Reaction/ Stings	791 (1.1)
Other[a]	6792 (9.5)

[a] All other complaints reported by dispatch accounted for ≤1% each

Table 4.3 Chief Complaint Anatomic Location by Age Group for EMS Activations of Sport-Related Injuries

Anatomic Location	Age Group (n,%)			Adult Versus Pediatric Injury Proportion Ratio (95% CI)
	Adult (≥18)	Pediatric (<18)	Total	
Abdomen	1658 (4.5)	327 (2.2)	1985 (3.9)	2.05 (1.83, 2.31)[a]
Back	942 (2.6)	695 (4.7)	1637 (3.2)	0.55 (0.50, 0.60)[a]
Chest	3314 (9.1)	708 (4.8)	4022 (7.8)	1.90 (1.75, 2.05)[a]
Lower Extremity	4468 (12.2)	2883 (19.5)	7351 (14.3)	0.63 (0.60, 0.65)[a]
Upper Extremity	2188 (6.0)	1788 (12.1)	3976 (7.7)	0.50 (0.47, 0.53)[a]
General/ Global	19065 (52.2)	5010 (33.9)	24075 (46.9)	1.54 (1.50, 1.58)[a]
Genitalia	89 (0.2)	15 (0.1)	104 (0.2)	2.40 (1.39, 4.15)[a]
Head	4373 (12.0)	2411 (16.3)	6784 (13.2)	0.73 (0.70, 0.77)[a]
Neck	430 (1.2)	952 (6.4)	1382 (2.7)	0.18 (0.16, 0.20)[a]
Total	36527 (100.0)	14789 (100.0)	51316 (100.0)	NA

Abbreviations: CI, confidence interval; NA, not applicable

[a] Statistically significant 95% CI

Table 4.4 Chief Complaint Organ System by Age Group for EMS Activations of Sport-Related Injuries

Organ System	Age Group (n,%)			Adult Versus Pediatric Injury Proportion Ratio (95% CI)
	Adult (≥18)	Pediatric (<18)	Total	
Behavioral/ Psychiatric	935 (2.5)	159 (1.1)	1094 (2.1)	2.36 (2.00, 2.79)[a]
Cardiovascular	3122 (8.3)	209 (1.4)	3331 (6.3)	5.99 (5.21, 6.88)[a]
CNS/ Neurological	5832 (15.5)	1871 (12.4)	7703 (14.6)	1.25 (1.19, 1.31)[a]
Endocrine/ Metabolic	1101 (2.9)	207 (1.4)	1308 (2.5)	2.13 (1.84, 2.47)[a]
Gastrointestinal	1299 (3.4)	213 (1.4)	1512 (2.9)	2.45 (2.12, 2.82)[a]
Global/ General	15479 (41.1)	5064 (33.5)	20543 (38.9)	1.23 (1.19, 1.26)[a]
Lymphatic/ Immune	147 (0.4)	52 (0.3)	199 (0.4)	1.13 (0.83, 1.55)
Musculoskeletal/ Skin	8455 (22.4)	6753 (44.7)	15208 (28.8)	0.50 (0.49, 0.52)[a]
Reproductive	125 (0.3)	10 (0.1)	135 (0.3)	5.01 (2.63, 9.54)[a]
Pulmonary	1145 (3.0)	568 (3.8)	1713 (3.2)	0.81 (0.73, 0.89)[a]
Renal	27 (0.1)	0 (0.0)	27 (0.1)	NA
Total	37667 (100.0)	15106 (100.0)	52773 (100.0)	NA

Abbreviations: CI, confidence interval; NA, not applicable; CNS, central nervous system

[a] Statistically significant 95% CI

Table 4.5 Primary Symptoms Documented by EMS Providers for Sport-Related Injuries

Primary Symptom[a]	**n (%)**
Pain, unspecified	9642 (14.6)
Syncope and collapse	3963 (6.1)
Weakness	2815 (4.4)
Altered mental status, unspecified	2578 (4.0)
Dizziness and giddiness	2548 (3.9)
Headache	1847 (2.9)
Chest pain, unspecified	1761 (2.7)
Injury unspecified	1573 (2.4)
Other general symptoms and signs	1440 (2.2)
Dorsalgia, unspecified	1423 (2.2)
Generalized idiopathic epilepsy and epileptic seizures	1105 (1.7)
Alcohol use, unspecified with other alcohol induced disorder	962 (1.5)
Unspecified convulsions	952 (1.5)
Hemorrhage, not elsewhere classified	910 (1.4)
Unspecified injury of the head	798 (1.2)
Unspecified injury of unspecified lower leg	780 (1.2)
Shortness of breath	765 (1.2)
Nausea	728 (1.1)
Worries	683 (1.1)
Other[b]	27247 (42.2)

[a] Primary symptom was not documented in 6802 cases

[b] All other primary symptoms accounted for ≤1.0% each

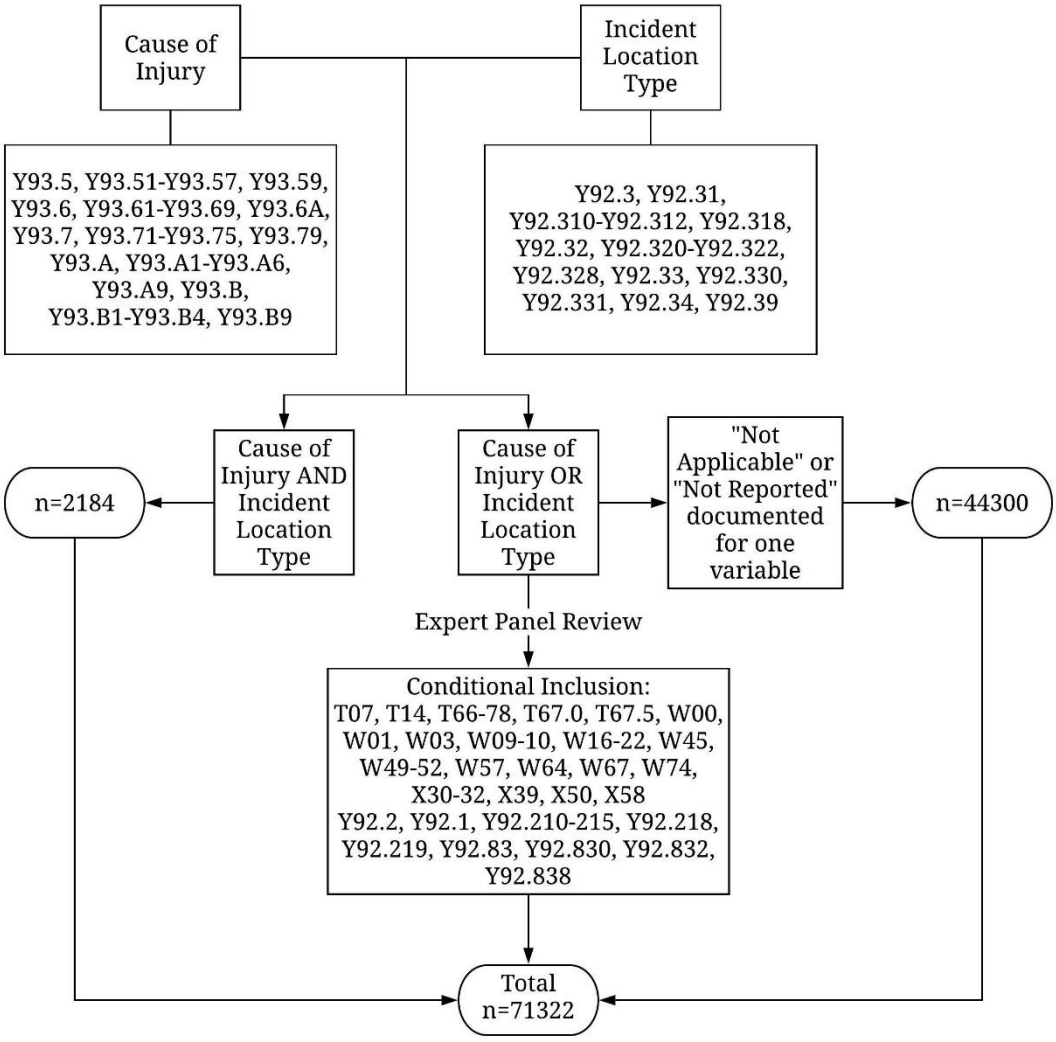

Figure 4.1 Inclusion Criteria for Identifying EMS Activations for Sport-Related Injuries

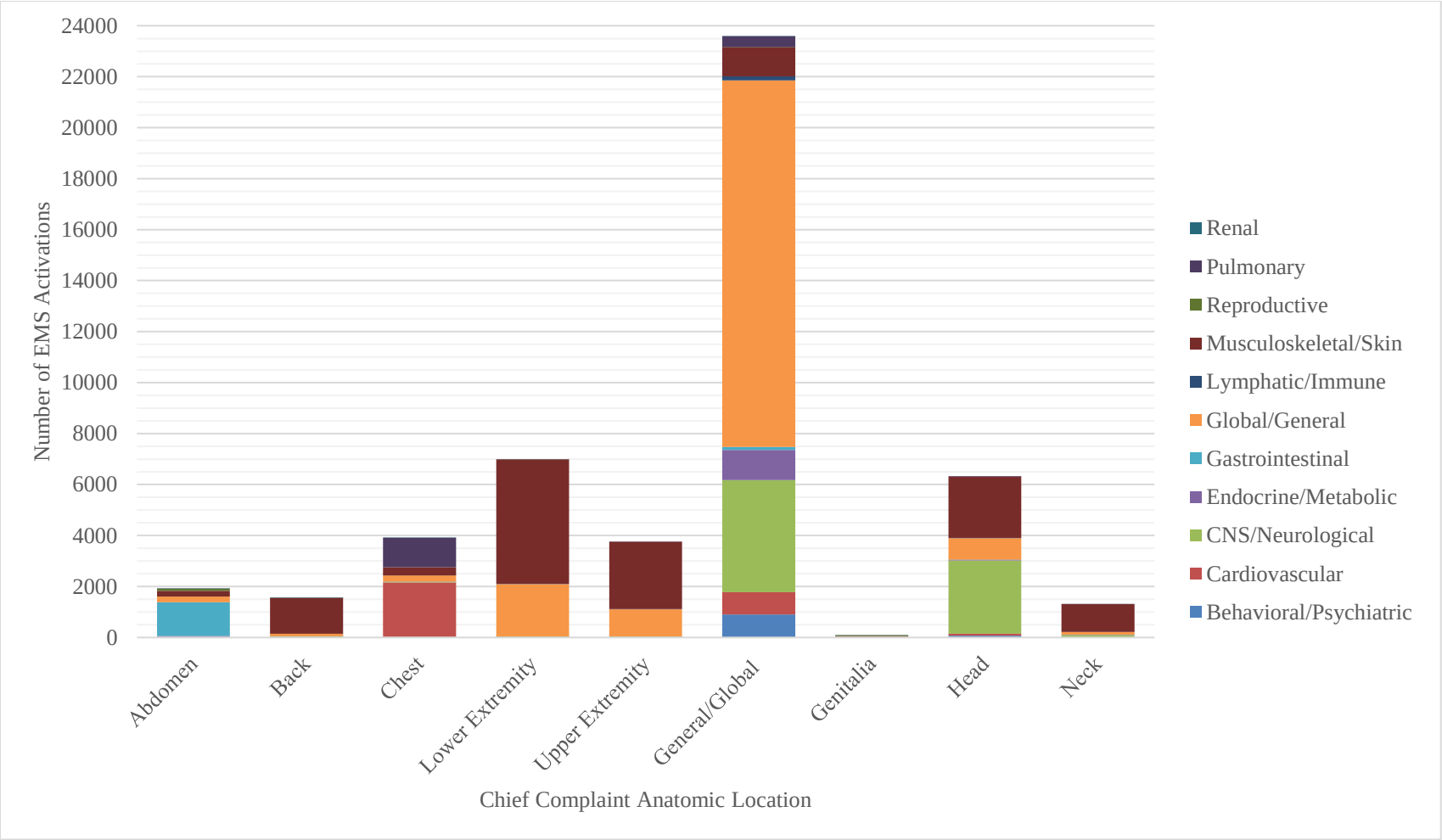

Figure 4.2 Chief Complaint Anatomic Location by Organ System Affected for Sport-Related Injuries

CHAPTER 5

EMERGENCY MEDICAL SERVICES MANAGEMENT OF SPORT-RELATED INJURIES[2]

[2] Hirschhorn RM, Kerr ZY, Mensch JM, Huggins RA, Dompier TP, Rudisill C, Yeargin SW. To be submitted to *Prehospital Emergency Care*

ABSTRACT

Severe and catastrophic injuries occur in sports. Research has not yet examined the care patients with sport-related injuries receive from emergency medical services (EMS) providers when being transported to the hospital. The purpose of this study was to examine how EMS providers managed sport-related injuries. Data were obtained from the National EMS Information System Database from 2017-2018. Sport-related injuries were identified using incident location and cause of injury variable criteria. Patients aged 3-99 were included. Independent variables were EMS disposition (if EMS activation resulted in treatment/transport by EMS) and level of care provided (advanced or basic life support). Dependent variables included patient age group, gender, U.S. census region, urbanicity, incident/patient disposition, provider's primary impression, and procedures. Frequencies and proportions were calculated for each variable. Stepwise multiple logistic regressions were performed to determine which variables were predictive of EMS disposition and level of care provided. The average patient age was 36.6±22.9 years and most were male (n=41132, 57.7%). Most EMS activations (n=52,441,73.5%) resulted in transportation by EMS and received an advanced level of care (n=25885, 85.5%). An average 1.5 procedures were performed per EMS transport, the most frequent being catheterization of the vein (n=25449). Variables predictive of EMS disposition were age group (Wald $\chi2=546.01$, df=4, $p<0.0001$), patient gender (Wald $\chi2=123.30$, df=4, $p<0.0001$), U.S. census region (Wald $\chi2=201.18$, df=3, $p<0.0001$), possible injury (Wald $\chi2=860.88$, df=4, $p<0.0001$), chief complaint anatomic location (Wald $\chi2=738.01$, df=10, $p<0.0001$), and chief complaint organ system (Wald $\chi2=397.10$, df=12, $p<0.0001$).Variables predictive of an advanced level of care provided were age group

(Wald $\chi 2=105.45$, df=4, $p<0.0001$), patient gender (Wald $\chi 2=15.87$, df=3, $p=0.0012$), urbanicity (Wald $\chi 2=29.62$, df=3, $p<0.0001$), U.S. Census Region (Wald $\chi 2=1576.00$, df=3, $p<0.0001$), possible injury (Wald $\chi 2=44.91$, df=4, $p<0.0001$), chief complaint anatomic location (Wald $\chi 2=402.86$, df=10, $p<0.0001$), and chief complaint organ system (Wald $\chi 2=883.76$, df=12, $p<0.0001$). Geographical differences in EMS agency staffing and protocols may explain the association with EMS disposition and level of care received. Most sport-related injuries receive an advanced level of care and resulted in procedures being performed, indicating the use of EMS transportation was likely necessitated. (341/350 words)

Keywords: ambulance, athlete, provider impression, procedures, disposition

INTRODUCTION

The number of sport-related injuries presenting to United States (U.S.) emergency departments (EDs) increases annually.[11] Sprains, strains, contusions and fractures are commonly reported diagnoses of sport-related injuries evaluated in EDs.[4,11,12] Sport-related injuries considered systemic or affecting the abdomen, chest, and head are at an increased relative risk of being admitted to the hospital.[3] Almost a million life-threatening sport-related injuries presented to U.S. EDs over a 10 year period, accounting for 14% of their life-threatening injuries.[15] Nearly 7% of children arrive via ambulance to the ED for a sport-related injury;[1] however, this proportion is unknown in adults. A more expansive examination of the use of emergency medical services (EMS) for the care and transportation of sport-related injuries is needed due to the variety and severity of sport-related injuries seen in EDs.

Most high schools and colleges report calling EMS at least once for a sport-related emergency at their organized sporting events.[27,29] However, some reported activating EMS over six times within one season for football alone.[29] The most commonly reported sport-related emergencies needing EMS transport were extremity musculoskeletal injuries.[27] Other sport-related emergencies included lacerations, fractures, head injuries, dehydration, shock, respiratory distress, heat-related conditions and chest/abdominal blunt injury. It is unknown how often athletic events outside of the high school or collegiate setting call for EMS in response to a sport-related emergency. While severe and catastrophic injuries due to sports participation have been studied,[19-22] the role of EMS, if any, in the immediate care and transportation of the injured or ill athlete is unknown. Studies that have specifically examined sport-related injuries that

resulted in emergency transportation have not examined the management of these injuries by EMS providers.[5]

Between 49% and 89% of EMS activations result in transportation to EDs by EMS providers.[40,100] Procedures performed by EMS have been examined in both children and adults,[8,9,40,45,46] but not specific to sport-related injuries. Children have been reported to receive an advanced level of care (above the level of an emergency medical technician (EMT)) in ~15% of transports.[9,40] On average, at least one procedure was performed per EMS response with monitoring procedures occurring more often than therapeutic and critical advanced life support (ALS) procedures.[45] Understanding the level of care and type of procedures performed by EMS for sport-related injuries can help inform medical coverage decisions for athletic events (e.g., standby versus dedicated unit and level of care of the unit dispatched). Additionally, findings may identify sport-related emergency scenarios where additional training may be warranted for first responders and EMS providers.

In a national study of pediatric hospital admissions for sport-related injuries, approximately 73% of patients were admitted through the ED.[14] Emergency department financial charges for sport-related injuries have the potential to be more than those resulting from motor-vehicle crashes.[2] Research examining hospital charges have reported financial costs ranging from $12,000 to $14,000 per injury, with hospital admission reaching upwards of $166,000.[47] Cumulative hospital charges of almost 5 million have been reported for sport-related injuries.[14] Hospital care for sport-related injuries result in significant costs to the patients and their families. However, it is not

known what type of costs also result from the utilization of EMS for these sport-related injuries.

Emergency medical services play a critical role in the medical care provided to patients who have sustained a sport-related injury necessitating evaluation and care at the ED. Therefore, the purpose of this study was to describe the management of sport-related injuries by EMS providers. Our research questions were 1) How do EMS providers manage sport-related injuries (i.e., incident/patient disposition, primary impression, procedures performed)?, 2) What types of sport-related injuries are more likely to result in EMS transport?, 3) What types of sport-related injuries transported by EMS were more likely to receive an ALS level of care?, and 4) What is the estimated cost of EMS activations for sport-related injuries?

METHODS

Study Design

A descriptive epidemiological design was conducted utilizing data from the NEMSIS for the 2017 and 2018 calendar years. These years were chosen because the NEMSIS began using ICD-10-CM codes in 2017. Emergency medical services activations included in this study were limited to 9-1-1 responses for a sport-related injury for individuals aged 3 to 99. This range was selected due to 3 being the typical age at which children begin to participate in formal sporting activities, and 99 being the highest defined upper age limit for the world master's athletics.[77] The current study was conducted as part of a larger examination of sport-related injuries presenting to EMS.

Study Procedures

A data request was submitted to the NEMSIS for the 2017 and 2018 Public-Release Datasets. The NEMSIS collects data voluntarily reported by participating EMS agencies across the U.S. using compatible documentation software. For each EMS activation, a patient care report is completed by the EMS provider. Emergency medical services agencies determine which elements to include in their documentation but must include required national and state-level elements. Starting in 2017, the NEMSIS utilized ICD-10-CM codes. The 2017 Public-Release Research Dataset included over 7.9 million EMS activations from 4,016 EMS agencies across 35 states and territories.[37] The 2018 Public-Release Research Dataset from the NEMSIS included over 22.5 million EMS activations from 9,599 EMS agencies across 43 states and territories.[78] Each public release dataset contained all required national-level variables. Data received from participating agencies was checked by the NEMSIS Technical Assistance Center for completeness, logical consistency and formatting, and quality assurance. All data were de-identified.

A sport-related injury was operationally defined as an EMS activation within the NEMSIS based on incident location type and cause of injury. The ICD-10-CM codes were selected within the patient care report as determined by the EMS provider. *Incident location type* is defined as the kind of location where the incident happened.[80] *Cause of injury* is the category of the reported/suspected external cause of the injury.[80] Reports were narrowed initially from the dataset by any cause of injury attributed to sports activity and/or the incident location as a sports and athletic area. Second, the resulting cases in which the cause of injury *or* incident location type were met, were then reviewed

by a panel of sports injury experts to determine if they were likely due to sports participation. Those determined to be a sport-related injury were kept in the dataset. This process, with the corresponding ICD-10-CM codes, are presented in Figure 5.1.

Variables of Interest

The NEMSIS variables of interest in this study were: patient age (years), patient gender, patient race, U.S. census region, U.S. census division, urbanicity, CMS service level, primary role of the unit, level of care of this unit, incident/patient disposition, provider's primary impression, provider's secondary impression, and procedure. Patient age (in years), U.S. census division,[81] U.S. census region,[81] and urbanicity[82] were variables calculated and provided by the NEMSIS, but not directly entered by the EMS provider completing the patient care report. *CMS service level* was based on the level of care and services provided to the patient during transport and was documented by the EMS provider for each encounter. Each service level is reimbursed at a different rate by the CMS and corresponds to a relative value unit accounting for the resources associated with providing care at each level.[79] *Primary role of the unit* was the type of EMS unit (e.g., ground transport, non-transport assistance, air-transport) which responded to the specific event. *Level of care of this unit* identifies the level of care the EMS unit was capable of providing, regardless of patient need, based on the unit's EMS provider staffing and treatment capabilities. For example, if a unit was staffed with a Paramedic, but the unit was licensed or stocked at a basic life support (BLS) level, the appropriate level of care was "BLS-Basic". *Incident/patient disposition* was the resulting treatment and/or transport of the EMS event (e.g., call cancelled prior to arrival at scene, patient refused evaluation/care, patient treated and transported by EMS). *Provider's primary*

impression was the EMS provider's impression of the patient's predominant problem or most significant condition which led to the management procedures (treatments, medications, or monitoring). *Provider's secondary impression* was the EMS provider's impression of the patient's secondary problem, if one existed, which led to additional management procedures. *Procedures* are any type of care performed on the patient, not including those documented as a vital sign. *Possible injury* indicated whether an injury (e.g., traumatic) mechanism occurred to the patient resulting in the EMS activation.

It is important to note that not all variables were required to be completed for every electronic patient care report.[83] Variables collected by the NEMSIS were designated as either mandatory, required, recommended, or optional. All variables included in this study were either mandatory or required. Mandatory variables were required to be completed by the EMS provider for every report. Required variables had to be completed for every report, but "not values" (i.e., not applicable or not reported) were allowed to be selected. "Missing" variables were blank entries within the NEMSIS database that had not been coded as "not applicable" or "not reported".

Additional variables created for the purpose this study were *EMS disposition* (if the EMS activation resulted in treatment and transportation by EMS) and the *level of care provided* to the patient (BLS or ALS). The variable *EMS disposition* was determined using the NEMSIS variable *incident/patient disposition*. Cases treated and transported by EMS included those documented as "patient treated, transferred care to another EMS unit" and "patient treated, transported by this EMS unit". All others were considered not to be transported by EMS. The *level of care provided* to the patient was determined using the NEMSIS variable *CMS service level*. Cases considered BLS were defined as "BLS"

or “BLS, Emergency”. Cases considered ALS were defined as “ALS, Level 1”, “ALS, Level 1 Emergency”, “ALS, Level 2”, “Paramedic Intercept”, “Specialty Care Transport”, “Fixed Wing Airplane”, and “Rotary Wing (Helicopter)”.

Statistical Analysis

Data were analyzed using SAS® software (Version 9.4, SAS Institute Inc., Cary, NC, USA). The mean and standard deviation were calculated for patient age. Age was also grouped into the following categories: <13, 13-18, 19-24, 25-64, and >64.

Research Question #1: How do EMS providers manage sport-related injuries (i.e., incident/patient disposition, primary impression, procedures performed)? Frequencies and proportions were calculated for primary role of the unit, level of care of the unit, possible injury, incident/patient disposition, provider’s primary impression, provider’s secondary impression, and procedure.

Research Question #2: What types of sport-related injuries are more likely to result in EMS transport? The dependent variable for this analysis was EMS disposition. The independent variables included in the initial model were patient age group, patient gender, urbanicity, U.S. census region, possible injury, chief complaint anatomic location, and chief complaint organ system. The variables patient race and CMS service level were excluded from the model due to the large proportion of cases where these were missing. Additionally, the variables provider’s primary impression, cause of injury, incident location type, and procedure were not included in the model due large number of options for EMS providers to select in their patient care report, prohibiting meaningful and accurate calculation of odds ratio for these variables. A stepwise multiple logistic

regression was performed to determine the adjusted odds ratios (aOR) for which types of EMS activations were more likely to result in treatment and transport by EMS. Odds ratios with 95% confidence intervals excluding 1.00 were considered significant.

Research Question #3: What types of sport-related injuries transported by EMS were more likely to receive an ALS level of care? The dependent variable for this analysis was level of care provided. The independent variables included in the initial model were patient age group, patient gender, urbanicity, U.S. census region, possible injury, chief complaint anatomic location, and chief complaint organ system. The variables patient race and CMS service level were excluded from the model due to the large proportion of cases where these were missing. Additionally, the variables provider's primary impression, cause of injury, incident location type, and procedure were not included in the model due large number of options for EMS providers to select in their patient care report, prohibiting meaningful and accurate calculation of odds ratio for these variables. A stepwise multiple logistic regression was performed to determine the aOR for which types of EMS activations were more likely to receive an ALS level of care during transportation to the ED. Odds ratios with 95% confidence intervals excluding 1.00 were considered significant.

Research Question #4: What is the estimated cost of EMS activations for sport-related injuries? To estimate the average cost for EMS activations due to sport-related injuries, the frequency of EMS activations was determined by calendar year for the variable CMS service level. The average base rate (in dollars) was calculated for each Relative Value Unit.[79] The average base rate was then multiplied by the Relative Value Unit to determine the adjusted base rate for each service level. The adjusted base rate for

each service level was then multiplied by the number of EMS activations documented at each service level.

RESULTS

Research Question #1: How do EMS providers manage sport-related injuries (i.e., incident/patient disposition, primary impression, procedures performed)?

There were 71322 EMS activations for sport-related injuries that were identified in our dataset (2017: 0.3%, n= 20903/7907829 total EMS activations; 2018: 0.2%, 50419/22532890 total EMS activations). The average patient age was 36.6±22.9 years (range 3 to 99), and most patients were White (55.1%, n=19038) and males (57.7%, n=41132). Patient characteristics (i.e., patient age, gender, race) and geographic variables (i.e., U.S. census region, U.S. census division, urbanicity) are presented in Tables 5.1a and 5.1b. The primary role of responding units were ground transport (86.6%, n=61761) followed by non-transport assistance (6.6%, n=4700) and non-transport rescue (6.0%, n=4276). Most units were staffed as ALS-Paramedic (80.0%, n=57058), followed by BLS-Basic/EMT (13.0%, n=9242). Five percent (n=3564) of responding units were staffed at the Advanced EMT or Intermediate level. Possible injury was documented as "yes" (an injury mechanism occurred to the patient) in 39.7% (n=28334) of cases.

When examining incident/patient disposition, the patient was treated by EMS in 87.9% (n=62677) of cases. The EMS response was canceled in 0.1% (n=96 cases) of EMS activations. Standby services occurred in 0.5% (n=281) events. In 4.5% of cases (n=3240) the patient was evaluated and determined to not need treatment or transport by EMS and in 5.6% of cases (n=4011) the patient refused evaluation/care and transport by

EMS. There were 168 (0.2%) events where the patient was documented as dead at the scene. Table 5.2 presents the disposition of all patients treated by EMS.

The most commonly selected primary impression by EMS providers was “injury, unspecified” (16.7%, n=11175), followed by “syncope and collapse” (7.9%, n=5291) and “acute pain, not elsewhere classified” (4.4%, n=2947). Additional primary impressions included “unspecified injury of the head” (3.1%, n=2100), “weakness” (2.5%, n=1664), and “altered mental status, unspecified” (2.5%, n=1639). The most frequently documented primary provider impressions are presented in Table 5.3. Primary impression was “not applicable” or “not reported” in 936 cases (1.4%) and missing in 4288 cases. The most common secondary impressions were “encounter for general medical examination without abnormal findings” (14.5%, n=5715), “acute pain, not elsewhere classified” (5.8%, n=2284), and “injury, unspecified” (5.3%, n=2071). A secondary provider impression was “not applicable” or “not reported” in 10818 cases (27.5%) and was missing in 31952 cases.

In total, 98326 procedures were documented in our study, resulting in an average of 1.5 procedures (98326/67311) performed per EMS activation in which the patient was treated by EMS. The most commonly performed procedures were catheterization of the vein (25.9%, n=25449), electrocardiogram 3-lead (13.2%, n=12953), and electrocardiogram 12-lead (12.2%, n=11966). Other notable procedures performed for sport-related injuries included splint application (5.2%, n=5081), pulse oximetry (2.5%, n=2415), cervical spine immobilization (2.1%, n=2079), and active external cooling (1.4%, n=1419). The most frequently documented procedures are presented in Figure 5.2. A procedure was “not applicable” or “not recorded” in 27910 cases.

Research Question #2: What types of sport-related injuries are more likely to result in EMS transport?

Approximately 73% (n=52441) of EMS activations for sport-related injuries resulted in treatment and transportation by EMS. The final multiple logistic regression model included the variables age group (Wald χ^2=546.01, *df*=4, p<0.0001), patient gender (Wald χ^2=123.30, *df*=4, p<0.0001), U.S. census region (Wald χ^2=201.18, *df*=3, p<0.0001), possible injury (Wald χ^2=860.88, *df*=4, p<0.0001), chief complaint anatomic location (Wald χ^2=738.01, *df*=10, p<0.0001), and chief complaint organ system (Wald χ^2=397.10, *df*=12, p<0.0001). Adjusted odds ratios for the types of sport-related injuries resulting in treatment and transportation by EMS are presented in Table 5.4a and 5.4b.

Compared to patients younger than 13, EMS activations for patients aged 13 to 18 (OR: 1.72, 95%CI: 1.61, 1.84), 19 to 24 (OR: 1.39, 95%CI: 1.29, 1.49), 25 to 64 (OR: 1.79, 95%CI: 1.68, 1.90), and older than 64 (OR: 1.86, 95%CI: 1.74, 1.99) all had increased odds of being treated and transported by EMS. Females had lower odds of being treated and transported by EMS compared to males (OR: 0.89, 95%CI: 0.86, 0.92). Compared to the West, EMS activations that occurred in the Midwest (OR: 0.78, 95%CI: 0.74, 0.82) or South (OR: 0.79, 95%CI: 0.76, 0.82) had decreased odds of treatment and transportation by EMS whereas those in the Northeast had increased odds (OR: 1.10, 95%CI: 1.03, 1.18). The odds of being treated and transported by EMS was 1.70 times higher for cases where a possible injury was documented (OR: 1.70, 95%CI: 1.62, 1.78).

Sport-related injuries affecting the abdomen (OR: 2.09, 95%CI: 1.72, 2.54), back (OR: 2.94, 95%CI: 2.48, 3.48), chest (OR: 1.33, 95%CI: 1.19, 1.49), lower extremity

(OR: 1.76, 95%CI: 1.62, 1.91), upper extremity (OR: 1.42, 95%CI: 1.29, 1.57), genitalia (OR: 2.19, 95%CI: 1.16, 4.13), and neck (OR: 3.03, 95%CI: 2.51, 3.65) had increased odds of being treated and transported by EMS compared to general/global complaints. Conversely, those affecting the head had decreased odds (OR: 0.74, 95%CI: 0.68, 0.79). Sport-related injuries that were psychiatric in nature (OR: 2.27, 95%CI: 1.92, 2.69) or affected the cardiovascular (OR: 1.39, 95%CI: 1.24, 1.56), neurological (OR:1.52, 95%CI: 1.42, 1.62), or reproductive (OR: 2.27, 95%CI: 1.24, 4.16) organ systems had increased odds of resulting in treatment and transportation by EMS whereas those affecting the lymphatic/immune (OR: 0.73, 95%CI: 0.54, 0.99) or musculoskeletal/skin (OR: 0.85, 95%CI: 0.80, 0.91) systems had decreased odds. All sport-related injuries affecting the renal system were treated and transported by EMS.

Research Question #3: What types of sport-related injuries transported by EMS were more likely to receive an ALS level of care?

Most EMS activations for sport-related injuries received an ALS level of care (85.5%, n=25885). However, the variable CMS service level, which was used to determine the level of care provided to the patient, was not documented in 41030 cases, significantly reducing the number of cases that could be included in this analysis. The final multiple logistic regression model included the variables age group (Wald χ^2=105.45, *df*=4, p<0.0001), patient gender (Wald χ^2=15.87, *df*=3, p=0.0012), urbanicity (Wald χ^2=29.62, *df*=3, p<0.0001), U.S. census region (Wald χ^2=1576.00, *df*=3, p<0.0001), possible injury (Wald χ^2=44.91, *df*=4, p<0.0001), chief complaint anatomic location (Wald χ^2=402.86, *df*=10, p<0.0001), and chief complaint organ system (Wald

χ^2=883.76, *df*=12, p<0.0001). Adjusted odds ratios for types of sport-related injuries resulting in ALS level of care provided are presented in Tables 5.5a and 5.5b.

Compared to patients younger than 13, patients aged 13 to 18 (OR: 1.52, 95%CI: 1.33, 1.73), 19 to 24 (OR: 1.53, 95%CI: 1.32, 1.79), 25 to 64 (OR: 1.78, 95%CI: 1.57, 2.02), and older than 64 (OR: 2.07, 95%CI: 1.77, 2.41) all had increased odds of receiving an ALS level of care. Compared to males, there was not a significant difference in the odds of receiving an ALS level of care for females (OR: 1.03, 95%CI: 0.95, 1.12). Compared to urban areas, EMS activations that occurred in rural (OR: 0.83, 95%CI: 0.72, 0.95) or wilderness (OR: 0.50, 95%CI: 0.38, 0.66) urbanicities had decreased odds of receiving an ALS level of care. Emergency medical services activations that occurred in the Midwest (OR: 0.12, 95%CI: 0.10, 0.13), Northeast (OR: 0.07, 95%CI: 0.07, 0.08), or South (OR: 0.20, 95%CI: 0.18, 0.23) had decreased odds of receiving an ALS level of care compared to those in the West. Sport-related injuries where a possible injury was documented had 1.27 increased odds of receiving an ALS level of care (OR: 1.27, 95%CI: 1.14, 1.40) compared to those where there was not.

Compared to general/global complaints, sport-related injuries affecting the lower extremity (OR: 0.76, 95%CI: 0.65, 0.88), upper extremity (OR: 0.78, 95%CI: 0.66, 0.93), genitalia (OR: 0.22, 95%CI: 0.10, 0.50) or head (OR: 0.33, 95%CI: 0.28, 0.38) were less likely to receive an ALS level of care. There was not a significant difference in the odds of receiving an ALS level of care for the other anatomic locations compared to general/global complaints. For organ system, injuries that were psychiatric in nature (OR: 0.64, 95%CI: 0.48, 0.84) or affected the musculoskeletal/skin (OR: 0.31, 95%CI: 0.28, 0.36) or renal (OR: 0.11, 95%CI: 0.02, 0.52) systems had decreased odds of receiving an

ALS level of care compared to general/global complaints. Injuries affecting the cardiovascular (OR: 3.11, 95%CI: 2.27, 4.26), neurological (OR: 3.76, 95%CI: 3.14, 4.51), endocrine/metabolic (OR: 2.49, 95%CI: 1.72, 3.58), gastrointestinal (OR: 1.76, 95%CI: 1.10, 2.81) or pulmonary (OR: 1.41, 95%CI: 1.04, 1.91) systems had increased odds of receiving an ALS level of care compared to general/global complaints.

Research Question #4: What is the estimated cost of EMS activations for sport-related injuries?

The variable CMS Service Level was completed in approximately 42% of the EMS activations in our study. The total estimated base cost of EMS activations for sport-related injuries during the study period was $13,302,725.08. The highest proportion of were categorized as "ALS, Emergency, Level 1" (30.7%, n=21871) and resulted in the highest total costs of $9,302,585.61. The next most frequently selected service level was "ALS, Non-emergency" resulting in $928,372.04 (4.8%, n=3453). However, the second highest total costs were for the service level "BLS, Non-emergency" (2.1%, n=1523, $1,737,192.99). The service level "BLS, Emergency" resulted in $1,034,531.46 (4.0%, n=2884) and "ALS, Emergency, Level 2" resulted in $266,908.46 (0.6%, n=433). The cost by service level and calendar year is presented in Table 5.6.

DISCUSSION

Management of Sport-Related Injuries by EMS providers

Nearly 75% of the EMS activations in our study resulted in treatment and transport by an EMS unit. The proportion of EMS activations that were treated and transported within published NEMSIS data has varied from 49% to 59% in previous

years.[100] Our findings indicate a larger proportion of individuals who sustained a sport-related injury accepted treatment and transport by EMS compared to the general population. This may be indicative of increased medical necessity for sport-related injuries.

Approximately 5% of patients refused evaluation, care, and transportation by EMS in our study, likely indicating the patient did not call EMS for themselves, as established in previous research.[48,103] For an EMS activation to occur, an emergency had to have been perceived by a patient, coach, teammate, bystander or medical providers present (e.g., athletic trainer, nurse) to call 9-1-1. Patient refusal of care and transportation by EMS could be due to a variety of reasons. The patient may not have perceived an emergency themselves, preferred to seek care elsewhere, or to avoid perceived costs associated with an EMS transport. Such cases may be an apparent abuse or waste of EMS resources, as there are limited number of units available at any one time to respond to emergencies within a service area. Refusal of EMS care or transportation to the ED can result in negative outcomes, including follow-up EMS activations, hospital admission, and death, if the necessary care was not subsequently received.[104-106] However, each EMS activation results in documentation of an event, should it need to be recalled at a later time, such as for legal purposes. Ten percent of patients in our study were treated by EMS providers but refused transportation to the ED. It is unknown if an alternative mode of transportation was taken to the ED instead. Patients who arrive to EDs by ambulance are more likely to arrive at the appropriate facility for their injury.[39] Less than one percent of patients were treated and indicated they would transport themselves to the ED via privately owned vehicle. Future research should examine

outcomes of patients who were transported to the ED for a sport-related injury in order to determine medical necessity of the EMS transport. Having an on-site medical provider, such as an athletic trainer, may result in fewer unnecessary EMS activations rather than relying on untrained personnel to appropriately triage sport-related injuries.

The most common provider impressions documented in our study – injury, syncope and collapse, acute pain – have also been prevalent in previous literature examining sport-related EMS activations and among the general population.[7,45,87] Strains, sprains, fractures, concussions, and contusions are common sport-related injury diagnoses that have resulted in transportation by EMS,[5] and could align with several of the provider impressions relating to injury types and pain present in our study. Provider impressions are largely based on the subjective symptoms reported by the patient, mechanism of injury or onset of illness, and any visuals signs noticed by the EMS provider. There are limited diagnostic capabilities (e.g., glucometers, cardiac monitors) available in the prehospital setting. Therefore, EMS providers are trained to treat what they can and ensure prompt, safe transportation to the ED for definitive care. While EMS data provides valuable insight into sport-related injuries from the EMS provider's perspective, the accuracy of the provider impressions relative to the diagnoses determined in the ED is unknown. The ability of EMS agencies to link their electronic patient care reports to the hospital electronic medical records would serve as a valuable quality improvement tool and be able to identify where additional training or protocol modifications may be needed.

On average, more than one procedure was performed per patient treated and transported by EMS. The most commonly performed procedures were catheterization of

the vein (e.g., intravenous access) and electrocardiograms (3- or 12-lead), both of which are advanced skills at the Advanced EMT or Paramedic levels according to the National Registry of EMTs.[107] Advanced life support level procedures are not commonly performed when looking at overall EMS activations in a population, not specific to a medical condition.[8,9,40,46] Considering the primary impressions documented in our study, obtaining intravenous access is important for the administration of intravenous fluids, as may have been indicated for hydration or heat exhaustion, or intravenous medications for pain, hypoglycemic, neurological or other medical conditions.

Cervical spine immobilization was performed more often than spinal immobilization in our study, which may indicate the use of spinal motion restriction (e.g., cervical collar application without the use of a longboard) over full spinal immobilization. An updated joint position statement was released in 2018 for prehospital care providers on the application of spinal motion restriction in trauma patients.[108] Protocols on spinal motion restrictions versus spinal immobilization will vary by EMS agency, so individuals developing emergency action plans for athletic venues should develop these plans with their local EMS agency, with specific attention paid to these protocols.

Active external cooling of the patient was performed in 1419 cases; however, a provider impression of heat exhaustion was only documented in 1201 cases. It is possible that cases where syncope or altered mental status were documented as the primary impression could have also been symptoms of a more severe exertional heat illness – exertional heat stroke. Performing effective external cooling of a patient is challenging within the confines of an ambulance, especially in cases of external heat stroke where

rapid whole-body cooling is the standard of care.[109] Individuals developing emergency action plans for athletics should discuss the recognition and management of exertional heat illnesses, with a particular emphasis on exertional heat stroke, to ensure adequate cooling measures are available and provided in a timely manner.

EMS Disposition of Sport-Related Injuries

Variables found to influence the odds of being treated and transported by EMS were U.S. census region, patient age group, patient gender, possible injury, chief complaint anatomic location and chief complaint organ system. Urbanicity did not significantly influence EMS disposition. The examination of EMS disposition provides insight into current triage practices in the prehospital setting for sport-related injuries. Triage occurs in three phases: at the time of EMS dispatch, at the scene by the first attending EMS provider, and upon arrival at the ED.[110] Within the context of this study, we have focused upon the on-scene triage (i.e. treatment and transportation). The ability of the patient to provide consent for evaluation and care (based on age and mental status) and medical necessity (e.g., pain management, bleeding control, abnormal vital signs) influence triage decisions.[111,112] However, EMS providers must also consider the availability of alternative means of transportation to the ED.[113] Unfortunately, we do not know what proportion of cases would be considered medically necessary, and criteria for determining medical necessity has yet to be established.[113,114]

Compared to children under the age of 13, all other age groups had increased odds of being treated and transported by EMS. All patients under the legal age of consent should receive an initial evaluation by EMS regardless of the presence of a parent or

guardian.[112] Emergency medical services providers have a duty to provide care that is in the best interest of the child when a parent or guardian is not present.[112] It is possible that parents or guardians of younger children could have been present and denied treatment and transport by EMS in favor of an alternative means. It is also possible that adolescents and adults sustained more severe sport-related injuries necessitating EMS care and transportation.

When compared to general/global complaints, EMS disposition varied by anatomic location and organ system affected. These findings may suggest that generalized complaints that did not specifically affect any body part or organ system were less severe in nature, therefore the patients and/or EMS providers did not feel transportation to the ED was indicated. Interestingly, injuries to the head had decreased odds of being treated and transported by EMS. Differential diagnoses for head injuries in sport should include concussion, second impact syndrome, intracranial hemorrhage, post-concussion syndrome, skull or facial fractures, and lacerations.[115-117] Our findings also demonstrated that injuries affecting the neurological system had increased odds of being treated and transported by EMS while those musculoskeletal in nature had decreased odds. Considering head injuries account for nearly 15% of catastrophic sport-related injuries,[22] EMS providers should conduct a thorough neurological evaluation and exercise caution when considering not to treat and transport a patient who has sustained a head injury, particularly when a traumatic mechanism is noted.

Level of Care Provided for Sport-Related Injuries

Most patients received an ALS level of care in our study, indicating treatment and transport by EMS were likely necessary. Emergency medical services agencies should consider assigning an ALS level unit when providing dedicated or stand-by services for athletic events. Variables found influencing the level of care provided for a sport-related injury were urbanicity, U.S. census region, age group, patient gender, possible injury, chief complaint anatomic location, and chief complaint organ system.

Our findings indicate regional differences in EMS agency staffing and protocols directing EMS resource utilization (e.g., level of units dispatched). Urbanicity has been associated with EMS provider over-commitment (i.e., working for multiple agencies),[118] scene and transport times,[119] but has not been examined in relation to sport or injury-associated EMS activations until now. In our study, patients located in urban areas were more likely to receive an ALS level of care than those located in rural or wilderness areas. The level of first response (i.e., first EMS provider on scene) and the level of transport (i.e., level of care of the transporting EMS unit) have been shown to vary by urbanicity and U.S. census region.[120] In urban areas, 54% of EMS agencies have a BLS level response, but 72% report having an ALS level transport from the scene to the hospital,[120] indicating an advanced level of care was indicated in many cases. There is also increased utilization of intermediate level units in suburban, rural, and wilderness areas compared to urban, and an increased reliance on volunteer EMS providers. Agencies in the South report the highest proportion of ALS level units for both first response and transport whereas agencies in the West report the highest proportion of intermediate level units for the same.[120] Differences in EMS agency capabilities (e.g., less

ALS-capable units) and staffing may also contribute to the difference in level of care provided based on region and urbanicity seen in our study. Emergency planning for athletic events should be conducted with local EMS agencies as athletics organizations and administrators are likely unfamiliar with EMS resources. Proper emergency planning is particularly important for large events, such as road races or ultimate sporting events, where additional EMS units may need to be staffed to provide adequate coverage for both participants and spectators.

Individuals over the age of 13 were more likely to receive an ALS level of care in our study, suggesting sport-related injuries in older individuals were more severe in nature. Severe injuries (i.e., an injury resulting in >21 days lost from sport participation) have been examined in high school and collegiate student-athletes, but not directly compared.[19,20] Other research has shown that adults older than 50 are over eight times more likely to require hospital admission due to a sports injury compared to individuals under the age of 30.[3] Further research is warranted to examine differences in the types and severity of sport-related injuries across age-groups. While age is associated with the level of care provided for sports-related injuries, dispatch and management decisions should not solely be based on the patient's age.

Musculoskeletal injuries (e.g., sprains, strains, fractures) have accounted for large proportions of sport-related injuries transported by EMS;[5] however, our findings indicate they are less likely to necessitate an advanced level of care bringing into question the appropriateness of EMS utilization for these injuries. Musculoskeletal injuries are also less likely to be perceived as a true emergency (i.e., a medical condition of injury requiring medical care as soon as possible at the ED) by EMS providers.[121] The

management of musculoskeletal injuries in the prehospital setting is typically limited to splinting, cervical or spinal immobilization, and patient monitoring, which can be performed at the BLS level and were documented in our study. The mechanism of injury may also be an important indicator of injury severity and therefore influence the level of care necessitated. Sport-related injuries where possible injury was documented by the EMS provider in our study had increased odds of receiving an ALS level of care. Additionally, over one-third of catastrophic sports injuries result from a traumatic injury mechanism.[22] The development of clinical prediction rules for sport-related injuries considering mechanism of injury, anatomic location and organ system affected may be beneficial to guide prehospital decisions on when the use of EMS is indicated and what level unit should be dispatched.

Cost of EMS Activations for Sport-Related Injuries

We estimated the cost of ambulance transport for sport-related injuries based on the NEMSIS variable "CMS Service Level". The amount billed for ambulance services is not collected by the NEMSIS, so it was not possible to directly calculate the cost of EMS utilization for sports-related injuries nor examine reimbursement by payor type. Increased ambulance utilization has been shown among patients with Medicaid or no insurance.[43,44] Additionally, Medicaid recipients have accounted for the majority of unnecessary ambulance transports.[48] The CMS Ambulance Fee Schedule outlines how ambulance services provided under Medicare Part B are reimbursed and is publicly available.[122] Using the average base rate for each service level, we estimated EMS utilization for sport-related injuries resulted in over $13 million. Our estimate did not take into account any additional charges for mileage, which would have resulted in higher costs for

individuals who live farther from a hospital. Our results demonstrate sport-related injuries result in significant costs resulting from EMS utilization. Efforts to reduce unnecessary EMS utilization, as previously discussed, would also reduce the economic impact of sport-related injuries on the healthcare system. Additional research on the economic burden of EMS utilization for sport-related injuries is needed.

Strengths and Limitations

A major strength of our study is that we specifically examined EMS management of sport-related injuries and used data from a national-level database. The NEMSIS database relies on a convenience sample of EMS agencies who voluntarily provide their agency's data for inclusion in the dataset. Therefore, while most states and territories are represented to a degree in our sample, our findings may not be generalizable to all geographic areas and EMS agencies. Additionally, each EMS activation represents an event documented by a responding EMS agency; therefore, it is possible for multiple EMS activations to have occurred for a single patient. Another limitation to our study was the large proportion of cases missing CMS service level which was used to determine the level of care provided. Future research should examine outcomes (e.g., ED care provided, hospital disposition, re-contact of EMS) of patients for whom a sport-related EMS activation occurred. The ability to link data from EMS agencies and receiving hospital would provide valuable insight into the accuracy of EMS provider impressions, care provided and aid in the determination of medical necessity to better inform prehospital care decisions.

CONCLUSION

Most EMS activations for sport-related injuries resulted in transportation by EMS at an ALS level and had at least one procedure performed, indicating the EMS activation was likely necessary. It is recommended to have a trained on-site medical provider for athletic events to reduce potentially unnecessary EMS activations, provide immediate care, and coordinate the EMS response. When developing emergency action plans, special attention should be paid to spinal motion restriction versus immobilization and the treatment of exertional heat stroke, to ensure appropriate equipment is available. Additionally, all planning should be conducted in coordination with local EMS agencies, especially for larger athletic events that may strain local medical resources should a large-scale emergency occur. Emergency medical services agencies providing medical coverage for athletic events should consider providing an ALS-level unit when resources allow.

Manuscript word count: 6311

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Table 5.1a Patient Demographics of EMS Activations for Sport-Related Injuries from 2017-2018

Variable		n (%)
Patient Age		
	<13	7526 (10.6)
	13 to 18	14791 (20.7)
	19 to 24	8297 (11.6)
	25 to 64	29178 (40.9)
	>64	11530 (16.2)
	Average±SD (Range)	36.6±22.9 (3-99)
Patient Gender[a]		
	Female	29618 (41.5)
	Male	41132 (57.7)
	Unknown (Unable to Determine)	30 (0.0)
Patient Race[b]		
	American Indian or Alaska Native	329 (1.0)
	Asian	486 (1.4)
	Black or African American	4356 (12.6)
	Hispanic or Latino	2837 (8.2)
	Native Hawaiian or Other Pacific Islander	158 (0.5)
	White	19038 (55.1)

[a] Patient gender was "not reported" or "not applicable" in 542 cases
[b] Patient race was "not reported" or "not applicable" in 7357 cases, and missing in 36761 cases

Table 5.1b Geographic Distribution of EMS Activations for Sport-Related Injuries from 2017-2018

Variable	n (%)
U.S. Census Division	
East North Central (IL, IN, MI, OH, WI)	5574 (7.8)
East South Central (AL, KY, MS, TN)	4231 (5.9)
Middle Atlantic (NJ, NY, PA)	3546 (5.0)
Mountain (AZ, CO, ID, MT, NM, NV, UT, WY)	13952 (19.6)
New England (CT, ME, MA, NH, RI, VT)	2943 (4.1)
Pacific (AK, CA, HI, OR, WA)	14034 (19.7)
Territories	136 (0.2)
West North Central (IA, KS, MN, MO, NE, ND, SD)	5009 (7.0)
West South Central (AR, LA, OK, TX)	5306 (7.4)
U.S. Census Region[a]	
Island Areas	136 (0.2)
Midwest	10583 (14.8)
Northeast	6489 (9.1)
South	26128 (36.6)
West	27986 (39.2)
Urbanicity[b]	
Rural	5005 (7.3)
Suburban	3146 (4.6)
Urban	59127 (86.2)
Wilderness	1323 (1.9)

[a] The Midwest region includes the West North Central and East North Central Divisions. The Northeast regions includes New England and Middle Atlantic divisions. The South region includes the South Atlantic, East South Central and West South Central divisions. The West regions includes the Pacific and Mountain divisions.

[b] Urbanicity was missing in 2721 cases

Table 5.2 Incident/Patient Disposition of EMS Activations for Sport-Related Injuries

Incident/Patient Disposition	**n (%)**
Patient Refused Evaluation/Care, Without Transport	4011 (5.6)
Patient Treated, Released (AMA)	7095 (10.0)
Patient Treated, Released (Per Protocol)	2467 (3.5)
Patient Treated, Transferred Care to Another EMS Unit	5056 (7.1)
Patient Treated, Transported by this EMS Unit	47385 (66.4)
Patient Treated, Transported by Law Enforcement	110 (0.2)
Patient Treated, Transported by Private Vehicle	564 (0.8)

Abbreviations: AMA, against medical advice; EMS, emergency medical services

Table 5.3 Most Common Primary Impressions Within EMS Activations for Sport-Related Injuries

Provider Primary Impression[a]	**n (%)**
Injury, Unspecified	11175 (16.7)
Syncope and Collapse	5291 (7.9)
Acute Pain, Not Elsewhere Classified	2947 (4.4)
Unspecified Injury of Head	2100 (3.1)
Weakness	1664 (2.5)
Altered Mental Status, Unspecified	1639 (2.5)
Alcohol Use, Unspecified	1508 (2.3)
Epilepsy, Unspecified, Not Intractable, Without Status Epilepticus	1326 (2.0)
Heat Exhaustion, Unspecified	1201 (1.8)
Dizziness and Giddiness	1148 (1.7)
Dehydration	1120 (1.7)
Unspecified Injury of Lower Leg	999 (1.5)
Dorsalgia, Unspecified	897 (1.3)
Unspecified Convulsions	873 (1.3)
Acute Respiratory Distress Syndrome	832 (1.2)
Pain, Unspecified	826 (1.2)
Cardiac Arrhythmia, Unspecified	758 (1.1)
Angina Pectoris, Unspecified	740 (1.1)
Other[b]	25872 (37.63)

[a] Provider primary impression was "not applicable" or "not reported" in 936 cases and missing in 4288 cases

[b] All other provider primary impressions accounted for ≤1.0% individually

Table 5.4a Odds of EMS Activation for Sport-Related Injury Resulting in Treatment and Transportation by EMS

Variable	Treated & Transported by EMS, n (%)		aOR (95% CI)[a]
	Yes	No	
U.S. Census Region			
West	21423 (76.6)	6563 (23.5)	Referent
Midwest	7494 (70.8)	3089 (29.2)	0.78 (0.74, 0.82)[b]
Northeast	5045 (77.8)	1444 (22.3)	1.10 (1.03, 1.18)[b]
South	18358 (70.3)	7770 (29.7)	0.79 (0.76, 0.82)[b]
Island Areas	121 (89.0)	15 (11.0)	--
Age Group			
<13	4956 (65.9)	2570 (34.2)	Referent
13 to 18	11373 (76.9)	3418 (23.1)	1.72 (1.61, 1.84)[b]
19 to 24	5851 (70.5)	2446 (29.5)	1.39 (1.29, 1.49)[b]
25 to 64	21693 (74.4)	7485 (25.7)	1.79 (1.68, 1.90)[b]
>64	8568 (74.3)	2962 (25.7)	1.86 (1.74, 1.99)[b]
Patient Gender			
Male	30835 (75.0)	10297 (25.0)	Referent
Female	21374 (72.2)	8244 (27.8)	0.89 (0.86, 0.92)[b]
Unknown	18 (60.0)	12 (40.0)	0.65 (0.30, 1.41)
Not Recorded	213 (43.6)	276 (56.4)	--
Not Applicable	1 (1.9)	52 (98.1)	--
Possible Injury			
No	25576 (71.3)	10275 (28.7)	Referent
Yes	22637 (79.9)	5697 (20.1)	1.70 (1.62, 1.78)[b]
Unknown	1328 (69.6)	580 (30.4)	1.03 (0.92, 1.15)
Not Recorded	2861 (58.1)	2061 (41.9)	--
Not Applicable	39 (12.7)	268 (87.3)	--

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; EMS, emergency medical services

[a] 2721 observations excluded due to missing values for the response or explanatory variables.

[b] Statistically significant odds ratio

-- Indicates aORs unable to be calculated or excluded due to lack of clinical relevance

Table 5.4b Odds of EMS Activation for Sport-Related Injury Resulting in Treatment and Transportation by EMS

Variable	Treated & Transported by EMS, n (%)		aOR (95% CI)[a]
	Yes	No	
Chief Complaint Anatomic Location			
General/Global	17757 (73.8)	6318 (26.2)	Referent
Abdomen	1679 (84.6)	306 (15.4)	2.09 (1.72, 2.54)[b]
Back	1454 (88.8)	183 (11.2)	2.94 (2.48, 3.48)[b]
Chest	3171 (78.8)	851 (21.2)	1.33 (1.19, 1.49)[b]
Lower Extremity	6195 (84.3)	1156 (15.7)	1.76 (1.62, 1.91)[b]
Upper Extremity	3204 (80.6)	772 (19.4)	1.42 (1.29, 1.57)[b]
Genitalia	91 (87.5)	13 (12.5)	2.19 (1.16, 4.13)[b]
Head	4797 (70.7)	1987 (29.3)	0.74 (0.68, 0.79)[b]
Neck	1233 (89.2)	149 (10.8)	3.03 (2.51, 3.65)[b]
Not Recorded	11859 (66.9)	5865 (33.1)	--
Not Applicable	1001 (43.9)	1281 (56.1)	--
Chief Complaint Organ System			
General/Global	15181 (73.9)	5362 (26.1)	Referent
Behavioral/Psychiatric	920 (84.1)	174 (15.9)	2.27 (1.92, 2.69)[b]
Cardiovascular	2674 (80.3)	657 (19.7)	1.39 (1.24, 1.56)[b]
CNS/Neurological	6000 (77.9)	1703 (22.1)	1.52 (1.42, 1.62)[b]
Endocrine/Metabolic	941 (71.9)	367 (28.1)	1.04 (0.92, 1.19)
Gastrointestinal	1256 (83.1)	256 (16.9)	1.13 (0.91, 1.40)
Lymphatic/Immune	131 (65.8)	68 (34.2)	0.73 (0.54, 0.99)[b]
Musculoskeletal/Skin	12033 (79.1)	3175 (20.9)	0.85 (0.80, 0.91)[b]
Reproductive	122 (90.4)	12 (9.6)	2.27 (1.24, 4.16)[b]
Pulmonary	1248 (72.8)	465 (27.2)	1.03 (0.90, 1.19)
Renal	27 (100.0)	0 (0.0)	>999.999 (<0.001, >999.99)
Not Recorded	10991 (67.1)	5379 (32.9)	--
Not Applicable	917 (42.1)	1262 (57.9)	--

Abbreviations: aOR, adjusted odds ratio; CNS, central nervous system; CI: confidence interval; EMS, emergency medical services

[a] 2721 observations excluded due to missing values for the response or explanatory variables.

[b] Statistically significant odds ratio

-- Indicates aORs unable to be calculated or excluded due to lack of clinical relevance

Table 5.5a Odds of EMS Activation for Sport-Related Injury Resulting in ALS Level of Care Provided

Variable	Level of Care Provided, n (%)		aOR (95% CI)[a]
	ALS	BLS	
U.S. Census Region			
West	13450 (97.0)	417 (3.0)	Referent
Midwest	1911 (69.3)	845 (30.7)	0.12 (0.10, 0.13)[b]
Northeast	1800 (57.5)	1331 (42.5)	0.07 (0.07, 0.08)[b]
South	8720 (83.0)	1792 (17.1)	0.20 (0.18, 0.23)[b]
Island Areas	4 (15.4)	22 (84.6)	--
Urbanicity			
Urban	22993 (87.1)	3397(12.9)	Referent
Suburban	1047 (78.8)	282 (21.2)	1.04 (0.89, 1.21)
Rural	1342 (77.7)	385 (22.3)	0.83 (0.72, 0.95)[b]
Wilderness	196 (66.0)	101 (34.0)	0.50 (0.38, 0.66)[b]
Age Group			
<13	2144 (74.8)	722 (25.2)	Referent
13 to 18	4857 (80.1)	1208 (19.9)	1.52 (1.33, 1.73)[b]
19 to 24	2992 (85.1)	524 (14.9)	1.53 (1.32, 1.79)[b]
25 to 64	11706 (89.1)	1438 (10.9)	1.78 (1.57, 2.02)[b]
>64	4186 (89.0)	515 (11.0)	2.07 (1.77, 2.41)[b]
Patient Gender			
Male	14690 (84.4)	2723 (15.6)	Referent
Female	11154 (87.1)	1653 (12.9)	1.03 (0.95, 1.12)
Unknown	9 (81.8)	2 (18.2)	1.77 (0.27, 11.39)
Not Recorded	32 (52.5)	29 (47.5)	--
Not Applicable	0 (0.0)	0 (0.0)	--
Possible Injury			
No	15117 (89.5)	1769 (10.5)	Referent
Yes	10277 (81.8)	2283 (18.2)	1.27 (1.14, 1.40)[a]
Unknown	188 (61.8)	116 (38.2)	0.77 (0.57, 1.03)
Not Recorded	285 (55.6)	228 (44.4)	--
Not Applicable	18 (62.1)	11 (37.9)	--

Abbreviations: aOR, adjusted odds ratio; ALS, advanced life support; BLS, basic life support; CI, confidence interval

[a] 41579 observations excluded due to missing values for the response or explanatory variables.

[b] Statistically significant odds ratio

-- Indicates aORs unable to be calculated or excluded due to lack of clinical relevance

Table 5.5b Odds of EMS Activation for Sport-Related Injury Resulting in ALS Level of Care Provided

Variable	ALS Level of Care Provided, n (%)		aOR (95% CI)[a]
	ALS	BLS	
Chief Complaint Anatomic Location			
General/Global	12882 (93.3)	933 (6.8)	Referent
Abdomen	1288 (95.0)	68 (5.0)	1.43 (0.96, 2.14)
Back	665 (81.4)	152 (18.6)	1.06 (0.84, 1.33)
Chest	2175 (93.8)	143 (6.2)	0.98 (0.76, 1.28)
Lower Extremity	2697 (80.7)	647 (19.4)	0.76 (0.65, 0.88)[b]
Upper Extremity	1375 (80.0)	343 (20.0)	0.78 (0.66, 0.93)[b]
Genitalia	21 (56.7)	16 (43.2)	0.22 (0.10, 0.50)[b]
Head	2309 (79.7)	588 (20.3)	0.33 (0.28, 0.38)[b]
Neck	483 (79.1)	128 (21.0)	0.95 (0.74, 1.23)
Not Recorded	1848 (57.8)	1348 (42.2)	--
Not Applicable	142 (77.6)	41 (22.4)	--
Chief Complaint Organ System			
General/Global	10074 (91.3)	961 (8.7)	Referent
Behavioral/Psychiatric	611 (88.4)	80 (11.6)	0.64 (0.48, 0.84)[b]
Cardiovascular	1758 (96.3)	67 (3.7)	3.11 (2.27, 4.26)[b]
CNS/Neurological	5113 (96.1)	209 (3.9)	3.76 (3.14, 4.51)[b]
Endocrine/Metabolic	947 (96.4)	35 (3.6)	2.49 (1.72, 3.58)[b]
Gastrointestinal	1057 (96.3)	41 (3.7)	1.76 (1.10, 2.81)[b]
Lymphatic/Immune	119 (93.7)	8 (6.3)	1.55 (0.69, 3.45)
Musculoskeletal/Skin	3481 (67.1)	1704 (32.9)	0.31 (0.28, 0.36)[b]
Reproductive	60 (85.7)	10 (14.3)	0.83 (0.35, 1.93)
Pulmonary	942 (91.5)	88 (8.5)	1.41 (1.04, 1.91)[b]
Renal	4 (50.0)	4 (50.0)	0.11 (0.02, 0.52)[b]
Not Recorded	1573 (57.6)	1160 (42.4)	--
Not Applicable	146 (78.5)	40 (21.5)	--

Abbreviations: aOR, adjusted odds ratio; ALS, advanced life support; CI, confidence interval; CNS, central nervous system

[a] 41579 observations excluded due to missing values for the response or explanatory variables.

[b] Statistically significant odds ratio

-- Indicates aORs unable to be calculated or excluded due to lack of clinical relevance

Table 5.6 Cost Estimation of EMS Activations for Sport-Related Injuries

CMS Service Level (RVU)	2017			2018		
	Adj. Average Base Rate[a]	EMS Activations (n)	Estimated Base Cost	Adj. Average Base Rate[a]	EMS Activations (n)	Estimated Base Cost
BLS, Non-emergency (1.00)	$1,132.40	361	$408,796.21	$1,143.19	1162	$1,328,386.78
ALS, Non-emergency (1.20)	$266.75	973	$259,545.80	$269.69	2480	$668,826.24
BLS, Emergency (1.60)	$355.66	640	$227,624.96	$359.58	2244	$806,906.50
Paramedic Intercept (1.75)	$389.01	5	$1,945.04	$393.30	22	$8,652.49
ALS, Emergency, Level 1 (1.90)	$422.35	7833	$3,308,275.38	$427.01	14038	$5,994,310.23
ALS, Emergency, Level 2 (2.75)	$611.30	104	$63,574.94	$618.04	329	$203,333.52
Specialty Care Transport (3.25)	$722.44	12	$8,669.31	$730.40	19	$13,877.70
Total		9928	$4,278,431.64		20294	$9,024,293.44

Abbreviations: ALS, advanced life support; BLS, basic life support; CMS, Center for Medicare and Medicaid Services; EMS, emergency medical services; RVU, relative value unit

Note: There were 7449 EMS activations documented as “not applicable” and 33581 EMS activations documented as “not reported”.

[a] Base Rate does not include additional charges for mileage

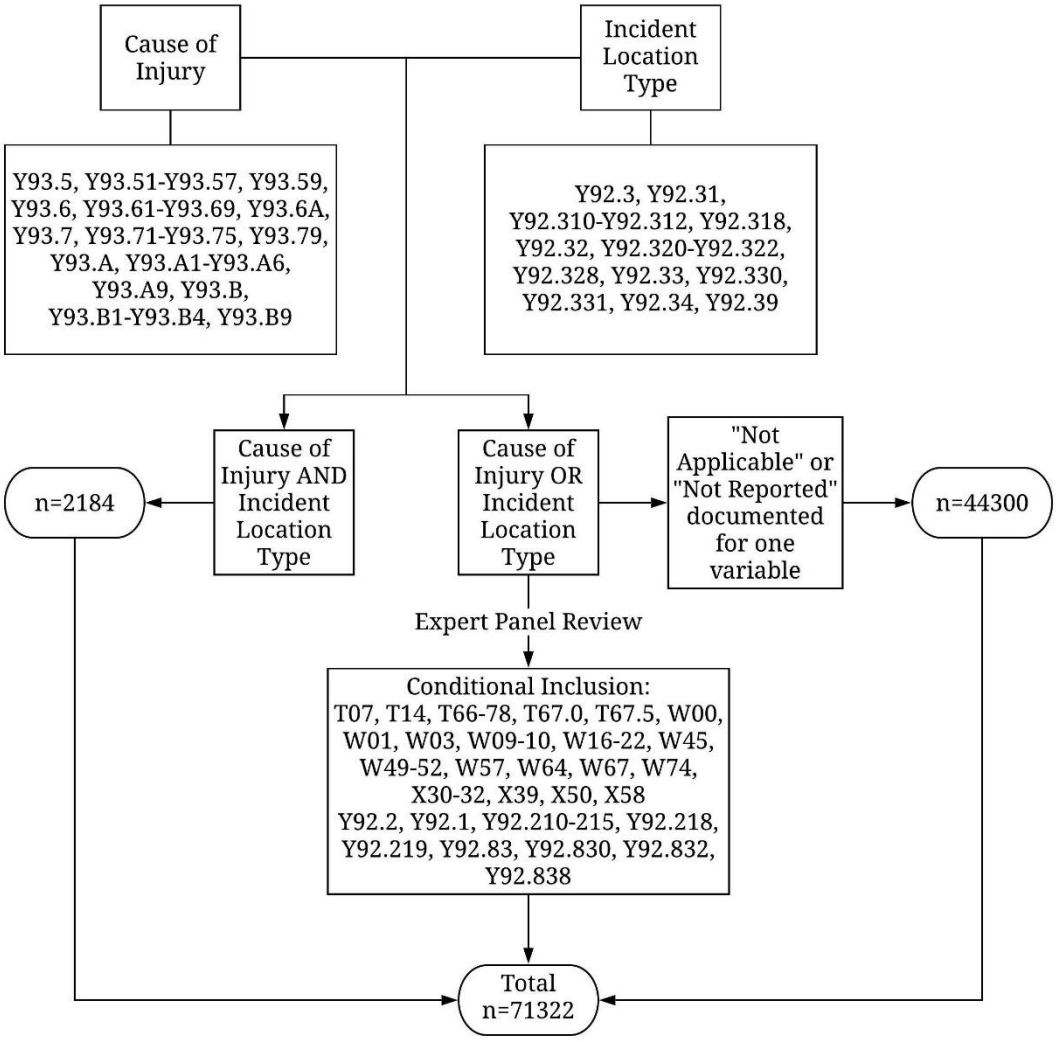

Figure 5.1 Inclusion Criteria for Identifying EMS Activations for Sport-Related Injuries

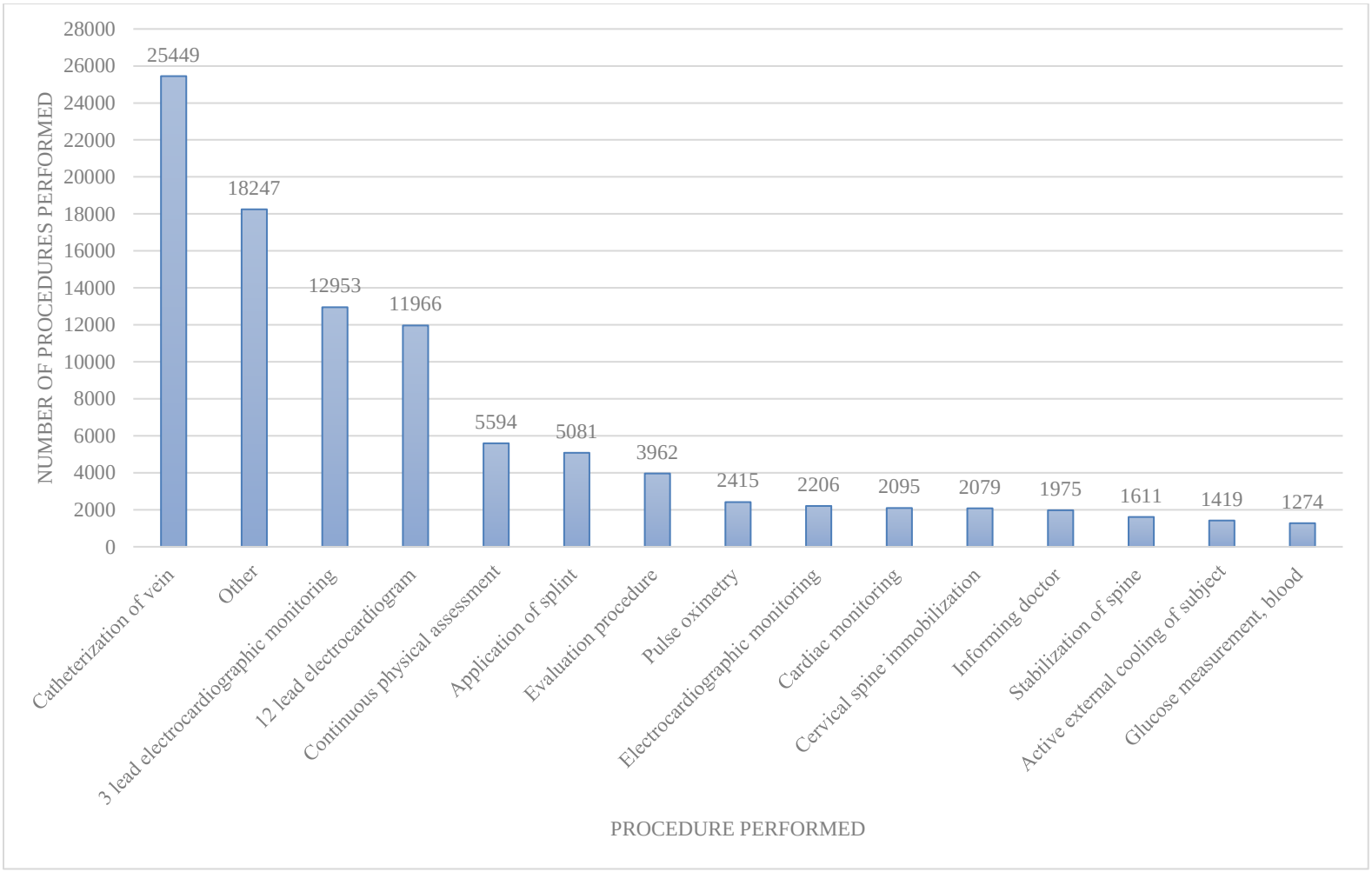

Figure 5.2 Most Common Procedures Performed by EMS Providers

CHAPTER 6

THE ASSOCIATION BETWEEN ACCESS TO ATHLETIC TRAINERS AND EMERGENCY MEDICAL SERVICES ACTIVATIONS FOR SPORT-RELATED INJURIES[3]

[3] Hirschhorn RM, Huggins RA, Kerr ZY, Mensch JM, Dompier TP, Rudisill C, Yeargin SW. To be submitted to *Journal of Athletic Training*

INTRODUCTION

Over 7.9 million boys and girls participate in high school athletics each academic year.[123] Of concern, approximately 1.4 million sport-related injuries occurred in this population during the 2005-2006 academic year,[18] a number that has likely risen since then. Rare and severe injuries have accounted for 3-15% of all sport-related injuries.[19,21] In the most recent report from the National Center for Catastrophic Sport Injury Research, 56 catastrophic events were reported among high school student-athletes.[22] Thirty percent of the catastrophic injuries reported among high school and collegiate student-athletes were fatal. Over a 20-year period, 203 deaths occurred in high school football athletes, averaging 10 each year, most commonly due to cardiac and brain injuries.[24] While it is likely some of these injuries and fatalities necessitated care and transportation by emergency medical services (EMS), none of the aforementioned studies examined the involvement of EMS directly.

Sports accounted for over 35% of school-based EMS activations;[41] however, this study was limited to a single state. In a national examination of high school sport-related injuries documented by athletic trainers (ATs), 0.3% of injuries resulted in transportation by EMS.[5] High school ATs activate EMS more frequently than ATs working in the collegiate setting.[29] As many as 54% of ATs reported activating their emergency action plan (EAP) for a sport-related emergency,[27] and nearly 40% of high school ATs have activated EMS an average of one to two times per year for football alone.[29] However, these studies either only examined EMS activations initiated by ATs,[5,27,29] or the presence of ATs is unknown.[41]

Athletic trainers are the preferred on-site medical provider for secondary school-aged athletes.[53,54] The most recent report from the Athletic Training Location and Services (ATLAS) Project found that only 66% of secondary schools in the U.S. have access to athletic training services, ranging from 13% to 90% within states.[67] Most ATs are employed through a medical or university facility or directly by a school district.[67] Athletic training services vary greatly by service level and employment model across the U.S. Athletic trainers are typically the individuals responsible for EAP development, and automated external defibrillator maintenance, storage, and use.[69-72] Further, the existence of an AT is associated with having venue-specific EAPs and AEDs in secondary schools.[73,74] Therefore, in schools with limited or no access to an AT, it is unlikely that proper steps have been put in place to respond to a sport-related emergency. Findings from a recent microsimulation analysis estimated that having access to an AT results in less emergency department visits by injured student-athletes.[75] In lieu of ATs, 49% of private and 80% of public high schools have EMS present during athletic competitions.[52] It is unknown if there is an association between access to athletic training services or athletic training employment model and the utilization of EMS.

Therefore, the primary purpose of this study is to compare the incidence of EMS activations for sport-related injuries among high school-aged patients (i.e., 13 to 18 years old) between zip-codes by athletic training service level and employment type. It is hypothesized that zip-codes categorized as having access to athletic training services will have fewer EMS activations than those categorized as not having access to athletic training services. It is also hypothesized that there will be no difference in the number of EMS activations between zip-codes categorized as having full-time or part-time athletic

training services, nor will there be a difference in the number of EMS activation by employment type.

METHODS

This study, as part of a larger examination of EMS activations for sport-related injuries, used a retrospective cohort design with selected data from the National EMS Information System (NEMSIS) database and the ATLAS Project from 2017-2018. Cases were limited to 9-1-1 EMS activations for sport-related injuries among high school-aged patients (i.e. 13-18 years). The NEMSIS database contains data voluntarily reported by EMS agencies across the U.S. The ATLAS Project includes information on 16,076 public secondary schools and 4,196 private schools across all 50 states and the District of Columbia; however, only schools with an interscholastic athletics program for grades between 9-12 were included in their database.[10]

Study Procedures

A data request was submitted to the NEMSIS for the 2017 and 2018 Public-Release Datasets. Sport-related injuries were identified using selected ICD-10-CM codes for incident location type and cause of injury. In total, 71,322 EMS activations due to sport-related injuries were identified during the time period for individuals aged 3-99. A data request was also submitted to the Korey Stringer Institute for the most recent high school data from the ATLAS Project. The ATLAS data requested was for school zip-code, presence of an AT (yes/no), and athletic training services information. Athletic training service information included the level of service the school receives (full-time or part-time), employment provider type (i.e., school district, school district with teaching

responsibilities, medical/university facility), and if other medical services were present at home games for football and all other sports. Additionally, American Community Survey data collected by the ATLAS Project (median household income, median family income, number of households, number of families, and socioeconomic status) was requested. Once received, a file was created to code the existence of an AT and their employment level by zip-code. Zip-code is considered a state-level variable by the NEMSIS and could not be included in requested data. Therefore, the zip-code coding scheme was sent to the NEMSIS Technical Assistance Center who created a new blinded variable for zip-code which was then returned to the researchers for analysis.

Statistical Analysis

Descriptive statistics (frequencies and proportions) were calculated for each descriptive variable. For athletic training service level, an aggregate score was created for each zip-code. Schools with full-time athletic training services received a 1, schools with part-time athletic training services received a 0.5 and schools with none received a 0. The average score across all schools within each zip-code was then calculated. The variable AT employment type was treated as a categorical variable with the following options: medical or university facility (MUF), school district (SD), independent contractor (IC), mixed-employment types (MIX), or none (NONE) where no AT was employed. The number of ATs employed within each zip-code was also calculated. Poisson regressions will be performed to determine if the frequency of EMS activations for sport-related injuries will vary by athletic training service level, athletic training employment type, and number of ATs employed.

RESULTS

At this time, the zip-code coding scheme created using the ATLAS data has been sent to the NEMSIS and we are waiting to receive the blinded zip-code variables in return. Due to the demand placed on the NEMSIS by the SARS-CoV2 pandemic, this process was not able to be completed in the proposed timeline. Once the new data is received from the NEMSIS, this study will be completed and prepared for manuscript submission.

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and do not necessarily represent the official views of the KSI, the NATA or any of the supporters.

CHAPTER 7

CONCLUSION

OVERALL

This study aimed to 1) describe EMS activations for sport-related injuries from a national sample, 2) describe EMS management of sport-related injuries, and 3) compare the incidence of EMS activations for sport-related injuries for high school-aged patients (i.e., age 13 to 18) between zip-codes coded by athletic training service level and employment type. Our study included data from the 2017 and 2018 calendar years. This study was the first to examine EMS activations for sport-related injuries using a national database, including pediatric and adult populations. This was also the first study to use a refined definition for sport-related injury based on incident location and cause of injury. Until now, literature examining sport-related injuries using data derived from EMS agencies has been limited to the pediatric population, only used location criteria to identify sport-related injuries and was limited to a single state.[7]

AIM 1

We sought to answer the following research questions within aim #1: What proportion of EMS activations are due to sport-related injuries? How do sport-related injuries differ between pediatric (<18 years) and adult (≥18 years) patients in regard to chief complaint anatomic location and organ system affected? There were 71,322 EMS

activations for sport-related injuries identified in our sample, accounting for approximately 0.2% of EMS activations. All ages, from 3 to 99, were represented in our sample, indicating sport-related injuries are not limited to the populations typically studied (i.e., children and young adults) or organized sports. In this study, the most frequently documented chief complaint anatomic locations were general/global, lower extremity, and head. We hypothesized that adults will have higher proportions of abdomen, chest and general/global injuries than the pediatric population and that the pediatric population will have higher proportions of musculoskeletal/skin injuries than the adult population. Adults had higher proportions of injuries to the abdomen, chest, general/global, and genitalia compared to children. Adults had lower proportions of injuries affecting the musculoskeletal/skin and pulmonary organ systems compared to children. We also hypothesized there will not be difference between adult and pediatric populations with regards to other anatomic locations and organ systems. Our findings supported, some, but not all, of our hypotheses. There were significant differences between pediatric and adult populations for every anatomic location and organ system except for lymphatic/immune. Future research examining sport-related injuries in the adult population, beyond collegiate athletics, is warranted to better understand how aging affects injury risk and subsequent EMS and ED utilization.

AIM 2

We sought to answer the following research questions within aim #2: What types of injuries are more likely to result in transportation by EMS? What types of sport-related injuries transported by EMS are more likely to receive an advanced life support level of care? What is the estimated cost for of EMS activations due to sport-related injuries?

Nearly 75% of EMS activations for sport-related injuries in our study resulted in treatment and transport by an EMS unit. United States census region, patient age group, patient gender, possible injury, chief complaint anatomic location and chief complaint organ system were predictive of if a sport-related injury had increased odds of being treated and transported by EMS. Examination of EMS disposition provides insight into current on-scene triage practices for sport-related injuries. Overall, general/global complaints had decreased odds of being treated and transported by EMS. These findings suggest that generalized complaints that did not specifically affect any body part or organ system were less severe in nature, therefore the patients and/or EMS providers did not feel transportation to the ED was indicated.

Most EMS activations that resulted in treatment and transport by EMS were documented as receiving an ALS level of care. Urbanicity, U.S. census region, patient age group, patient gender, possible injury, chief complaint anatomic location and chief complaint organ system were found to be predictive of if patients received an ALS level of care. We hypothesized that sport-related injuries to the abdomen, chest, head or neck; or affecting the cardiovascular, neurological, or pulmonary systems would most likely result in ALS level of care, as opposed to BLS. Our findings supported this hypothesis for the abdomen, cardiovascular system, neurological system, and pulmonary system, each of which had an increased odds of receiving an ALS level of care when compared to global/general complaints. No significant difference was found in the odds for chest or neck injuries, and head injuries had a decreased odds of receiving an ALS level of care. Musculoskeletal injuries account for a large proportion of injuries transported by EMS, but are less likely to receive an ALS level of care, indicating EMS may be over-utilized

for these injuries. Clinical prediction rules considering the mechanism of injury, anatomic location and organ system affected may be beneficial to guide prehospital decisions and more efficiently utilize EMS resources.

We estimated EMS utilization for sport-related injuries resulted in over $13 million. However, there were 41030 EMS activations where the variable “CMS Service Level” was not completed, resulting in our estimate only accounting for approximately 42% of the EMS activations in our study. Additionally, our estimate did not take into account any additional charges for mileage, which would result in higher costs for individuals who were injuried farther from a hospital. Our findings indicate sport-related injuries result in significant costs for EMS utilization. Additional research on the economic burden of EMS utilization for sport-related injuries is needed.

AIM 3

At this time, the zip-code coding scheme created using the ATLAS data has been sent to the NEMSIS and we are waiting to receive the blinded zip-code variables in return. Due to the demand placed on the NEMSIS by the SARS-CoV2 pandemic, this process was not able to be completed in the proposed timeline. Once the new data is received from NEMSIS, Aim #3 will be completed and prepared for manuscript submission.

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APPENDIX A

OFFICE OF RESEARCH COMPLIANCE DECLARATION OF NOT HUMAN SUBJECTS

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
DECLARATION of NOT HUMAN SUBJECTS

Rebecca Hirschhorn
Arnold School of Public Health
Exercise Science
Rm 226
Columbia, SC 29208 USA

Re: **Pro00095944**

Dear Ms. Rebecca Hirschhorn:

This is to certify that Research Proposal entitled ***Examination of Emergency Medical Services Activations for Sport-Related Injuries by Athletic Training Service Level*** was reviewed on **12/16/2019** by the Office of Research Compliance, an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). The Office of Research Compliance, on behalf of the Institutional Review Board, has determined that the referenced study meets the Not Human Subject criteria set forth by the Code of Federal Regulations (45 CFR 46) of:

a. the specimens and/or private information/data were not collected specifically for the currently proposed research project through an interaction/intervention with living individuals AND

b. the investigator(s) including collaborators on the proposed research cannot readily ascertain the identity of the individual(s) to whom the coded private information or specimens pertain

No further oversight by the USC IRB is required; however, the investigator should inform the Office of Research Compliance prior to making any substantive changes in the research methods, as this may alter the status of the project.

If you have questions, contact Lisa M. Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager

APPENDIX B

ADDITIONAL LITERATURE SUPPORT

APPROPRIATE MEDICAL CARE RECOMMENDATIONS FOR ATHLETES

In June of 1998, the American Medical Association Council on Scientific Affairs presented a resolution to the American Medical Association House of Delegates supporting the use of certified ATs in secondary schools.[124] In this report, the creation of an Athletic Medicine Unit that included a physician, an athletic health coordinator (preferably an AT), and other necessary personnel was recommended. This Athletic Medicine Unit should be responsible for injury prevention, provision of medical care, coordination of health care with necessary medical professionals, and rehabilitation of the injured. High school administrators and athletic directors were urged to work within their community to ensure funding to provide AT services at their schools. If schools were unable to secure AT services, school administrators and athletic directors should ensure coaches are trained in emergency first aid and basic life support (BLS). These recommendations have continued to evolve in recent years into more detailed recommendations for appropriate medical care. Numerous resource documents have established appropriate medical care and best practices for youth,[57] secondary school-aged,[53,54,125] and collegiate athletes.[23,58]

Youth Sport League Recommendations

To date, only one resource document, The Inter-Association Task Force Document on Emergency Health and Safety: Best-Practice Recommendations for Youth Sport Leagues, has been published specific to the youth athlete population.[57] The task force made seven recommendations for the national governing bodies of youth sport leagues to implement including the creation of EAPs, having appropriate emergency equipment, developing training related to emergency health and safety, monitoring non-compliance with safety policies, and EAP training. Specific policies for SCA, brain and neck injuries, exertional heat stroke, pre-existing medical conditions, environmental conditions, and medical services are also recommended. Organizations should provide access to appropriate medical care (i.e., ATs or EMS) for practices, competitions, and events. The prevalence and type of medical care provided to youth sports leagues are currently unknown.[25]

Secondary School-Aged Athlete Recommendations

The NATA published a summary statement on appropriate medical care for the secondary school-aged athlete in 2008.[53] An updated document, Appropriate Medical Care Standards for Organizations Sponsoring Athletic Activity for the Secondary-School Aged Athlete: A Summary Statement was released in 2019.[54] The recommendations outlined in each document are shown in Table 2.2.[53,54] Central to these recommendations is the development of an athletic health care team (AHCT) for which the medical physician director and certified AT are considered core members. Emergency medical services providers are also considered to be part of the AHCT, and together with the

certified AT, are part of the on-site personnel. The term qualified medical professional (i.e., an individual who is qualified by education, training, licensure/regulation, and facility privileging who performs a professional service within his/her scope of practice and independently reports that professional service) was introduced in the new statement.[54] The qualified medical professional may or may not be an AT, depending on the institution, circumstances, and service being provided. Another core component is the development and implementation of a comprehensive EAP. The EAP should include planning for potential emergencies among spectators, coaches, officials, athletes, crowd control, evacuation of the venue(s) in the event of severe weather, fire, or other natural disasters. The NATA position statement on emergency planning should be used as a guide.[69] In the updated document, the integration of the EAP with local EMS for each athletic venue is now emphasized.[54] Prompt recognition, on-site evaluation and immediate treatment of injuries, particularly for those that may be life-threatening, are recommended.[53,54] However, this recommendation has been expanded to include the appropriate referral of injuries and transitioned to recommending the use of a qualified medical professional for on-site care (e.g., coach with CPR and AED certification, EMS).[54] The creation of management plans for high-risk conditions (e.g., lightening, exertional heat illness, SCA) and the use of injury tracking to develop strategies for risk mitigation is also included.

Collegiate Appropriate Care Recommendations

Much of the literature previously discussed has focused on appropriate medical care for the secondary school-aged athlete. The NATA developed the Appropriate Medical Care for Intercollegiate Athletics (AMCIA) in 2000 with the most recent version

updated in 2010.[58] This tool uses injury rates, the potential for catastrophic injury, and treatment/rehabilitation demands for injuries to help institutions systematically determine the appropriate level of medical coverage for each sport it offers. Minimal qualifications for personnel involved in medical coverage of sports includes certification in CPR, AED use, first aid, and prevention of disease transmission. A summary of the medical coverage recommendations is provided in Table 2.3.[58] Additionally, any sports with a catastrophic index greater than 3.0 should have a certified AT physically present during all home competitions. The implementation of comprehensive, venue-specific EAPs are also emphasized in this document, citing the NATA position statement on emergency planning.[69] One study created a survey based on the AMCIA document to assess staffing characteristics of Football Bowl Division institutions.[126] On average, football athletic training staff consisted of 2.4 full-time athletic trainers, 0.2 part-time athletic trainers, 1.2 graduate assistant athletic trainers, 0.3 paid intern athletic trainers and 7.4 athletic training students. When compared to the AMCIA document recommendations, 34.2% of respondents met or exceeded the recommendations for full-time employees for football. Approximately 40% of those surveyed reported using the AMCIA document to evaluate their staffing size, the majority of whom reported doing so in an effort to increased staffing. Literature evaluating appropriate medical care in the collegiate level is sparse.

Preventing Sudden Death in Sports

The prevention of catastrophic injury and sudden death has been the objective of multiple resource documents include the NATA Position Statement on Preventing Sudden Death in Sports,[94] and others specific to collegiate strength and conditioning sessions,[23] secondary school athletics programs,[125] and collegiate athletes.[127]

Recommendations are provided targeting specific conditions including asthma, catastrophic brain injury, cervical spine injuries, diabetes, exertional heat stroke, exertional hyponatremia, exertional sickling, exertional rhabdomyolysis, head-down contact football, SCA, cardiac conditions, mental health emergencies, any exertional or non-exertional collapse, protective equipment, and lightening. Additional emphasis is placed on having appropriate medical coverage and sport-sponsoring institutions having a comprehensive, written EAP in place that is venue-specific and has been developing in coordination with local EMS. The most recent inter-association recommendations includes an extensive checklist for athletics healthcare administrators to use in the assessment of their institution's current policies, beyond the presence of EAPs.[127] Annual education and training on the prevention of sudden death is recommended for strength and conditioning professionals, sport coaches, athletic trainers, team physicians, collegiate athletes, and athletics administrators.[127]

Appropriate medical care recommendations and best practices for the prevention of catastrophic injury and sudden death have mainly focused on secondary school-aged,[53,54,124,125] and collegiate athletes.[23,58,127] Only recently have best practices for youth sports been established.[57] Providing access to an AT during sports activities is a key component to ensuring appropriate medical care; however, ATs do not have the sole responsibility for providing care. Administrators also have the responsibility to ensure appropriate medical coverage (e.g., ATs, physicians, local EMS) is provided to all sports participants.[23,53,54] Recommendations for secondary school-aged athletes may extend to formal recreational leagues outside of interscholastic athletes; however, informal

recreational sporting groups may lack the necessary oversight to evaluate need and implement appropriate medical care.

ASSESSMENT OF APPROPRIATE MEDICAL CARE

Extensive literature has been published on recommendations for appropriate medical care in athletics.[23,53,54,57,58,69,94,124,125,127] A team approach is necessary to ensure comprehensive and appropriate medical care is provided to athletes. Evaluation of the current medical coverage and the implementation of best-practice recommendations is necessary to determine where improvements need to be made and barriers that may exist in their implementation.

Assessment of Appropriate Medical Care in the Secondary School Setting

In 2010, the Appropriate Medical Care Assessment Tool (AMCAT), based on the NATA Appropriate Medical Care for the Secondary School-Age Athletes,[53] was developed to examine the comprehensive medical care provided by a secondary school for their student-athletes.[50] An Appropriate Care Index score was calculated using specific items from the AMCAT, ranging from 0 (lowest) to 1 (highest); the higher the score, the higher the quality of care being provided. Responses for items varied with some using a 0 to 3 Likert scale, and others rated on a 2-point yes/no scale. However, for all items, higher scores were more favorable. The AMCAT was then used to assess the status of medical care being provided to athletes in South Carolina high schools. The survey was most frequently completed by the athletic director, followed by the AT. The mean Appropriate Care Index for responding schools was 0.58, ranging from 0.15 to 0.94. The use of the AMCAT to assess appropriate medical care in other states was not

found. Following the release of the Appropriate Medical Care Standards for Organizations Sponsoring Athletic Activity for the Secondary School Age Athlete,[54] the Program Assessment for Safety in Sport tool was developed to assist ATs in evaluating appropriate medical care at their institution.[128] At this time, there is no literature available examining the adoption of appropriate medical care recommendations using the Program Assessment for Safety in Sport tool.

EMERGENCY PREPAREDNESS IN ATHLETICS

Best Practice Recommendations in Emergency Planning

In 2002, the NATA released a position statement on emergency planning in athletics.[69] Within this document are 12 recommendations for EAPs, which are summarized in Table 2.4. It should be emphasized that all institutions and organizations sponsoring athletic activities should have a written EAP in place. Additionally, specific management plans should be developed for the prevention, recognition and immediate care of asthma, catastrophic brain injury, cervical spine injuries, diabetes, exertional heat stroke, exertional hyponatremia, exertional sickling, head down contact in football, lightening injuries, and SCA.[54] In 2007, the "Inter-Association Task Force Recommendations on Emergency Preparedness and Management of Sudden Cardiac Arrest in High School and College Athletic Programs" was released.[70] Within this document, more specific recommendations for EAP development were made with a focus on the management of SCA. When developing an EAP, EMS should be included to identify poorly accessible areas, determine estimated response time for each venue, and efficient direction to each venue. Additionally, identification of the levels of service,

equipment, and training of EMS providers should be discussed and included. Life-threatening emergencies should be transported by EMS to the appropriate facility, and consideration should be taken to have an ambulance on-site for high-risk events. The response time of EMS should also be considered when determining medical coverage. Only recently has the implementation of these best practice recommendations been evaluated in the literature.[129]

Evaluation of Best Practices in Emergency Planning

In 2019, Scarneo et al.,[129] evaluated secondary schools' adoption of best practices in emergency planning based on this emergency planning position statement. Eighty-nine percent of ATs reported having an EAP. However, only 9.9% reported adopting all 12 components and 54.4% reported adopting 9 out of 12 components. Seventy-one percent of ATs were involved in the creation of their EAP, and 76.7% reported developing their EAP with local EMS. Eighty-seven percent of ATs reported having venue specific EAPs, but only 42.9% post the EAP at each venue. The least available emergency equipment reported were rectal thermometer (15.9%), oxygen (13.3%), and pulse oximeter (20%). Despite this survey being conducted approximately 15 years after the release of the NATA position statement on emergency planning, the overwhelming majority of secondary school ATs have not implemented all best practice recommendations.[69]

Other studies examining emergency preparedness in secondary schools have focused on the presence of EAPs,[26,73,74,130,131] AEDs,[26,130] the availability of emergency supplies,[131,132] the presence or involvement of ATs,[26,27,73,74,130,131] and prior events of sport-related emergencies or SCA.[26] The presence of an EAP has ranged from as little as

38% up to 95%.[26,73,74,130,131] However, not all schools with written EAPs had venue-specific EAPs. Schools with an AT are more likely to have an EAP and more likely to have venue-specific EAPs compared to schools without an AT.[74] Access to an AT varied from 36% to 80%, with reliance on EMTs, physicians, physician assistants, nurse practitioners, and physical therapists also reported.[27,73,74,130-132] When surveyed on the availability of emergency equipment, over 90% of ATs reported having ice or other external cooling devices for exertional heat illness, oral rehydration for dehydration, and extremity splints immediately available.[27] Less than 50% reported having albuterol metered-dose inhaler, bag valve mask, epinephrine auto-injector, backboard with restraints, eye shield for traumatic eye injuries immediately available. Another study found that school classification was associated with having a suitable vehicle and designated driver for immediate transport of an injured athlete, surveying the playing area for hazards before an athletic event, having emergency first aid supplies available for all competing teams, monitoring of environmental conditions, having an ample supply of drinking water, and reliance on an AT for structuring medical services at their school.[131] Development of an EAP with local EMS is strongly recommended; however 23% to 55% of institutions do not.[26,72,74,129]

AED Prevalence and Sudden Cardiac Arrest Preparedness

In a national survey of high school members of the National Federation of High Schools, 82% of responding schools had at least one AED on school grounds with an average of 2.9 AEDs per school.[26] However, only 83% of schools with an AED had an established EAP for SCA, and only 60% of those were developed with local EMS. A more recent national study of secondary schools found 86% of schools with an AED had

a written EAP, and 67.8% of these developed their EAP with their local EMS.[72] Approximately 84% of schools with AEDs reported bring able to defibrillate within 3 to 5 minutes of collapse at every venue.[72] In North Carolina, 72.5% of schools surveyed had at least one AED; however, only 66% reported they could administer an AED shock within 3 to 5 minutes.[130] The presence of an AED is associated with the presence of an EAP.[130] Sport facilities or the ATR were common locations for an AED (18.7% to 41.3%), with the remaining within the school building (27.8% to 32.2%).[72] The prevalence of AEDs have also been examined in NCAA institutions.[71,133] Only 72% of respondents reported having access to an AED for their athletics program, while others were dependent upon EMS should an AED be needed. Of institutions who reported not having an AED, over 38% had an EMS response time greater than five minutes for games and practices. In these events, the time from collapse to shock ranged from less than 30 seconds to four minutes. Emergency medical services arrival was between two and twenty minutes from activation of the EAP, with an average of approximately eight minutes.

DETERMINING MEDICAL NECESSITY OF EMERGENCY MEDICAL SERVICES TRANSPORTATION

Determining Criteria for Medical Necessity

Researchers have attempted to define criteria for determining the medical necessity of EMS transports.[114] A multi-stage survey was delivered to determine if consensus on medical necessity criteria could be reached. Participants (n=31) included emergency physicians, EMT/Paramedics, EMS administrators, and research assistants,

among others.[114] Respondents believed that dispatch criteria could be developed to safely determine if certain patients did not necessitate an EMS response. Respondents also believed a set of criteria could be developed for responding EMS providers to use at the scene to determine if EMS transport of the patient was medically necessary and safely recommend an alternate means of transportation or source of care. Dispatch criteria considered important in determining an EMS were caller complaints of chest pain, respiratory difficulty, altered mental status, syncope, focal neurological deficit/ cerebrovascular accident, gastrointestinal bleed and difficulty in pregnancy.[114] Outcome measures considered important to assess these dispatch criteria were prehospital airway interventions, emergent surgery, ED diagnosis, and any procedures done in the ED. For determining the need for EMS transport by prehospital providers, important clinical indicators were considered to be heart rate, blood pressure, respiratory rate, oxygen saturation, and Glasgow Coma Scale.[114] Important presenting conditions were considered to be chest pain, respiratory difficulty, altered mental status, syncope, focal neurological deficit/ cerebrovascular accident and gastrointestinal bleed. The need for cervical immobilization and airway interventions were considered important determinants as well.[114] Outcome measures considered important to assess field triage criteria were emergent surgery, ED diagnosis, and procedures performed in the ED. However, participants were not able to come to a consensus on an acceptable under-triage rate. The development of criteria for guiding EMS transportation decisions would not only be helpful for EMS providers but also ATs when they are determining whether or not it is appropriate to activate EMS for a sport-related injury. Additionally, these decision

criteria and outcome measures could be used to guide and assess athletic training education for prehospital management of sport-related emergencies.

Determination of Medical Necessity by Receiving Physician

In a survey of patients whose ambulance transports were deemed medically unnecessary by the receiving ED physicians, 39% used EMS transportation because they had no other way to get to the ED.[48] Five predetermined criteria were used to determine medical necessity: 1) the patient could not ambulate, 2) the patient required, or could have required, prehospital emergency care, 3) the patient required, or could have required, expedient transportation to the ED, 4) the patient was considered a harm to themselves or others, and 5) the transport was considered medically appropriate for another reason. However, the development of these subjective criteria was not presented by the authors and can encompass a variety of clinical conditions and presentations. Seventy-seven percent of patients had not called for an ambulance themselves.[48] When asked how they would return home if released, two percent indicated they would do so by ambulance. Availability of resources (e.g., transportation, health care services) may also need to be considered when determining medical necessity of EMS transport. Additionally, alternative means of transportation should be considered by ATs and sports program administrators in the development of their EAPs, as lack of alternative transportation accounts for over one-third of medically unnecessary EMS transports.

Ability of EMS Providers to Determine Medical Necessity

Multiple studies have examined EMS providers' ability to determine medical necessity at the scene using predetermined criteria.[101,134-136] When asked to categorize

patients to one of four alternatives (ambulance transportation to the ED, alternative transportation to the ED, referral to a primary care provider, or treatment at the scene only), 21.3% of patients did not require ambulance transportation to the ED.[134] Of the patients categorized as requiring ambulance transportation, 51% experienced a critical event. Thus, the protocol implemented had a sensitivity of 94.5% and a specificity of 32.8%. In a follow-up of patients categorized as not requiring ambulance transport to the ED, 9% were considered to be under-triaged.[135] Under-triaged patients were determined to require ambulance transport based on hospital outcome data but had been categorized as not requiring ambulance transport on the scene by EMS providers according to the experimental protocol. Based on hospital outcomes, the participating EMS providers had a sensitivity of 0.25 and specificity of 0.90. However, hospital outcome data was only available for 15% of the overall sample. Over 90% of the prehospital care providers determining medical necessity at the scene were Paramedics.[134]

Hauswald et al.,[136] reported minimal to weak agreement between paramedics and their ability to determine if a patient needed ambulance transport to the ED or if the patient could have been transported to a clinic or urgent care center. Agreement was examined between paramedics' decision and a pre-determined list of differential diagnoses, diagnostic tests, and therapeutic procedures from ED charts. However, the study was conducted over one month and only included paramedics from a single ambulance service. Gratton et al.,[101] reported agreement on medical necessity between paramedics and emergency physicians occurred in 76.2% of cases (K=0.42). Eleven percent of patients in this study were under-triaged by paramedics. Paramedics and emergency physicians most commonly agreed that the patient was experiencing severe

pain (89.6%, K=0.32), and the patient had the potential to harm self or others (89.6%, K=0.40). Agreement on if the patient required prehospital emergency care occurred in 71.9% of cases (K=0.43). The criteria with the lowest level of agreement were that the patients required expedient transport to an ED (77.7%, K=0.22). Poor to fair agreement was demonstrated across all five criteria.[101] In a survey of patients for whom EMS transportation was refused (based on local EMS protocols), 56.2% reported they sought care from a physician at a later time, over 80% of which was at the ED and 18.6% at a separate physician's office.[137] Refusals by EMS represented 33.9% of cases where patients were not transported by EMS to the ED. Over 9% of patients for whom transportation was refused by EMS were later admitted to the hospital.[137] Studies have reported under-triage rates of 9% to 11% by paramedics;[101,135] however, the ability of EMS providers with lower certification levels (i.e., EMT, Advanced EMT) to accurately determine medical necessity is unknown. Agreement between ATs and EMS providers or ATs and ED physicians for differential diagnoses or determination of medical necessity has not yet been examined.

Perceived Appropriate Use of EMS Transportation

Patient and provider perceptions of the appropriate use of transportation by EMS were examined at a single ED.[121] Emergency medical services providers were asked if they believed their patient's condition represented a true emergency necessitating EMS transportation and why. Patients were asked if they believed their condition was a true emergency necessitating EMS transportation. A true emergency was defined as "a medical condition or injury requiring medical care as soon as possible at the ED." However, patients who were transported with a serious acute condition requiring

immediate care upon arrival to the ED were automatically considered as having used EMS transportation appropriately.[121] Males, patients aged 51 to 60 years, and patients with a high school or equivalent education were more likely to have perceived as having a true emergency by EMS providers. Patients who were Black, with high school or equivalent education, were more likely to perceive their condition as an emergency. Blunt traumatic injury, altered mental status, abdomen/flank/pelvic pain, and shortness of breath/respiratory were the frequent complaints presenting to the ED via EMS. From the EMS provider perspective, blunt traumatic injury, shortness of breath/respiratory, and altered mental status were the most frequent perceived emergencies. Patients most frequently considered blunt traumatic injury, altered mental status, and shortness of breath/respiratory to be emergencies. Observed agreement between EMS providers and patients was 75% (kappa 0.84). Forty-seven percent of patients reported having an alternative means of transportation to the ED but chose to take an ambulance instead;[121] however, the reasons for which patients chose ambulance transportation over an available alternative means of transportation was not examined. Conditions perceived by EMS providers and patients to be emergencies may also be perceived as emergencies by ATs; however, ATs' perceptions of appropriate ambulance transportation have not been examined. Additionally, perceived emergencies may extend to bystanders, which, in an athletics setting, may include trained or untrained individuals who are in attendance.

Table B.1 Comparison of Appropriate Medical Care for Secondary School-Aged Athlete Summary Statement Recommendations

Summary Statement: Appropriate Medical Care for the Secondary School-Aged Athlete[53]	Appropriate Medical Care Standards for Organizations Sponsoring Athletic Activity for the Secondary School-Aged Athlete: A Summary Statement[54]
1. Develop and implement a comprehensive athletic health care administrative system	1. Athletes' readiness to participate in activity is determined through a standardized preparticipation physical examinations screening process
2. Determine the individual's readiness to participate through the preparticipation physical examination	2. Practice and competition equipment used by athletes and athletic health care facilities is safe and clean
3. Promote safe and appropriate practice, competition, and treatment facilities	3. Equipment worn by athletes is properly fitted and maintained and instructions for safe and appropriate use are provided
4. Advise on the selection, fit, function, and maintenance of athletic equipment	4. Protective materials and products used to prevent athletic injuries are safely and appropriately applied
5. Develop and implement a comprehensive emergency action plan	5. Athletic participation is a safe environment is ensured or activity is modified or canceled based on established environmental policies
6. Establish protocols regarding adverse environmental conditions	6. Education and counseling is provided for athletes on nutrition, hydration, and dietary supplements
7. Provide for on-site recognition, evaluation, and immediate treatment of injury and illness, with appropriate referrals	7. Wellness programs promote a safe progression of physical fitness and improve long-term health across an athlete's lifespan
8. Facilitate rehabilitation and reconditioning	8. Comprehensive athletic emergency action plan is established and integrated with local emergency medical services per athletic venue
9. Provide for psychosocial consultation and referral	9. On-site prevention, recognition, evaluation, and immediate care of athletic injuries and illnesses are provided with appropriate medical referrals
10. Provide scientifically sound nutritional counseling and education	10. On-site therapeutic intervention (presurgical, postsurgical, and nonsurgical conditions) outcomes are optimized by developing, evaluating, and updating a plan of care for athletes in coordination with members of the AHCT
11. Develop injury and illness prevention strategies	11. Comprehensive management plan for at-risk athletes with psychosocial concerns
	12. Comprehensive athletic health care administration system is established to ensure that appropriate medical care is provided

Table B.2 Summary of Appropriate Medical Coverage Recommendations for Intercollegiate Athletics

Risk Level	**Sports and Activities**	**Medical Coverage Recommendations**
Low Risk (combined IR and CI < 4.0)	Baseball Crew (M&W) Cross Country (M&W) Fencing (M&W) Golf (M&W) Outdoor Track (M&W) Softball Swimming (M&W) Tennis (M&W) Water Polo (M&W) Strength/Conditioning Individual Skill Sessions Voluntary Summer Workouts	An individual physically present with minimal qualifications
Moderate Risk (combined IR and CI or 4.0-5.0 or CI of 3.0)	Basketball (W) Diving (M&W) Field Hockey Indoor Track (M&W) Lacrosse (M&W) Soccer (M&W) Volleyball (M&W)	Certified AT or other designated individual with minimal qualifications physically present. If no AT physically present, one must be able to respond within 3-5 minutes.
Increased Risk (combined IRE and CI of ≥ 6.0 or CI of 4.0)	Basketball (M) Football Gymnastics (M&W) Ice Hockey (M&W) Skiing Wrestling	Certified AT physically present for all practices.
Abbreviations: IR: injury rate index; CI: catastrophic index; M: men's; W: women's		

Table B.3 Summary of Recommendations for Emergency Planning in Athletics[69]

1. Every institution sponsoring athletics should have a comprehensive, practical and flexible written EAP that can be adapted for any emergency situation.
2. The EAP must be a written document distributed to all key personnel (i.e. certified ATs, team and attending physicians, athletic training students, institutional and organizational safety personnel, institutional and organizational administrators and coaches. The EAP should also be developed in consultation with local EMS.
3. Personnel involved in carrying out the EAP must be identified, including their qualifications. The following personnel should be trained in CPR, AED use, first aid and prevention of disease transmission: sports medicine professionals, officials, coaches.
4. Emergency equipment needed to carry out the tasks outlined in the EAP should be specified within the plan as well as their location. Equipment available should be appropriate to the level of training of the personnel involved.
5. A clear mechanism of communication to emergency care providers should be established. The mode of transportation for an injured individual should also be included.
6. Each athletic venue should have a specific EAP developed for that location.
7. Appropriate care facilities to which an injured individual should be taken should be identified. These facilities should be notified in advance of scheduled events. Personnel at these facilities should also be included in the development of the EAP.
8. Necessary documentation supporting the implementation and evaluation of the emergency plan should be specified. This documentation should identify the individual responsible for recording actions taken during the emergency, an evaluation of the execution of the plan and personnel training.
9. The EAP should be rehearsed and reviewed at least annually. The results of each review and rehearsal should be documented and include any modifications that had to be made.
10. All personnel involved in the organization and sponsorship of athletic activities have a responsibility to provide emergency care to an injured individual, including the development of an EAP.
11. All personnel involved in the sponsorship of athletic activities share a legal duty to develop, implement and evaluation an EAP for all athletic activities.
12. The EAP should be reviewed by the sponsoring institution or organization's administrators and legal counsel.

APPENDIX C

ADDITIONAL RESULTS TABLES

Table C.1 Chief Complaint Anatomic Location by Age Group

Anatomic Location	**Age Group (n,%)**					
	<13	**13-18**	**19-24**	**25-64**	**>64**	**Total**
Abdomen	129 (1.7)	254 (1.7)	297 (3.6)	1033 (3.5)	272 (2.4)	1985 (2.78)
Back	273 (3.6)	500 (3.4)	176 (2.1)	550 (1.9)	138 (1.2)	1637 (2.3)
Chest	286 (3.8)	491 (3.3)	380 (4.6)	2132 (7.3)	733 (6.4)	4022 (5.64)
Extremity – Lower	790 (10.5)	2394 (16.2)	958 (11.6)	2567 (8.8)	642 (5.6)	7351 (10.31)
Extremity – Upper	732 (9.7)	1233 (8.3)	466 (5.6)	1115 (3.8)	430 (3.7)	3976 (5.57)
General/ Global	1835 (24.4)	3873 (26.2)	2892 (34.9)	10905 (37.4)	4570 (39.6)	24075 (33.76)
Genitalia	5 (0.0)	14 (0.1)	18 (0.2)	57 (0.2)	10 (0.1)	104 (0.15)
Head	1086 (14.4)	1520 (10.3)	698 (8.4)	2225 (7.6)	1255 (10.9)	6784 (9.51)
Neck	324 (4.3)	689 (4.7)	127 (1.5)	198 (0.7)	44 (0.4)	1382 (1.94)
Not Applicable	207 (2.8)	324 (2.2)	307 (3.7)	1061 (3.6)	383 (3.3)	2282 (3.2)
Not Recorded	1859 (24.7)	3499 (23.7)	1978 (23.8)	7335 (25.1)	3053 (26.5)	17724 (24.85)

Note: Proportions are percentage within age group.
$\chi^2 = 4557.56$, $df=40$, $p<0.0001$. Cramer's V = 0.1264

Table C.2 Chief Complaint Organ System by Age Group

Organ System	Age Group (n,%)					
	<13	**13-18**	**19-24**	**25-64**	**>64**	**Total**
Behavioral/ Psychiatric	31 (0.4)	174 (1.2)	177 (2.1)	670 (2.3)	42 (0.4)	1094 (1.5)
Cardiovascular	60 (0.8)	182 (1.2)	241 (2.9)	1927 (6.6)	921 (8.0)	3331 (4.7)
CNS/ Neuro	583 (7.8)	1526 (10.3)	903 (10.9)	3195 (11.0)	1496 (13.0)	7703 (10.8)
Endocrine/ Metabolic	72 (1.0)	167 (1.1)	193 (2.3)	722 (2.5)	154 (1.3)	1308 (1.8)
GI	90 (1.2)	163 (1.1)	226 (2.7)	836 (2.9)	197 (1.7)	1512 (2.1)
Global/ General	1924 (25.6)	3743 (25.3)	2363 (28.5)	8928 (30.6)	3585 (31.1)	20543 (28.8)
Lymphatic/ Immune	28 (0.4)	28 (0.2)	22 (0.3)	102 (0.4)	19 (0.2)	199 (0.3)
Musculoskeletal/ Skin	2520 (33.5)	4838 (32.7)	1741 (21.0)	4398 (15.1)	1711 (14.8)	15208 (21.3)
Reproductive	3 (0.0)	13 (0.1)	40 (0.5)	78 (0.3)	1 (0.0)	135 (0.2)
Pulmonary	276 (3.7)	337 (2.3)	181 (2.2)	685 (2.4)	234 (2.0)	1713 (2.4)
Renal	0 (0.0)	4 (0.0)	1 (0.01)	18 (0.1)	4 (0.0)	27 (0.0)
Not Applicable	187 (2.5)	304 (2.1)	308 (3.7)	1028 (3.5)	352 (3.1)	2179 (3.1)
Not Recorded	1752 (23.3)	3312 (22.4)	1901 (22.9)	6591 (22.6)	2814 (24.4)	16370 (23.0)

Note: Proportions are percentage within age group.
$\chi^2 = 4570.88$, $df=48$, $p<0.0001$. Cramer's V = 0.1266