

# Soccer-Related Injuries Treated in Emergency Departments: 1990–2014

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abstract

**OBJECTIVE:** To investigate the epidemiology of youth soccer-related injuries treated in emergency departments in the United States.

**METHODS:** A retrospective analysis was conducted of soccer-related injuries among children 7 through 17 years of age from 1990 through 2014 with data from the National Electronic Injury Surveillance System. Injury rates were calculated from soccer participation data.

**RESULTS:** An estimated 2 995 765 (95% confidence interval [CI], 2 309 112–3 682 418) children 7 through 17 years old were treated in US emergency departments for soccer-related injuries during the 25-year study period, averaging 119 831 (95% CI, 92 364–147 297) annually. The annual injury rate per 10 000 soccer participants increased significantly, by 111.4%, from 1990 to 2014. Patients 12 to 17 years old accounted for 72.7% of injuries, 55.5% of patients were male, and most injuries occurred in a place of sport or recreation (68.5%) or school (25.7%). Struck by (38.5%) and fell (28.7%) were the leading mechanisms of injury. Injuries most commonly were diagnosed as sprain or strain (34.6%), fracture (23.2%), and soft tissue injury (21.9%), and occurred to the upper extremity (20.7%), ankle (17.8%), and head or neck (17.7%). Concussions or other closed head injuries accounted for 7.3% of the injuries, but the annual rate of concussions/closed head injuries per 10 000 participants increased significantly, by 1595.6%, from 1990 to 2014.

**CONCLUSIONS:** This study is the first to comprehensively investigate soccer-related injuries and calculate injury rates based on soccer participation data among children at the national level. The increasing number and rate of pediatric soccer-related injuries, especially soccer-related concussions/closed head injuries, underscore the need for increased efforts to prevent these injuries.



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**WHAT'S KNOWN ON THIS SUBJECT:** Soccer is one of the most popular team sports in the United States, with >3 million registered soccer players <19 years of age in 2014, representing an almost 90% increase from 1990.

**WHAT THIS STUDY ADDS:** This study investigates pediatric soccer-related injuries and calculates injury rates based on soccer participation data at the national level. The increasing number and rate of pediatric soccer-related injuries, especially concussions/closed head injuries, underscore the need for increased prevention efforts.

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Soccer is one of the most popular team sports in the United States, with >15 million participants nationally.<sup>1</sup> According to US Youth Soccer, there were >3 million registered soccer players <19 years of age in 2014, representing an almost 90% increase from 1990.<sup>2,3</sup> High school soccer participation has more than doubled during that time period, making it one of the fastest-growing high school sports, especially among girls.<sup>1,4</sup> As participation in soccer has increased, so has the number of injuries associated with this sport.<sup>5,6</sup> An estimated 82 000 soccer-related injuries among children <15 years of age were treated in US emergency departments (EDs) in 2006.<sup>1</sup>

Despite soccer's popularity, published studies about the epidemiology of soccer-related injuries among children have important limitations. For example, some studies combined children and adults<sup>6</sup> or focused on a narrow age range, such as 13- to 17-year-olds<sup>7</sup> or high school students only.<sup>4,8</sup> Other studies combined sports,<sup>9</sup> were limited to a small number of EDs, teams, cities, or regions, or covered a short time period, such as 1 season.<sup>7,10-12</sup> Other studies were conducted in other countries and may have limited applicability to the United States.<sup>11-13</sup> Among the large US-based studies, 2 have used the National Electronic Injury Surveillance System (NEISS) but failed to calculate injury rates<sup>6</sup> or evaluate the mechanism of injury,<sup>5,6</sup> and 1 is more than a decade old.<sup>5</sup> The 2 studies that calculated soccer-related injury rates relied on population data for denominators rather than soccer participation data.<sup>5,14</sup> One of these studies analyzed data from the NEISS All Injury Program and covered only the year 2000.<sup>14</sup> Two other national studies examined soccer-related injuries only among high school students and were either limited to concussions<sup>8</sup> or examined a brief time period (2005–2007).<sup>4</sup>

To our knowledge, this study is the first to comprehensively investigate the epidemiology of US youth soccer-related injuries, including the mechanism of injury, treated in US EDs, using a nationally representative sample and calculating injury rates based on national youth soccer participation data. It evaluates these injuries over a 25-year period.

## METHODS

### Data Source

This study retrospectively examined soccer-related injuries (NEISS code 1267) among children ages 7 through 17 years treated in US EDs from 1990 through 2014. Data were obtained from the NEISS, which monitors consumer product-related and sports and recreational activity-related injuries treated in US EDs. The NEISS, which is operated by the US Consumer Product Safety Commission, collects data from a network of ~100 hospitals, which represents a stratified probability sample of the >5300 hospitals in the United States and its territories with a 24-hour ED with  $\geq 6$  beds.<sup>15,16</sup> In each participating hospital, professional NEISS coders review ED medical records for information about in-scope injury events, including patient age, patient gender, injury diagnosis, affected body region, products involved, disposition from the ED, the location where injury occurred, and a brief narrative describing the incident. If a child sustains multiple injuries, only the most severe injury is included in the NEISS database.

Injury rates were calculated from National Sporting Goods Association sports participation data<sup>17,18</sup> as the denominator (Supplemental Fig 5). These data are based on self-reports for people in the United States who are 7 to 17 years of age and participated in soccer at least once during a 12-month period from 1990 through 2014. Participation

data were available for children 7 to 11 and 12 to 17 years of age, but not by gender for these age groups; therefore, gender-specific rates could not be calculated.

### Study Variables

NEISS case narratives were reviewed to identify the mechanism of injury, which was grouped into 1 of the following categories: fell (including tripped, slipped, or fell and struck), collision (only player to player), struck by (including hit by, kicked by, stepped on, elbowed, or kneed), struck on (including ran into, hit, or kicked another player or object), struck (including unspecified contact such as "hit or struck during soccer"), twisted (including rolling or inversion or hyperextension of body region), or other. A person or object associated with the injury was classified as another player, a ball, or other (including wall, goalpost, pole, or bench). When the narrative did not specify another player, phrases such as "was elbowed," "got kneed," "was cleated," or "kicked during soccer" were assumed to involve another player.

Patient age was categorized as 7 to 11 or 12 to 17 years. Location of injury was grouped into sport or recreational place, school, or other. The injured body region was grouped into head or neck, upper extremity (including NEISS categories of shoulder, upper arm, elbow, lower arm, or wrist), hand or finger, trunk (including upper trunk, lower trunk, or pubic region), lower extremity (including upper leg and lower leg but excluding knee, ankle, or foot or toe), knee, ankle, foot or toe, or other. Injury diagnosis was grouped into concussion or other closed head injury (CHI; including internal organ injury to the head region), fracture, dislocation, sprain or strain, soft tissue injury (including NEISS categories of contusion, abrasion, hematoma, or crushing), laceration (including laceration, amputation,

nondental avulsion, or puncture), or other. Disposition from the ED was categorized as treated and released, hospitalized (including NEISS categories of treated and admitted, treated and transferred, and held for <24 hours for observation), or left against medical advice.

### Statistical Analyses

Data were analyzed in SPSS version 20.0 (IBM SPSS Statistics, IBM Corporation), and SAS version 9.3 (SAS Institute, Inc, Cary, NC) software. Statistical weights provided by the US Consumer Product Safety Commission were used to calculate national injury estimates. Data reported in this article are national estimates unless otherwise specified. Preliminary inspection of the scatterplots (Figs 2, 3, and 4) indicated a shift in the rate of change after 2008. Therefore, piecewise linear regression models were used to analyze the overall, gender-specific, and age group-specific trends with 2008 as a breakpoint. The estimated annual rate of change from the regression model, denoted by  $m$ , was reported along with the  $P$  value associated with the  $t$  test used to test for its statistical significance. If a statistically significant increase occurred during both periods, only the overall percentage increase was reported. Other analyses included the Rao-Scott  $\chi^2$  test for association, which adjusted for the NEISS sample design effect, and the calculation of relative risk (RR) with a 95% confidence interval (CI). The level of significance used for all statistical tests was  $\alpha = 0.05$ . This study was approved by the institutional review board of the authors' institution.

## RESULTS

### General Characteristics

From 1990 through 2014, an estimated 2 995 765 (95% CI, 2 309 112–3 682 418) children 7 to 17 years of age were treated in

US EDs for soccer-related injuries, averaging 119 831 (95% CI, 92 364–147 297) injuries annually or 141.43 (95% CI, 109.01–173.84) per 10 000 soccer participants 7 to 17 years old. Most injuries occurred at a sport or recreation place (68.5%) or school (25.7%), and 55.5% of the patients were boys (Table 1). The number of injuries peaked at ages 14 and 15 years (Fig 1), and the average age of an injured child was 13.2 years (SD 0.054; median 13.0 years; interquartile range 10.7–14.9). Children 12 to 17 years of age accounted for 72.7% of all injuries and had a higher injury rate per 10 000 participants (244.85; 95% CI, 187.91–301.79) than children 7 to 11 years of age (66.51; 95% CI, 51.17–81.85).

### Injury Trends

From 1990 through 2014, the annual soccer-related injury number and rate per 10 000 participants increased significantly, by 78.4% (1990–2008:  $m = 1948.2$ ,  $P < .001$ ; 2008–2014:  $m = 5166.2$ ,  $P < .001$ ) and by 111.4% (1990–2008:  $m = 1.53$ ,  $P = .003$ ; 2008–2014:  $m = 15.68$ ,  $P < .001$ ), respectively (Fig 2). Part of this increase was contributed by the increase in concussions/CHIs, especially after 2008 (Fig 3). Over the entire study period, the annual number and rate of concussion/CHI per 10 000 participants increased significantly by 1331.7% (1990–2008:  $m = 489.1$ ,  $P < .001$ ; 2008–2014:  $m = 2341.3$ ,  $P < .001$ ) and by 1595.6% (1990–2008:  $m = 0.53$ ,  $P < .001$ ; 2008–2014:  $m = 3.92$ ,  $P < .001$ ), respectively (Fig 3).

From 1990 to 2008, the annual number of soccer injuries did not increase significantly for boys (12.2%,  $m = 248.6$ ,  $P = .073$ ) but increased significantly for girls (101.9%,  $m = 1698.9$ ,  $P < .001$ ), and from 2008 through 2014, the number of injuries leveled off for girls (2.9% increase,  $m = 616.2$ ,  $P = .178$ ) but increased significantly for boys

(44.6%,  $m = 4554.4$ ,  $P < .001$ ) (Fig 2). Although the number of soccer injuries among children 7 to 11 years of age increased significantly during both periods, a significant increase in the injury rate occurred only from 2008 to 2014 (61.1%,  $m = 7.29$ ,  $P < .001$ ) (Fig 4). Among children 12 to 17 years old, both the soccer-related injury number and rate increased significantly during the 2 periods (Fig 4).

### Mechanism of Injury and Associated Person or Object

A mechanism of injury was identified for 66.4% of soccer-related injuries, and of those, struck by (38.5%), fell (28.7%), and twisted (12.8%) were the most common mechanisms (Table 1). Collision accounted for an additional 5.6% of the injuries. A person or object was associated with 35.0% of the injuries, and of those, most were another player (63.5%) or a ball (27.9%). Among injuries associated with another player, struck by (72.0%) and collision (16.8%) were the leading mechanisms, whereas struck by (77.4%) and struck on (16.2%) were the most common mechanisms associated with ball-related injuries. Compared with the other age group, younger patients (7–11 years) were more likely to sustain an injury associated with a fall (RR 1.38; 95% CI, 1.34–1.43) or a ball (RR 1.61; 95% CI, 1.53–1.70), whereas older patients (12–17 years) were more likely to sustain an injury associated with twisting (RR 1.62; 95% CI, 1.47–1.78) or a collision (RR 2.24; 95% CI, 1.98–2.53). Female patients were more likely to experience an injury from a twisting mechanism (RR 1.36; 95% CI, 1.27–1.44) than male patients.

### Injury Diagnosis and Injured Body Region

Sprain or strain accounted for 34.6% of injuries, followed by fracture (23.2%), soft tissue injury (21.9%), and concussion/CHI (7.3%)

**TABLE 1** Characteristics of Soccer-Related Injuries Among Children 7 to 17 Years of Age Treated in US EDs by Age Group, 1990–2014

	Age Group			
	7–11 y	12–17 y	7–17 y	95% CI
	N (%) <sup>a</sup>	N (%) <sup>a</sup>	N (%) <sup>a</sup>	95% CI
<b>Gender</b>				
Male	487 121 (59.6)	1 176 231 (54.0)	922 291–1 430 170	1 663 351 (55.5)
Female	329 792 (40.4)	1 002 313 (46.0)	745 685–1 258 941	1 332 105 (44.5)
Subtotal <sup>b</sup>	816 913 (100.0)	2 178 544 (100.0)	1 671 919–2 685 168	2 995 456 (100.0)
<b>Locale of injury</b>				
Sport or recreational place	411 899 (65.1)	1 192 890 (69.8)	844 167–1 541 613	1 604 790 (68.5)
School	167 513 (26.5)	435 378 (25.5)	305 098–565 657	602 890 (25.7)
Other place	53 689 (8.5)	80 022 (4.7)	56 121–103 922	133 711 (5.7)
Subtotal <sup>b</sup>	633 101 (100.0)	1 708 289 (100.0)	1 260 160–2 156 419	2 341 391 (100.0)
<b>Mechanism of injury</b>				
Struck by	210 489 (38.0)	555 968 (38.8)	428 931–683 004	766 457 (38.5)
Fell	199 280 (35.9)	372 471 (26.0)	275 939–469 104	571 752 (28.7)
Twisted	49 139 (8.9)	205 764 (14.3)	150 906–260 621	264 902 (12.8)
Struck on	50 005 (9.0)	117 088 (8.2)	91 240–142 936	167 093 (8.4)
Collided	16 494 (3.0)	95 475 (6.7)	68 212–122 738	111 970 (5.6)
Struck	17 135 (3.1)	46 043 (3.2)	26 589–65 497	63 178 (3.2)
Other	11 955 (2.2)	41 719 (2.9)	31 516–51 923	53 675 (2.7)
Subtotal <sup>b</sup>	554 498 (100.0)	1 434 528 (100.0)	1 088 847–1 780 210	1 989 026 (100.0)
<b>Associated person or object</b>				
Another player	142 835 (49.7)	523 515 (68.8)	401 231–645 800	666 350 (65.5)
Ball	110 857 (38.5)	181 720 (23.9)	139 224–224 216	292 577 (27.9)
Other	33 988 (11.8)	55 909 (7.3)	42 089–69 728	89 897 (8.6)
Subtotal <sup>b</sup>	287 680 (100.0)	761 144 (100.0)	584 794–937 495	1 048 824 (100.0)
Total (row %)	816 975 (27.3)	2 178 790 (72.7)	1 672 105–2 685 475	2 995 765 (100.0)
<b>Body region injured</b>				
Upper extremity	222 833 (27.3)	396 813 (18.2)	301 764–491 861	619 646 (20.7)
Ankle	99 479 (12.2)	432 344 (19.9)	330 428–534 259	531 823 (17.8)
Head or neck	124 239 (15.2)	404 356 (18.6)	301 808–506 904	528 595 (17.7)
Knee	75 038 (9.2)	260 526 (12.0)	197 018–324 035	335 584 (11.2)
Foot or toe	87 483 (10.7)	204 796 (9.4)	159 242–250 331	292 269 (9.8)
Hand or finger	113 490 (13.9)	174 373 (8.0)	133 210–215 537	287 864 (9.6)
Upper or lower leg	46 379 (5.7)	151 743 (7.0)	118 105–185 381	198 121 (6.6)
Trunk	42 992 (5.3)	141 842 (6.5)	109 202–174 482	184 834 (6.2)
Other	44 711 (0.5)	10 990 (0.5)	7622–14 357	15 461 (0.5)
Subtotal <sup>b</sup>	816 404 (100.0)	2 177 773 (100.0)	1 671 221–2 684 324	2 994 177 (100.0)
<b>Diagnosis</b>				
Sprain or strain	242 814 (29.8)	793 437 (36.5)	605 333–981 542	1 036 252 (34.6)
Fracture	231 776 (28.4)	461 611 (21.2)	350 276–572 945	693 387 (23.2)
Soft tissue injury	192 396 (23.6)	463 469 (21.3)	359 957–566 982	655 885 (21.9)
Concussion/GHI	45 016 (5.5)	172 346 (7.9)	122 441–222 251	217 362 (7.3)
Other	56 598 (6.9)	139 166 (6.4)	88 981–189 350	195 764 (6.5)
Laceration	40 339 (4.9)	102 626 (4.7)	79 025–126 227	142 964 (4.8)
Dislocation	6793 (0.8)	43 747 (2.0)	32 376–55 118	50 540 (1.7)

**TABLE 1** Continued

	Age Group			
	7–11 y	12–17 y	7–17 y	
	N (%) <sup>a</sup>	N (%) <sup>a</sup>	N (%) <sup>a</sup>	95% CI
Subtotal <sup>b</sup>	815 732 (100.0)	2 176 402 (100.0)	2 992 134 (100.0)	2 306 258–3 678 011
Disposition from ED				
Treated and released	803 271 (98.4)	2 139 216 (98.2)	2 942 487 (98.3)	2 266 201–3 618 773
Admitted	11 459 (1.4)	33 107 (1.5)	44 566 (1.5)	34 685–54 447
Left against medical advice	1756 (0.2)	5779 (0.3)	7535 (0.3)	4496–10 574
Subtotal <sup>b</sup>	2 178 102 (100.0)	816 486 (100.0)	2 994 588 (100.0)	2 308 047–3 681 129
Total (row %)	816 975 (27.3)	2 178 790 (72.7)	2 995 765 (100.0)	2 309 112–3 682 418

<sup>a</sup> Percentages may not sum to 100.0% because of rounding error.

<sup>b</sup> Subtotal may not be equal to the age group or study total because of missing values.

(Table 1). Most of the fractures were associated with a fall (44.5%) or struck by (32.2%), whereas most soft tissue injuries were associated with struck by an object or person (58.9%). Patients who were injured by being struck by an object or person were 1.61 (95% CI, 1.51–1.72) times more likely to sustain a concussion/CHI than those injured by other mechanisms. Compared with the other age group, patients 12 to 17 years of age were more likely to sustain a concussion/CHI (RR = 1.44, 95% CI, 1.31–1.58), and patients 7 to 11 years old were more likely to sustain a fracture (RR = 1.34, 95% CI, 1.29–1.39). Male patients were 3.10 times (95% CI, 2.83–3.40) more likely to sustain a laceration and 1.42 times (95% CI, 1.34–1.50) more likely to sustain a fracture than female patients. The proportion of concussion/CHI was higher among boys for patients aged 7 to 11 years (6.2% vs 4.5%) and among girls for patients aged 12 to 17 years (8.7% vs 7.3%).

The upper extremity (20.7%), ankle (17.8%), head or neck (17.7%), and knee (11.2%) were the most commonly injured body regions (Table 1). The majority of upper extremity injuries were associated with a fall (67.1%), and twisting accounted for 50.8% of ankle injuries. Patients injured by being struck by an object or person were more likely to sustain an injury to the head or neck (RR 1.94; 95% CI, 1.84–2.05), hand or finger (RR 1.81; 95% CI, 1.67–1.96), or lower extremity (RR 1.81; 95% CI, 1.67–1.96) than patients injured by other mechanisms. Female patients were more likely to experience an ankle injury (RR 1.41; 95% CI, 1.37–1.46) or knee injury (RR 1.29; 95% CI, 1.22–1.37) than male patients.

### Disposition From the Emergency Department

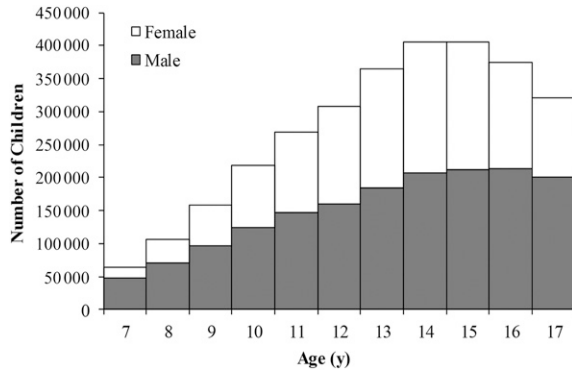
Most children with a soccer-related injury were treated and released from the ED (98.3%) (Table 1). Among those admitted to the

hospital, 70.4% were boys, and 60.6% sustained a fracture. Patients were more likely to be admitted to the hospital if they had a fracture (RR 5.10; 95% CI, 4.19–6.22) or a concussion/CHI (RR 2.06; 95% CI, 1.52–2.77) than patients with other injury diagnoses.

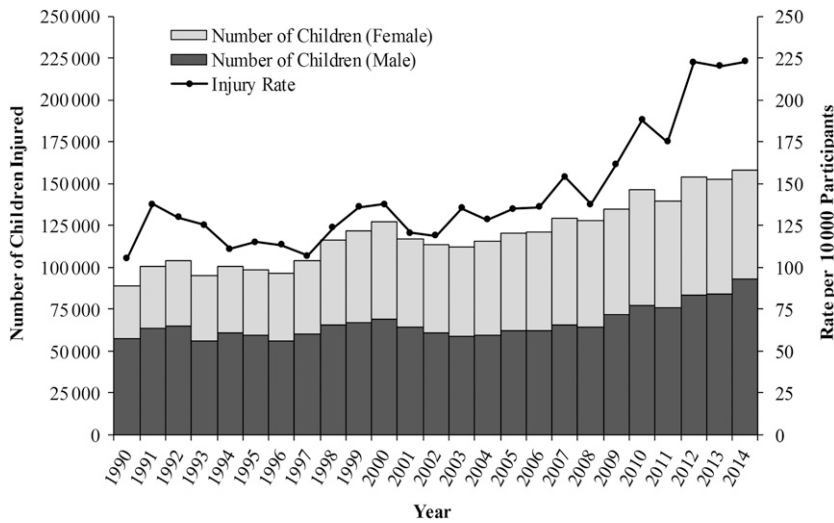
### DISCUSSION

During the 25-year study period, almost 3 million children 7 to 17 years of age were treated for soccer-related injuries in US EDs, and the injury rate more than doubled. Our findings are consistent with those of previous studies, which showed an increase in the number of pediatric soccer-related injuries<sup>6,19</sup> and an increase in the number and population-based rate of soccer-related injuries among girls.<sup>5</sup> The increase in the number of injuries treated in US EDs is a trend that also was observed for other pediatric sports from 2001 to 2013.<sup>19</sup> In our study, more than two-thirds (72.7%) of injuries occurred among children 12 to 17 years of age, and the rate of injury was >3 times higher in this age group than among younger soccer participants, probably because of the more aggressive play and the higher-energy impacts associated with the older age group. Although we were not able to calculate gender-specific injury rates because soccer participation data by gender were unavailable, the number of soccer-related injuries increased for both genders, with a greater increase among girls. This result is expected, given the much larger increase in soccer participation by girls than boys during the study period.<sup>4</sup>

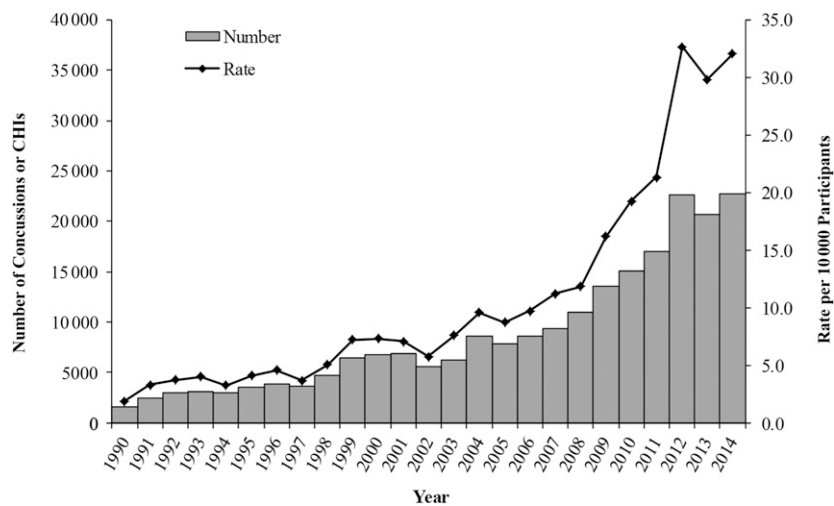
Although concussions/CHIs only accounted for 7.3% of injuries, both the number and rate increased >13-fold over the study period and contributed to the observed increase in soccer injuries overall. One study reported a similar percentage (10.8%) of concussions among high school soccer-related



**FIGURE 1** Number of children 7–17 years of age treated in US EDs for soccer-related injuries by age and gender, 1990–2014.



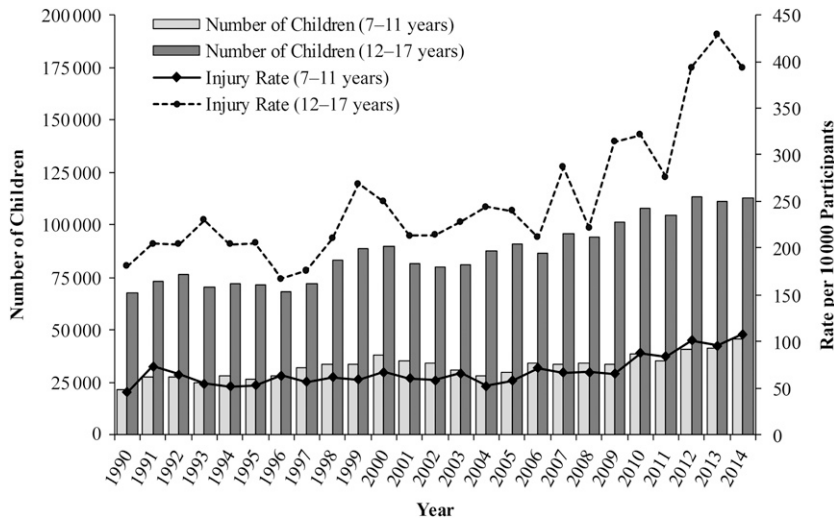
**FIGURE 2** Number and rate per 10,000 soccer participants 7 to 17 years of age treated in US EDs for soccer-related injuries by year and gender, 1990–2014.



**FIGURE 3** Number and rate per 10,000 soccer participants 7 to 17 years of age treated in US EDs for concussion/CHI by year, 1990–2014.

injuries during 2005 to 2007,<sup>4</sup> and others have reported an increase in concussions among youth athletes during the past 10 to 15 years in the United States.<sup>20–23</sup> The reasons for this observed increase are unknown, but several factors may have contributed. First, the incidence of concussion/CHI among youth soccer players may, in fact, be increasing. In addition, there has been a growing awareness among players, coaches, athletic trainers, medical professionals, and the public in general about the potentially serious consequences of sports-related concussion. Many states have passed youth sports concussion laws since 2009.<sup>24</sup> This awareness may have led to better recognition of concussions and referrals to EDs by soccer coaches and athletic trainers. Parents may have lower thresholds for taking their child to the ED for evaluation of a suspected concussion. ED medical personnel also may be diagnosing and documenting suspected concussion more often in recent years. The sharp increase after 2008 in concussions/CHIs in this study also has been observed in other youth sports,<sup>22</sup> especially youth football.<sup>23</sup>

In our study, patients with a concussion/CHI were twice as likely to be admitted to the hospital as patients with other diagnoses. This finding highlights the potential severity of these injuries. Patients 12 to 17 years of age were more likely to sustain a concussion/CHI than younger patients. The more aggressive play in this age group is a likely contributor to this finding. Injuries sustained by being struck by an object or person were more likely to occur to the head or neck region and were more likely to result in a concussion/CHI than other mechanisms of injury. According to previous studies, heading the ball and player-to-player contact were the most common activity and mechanism, respectively,



**FIGURE 4** Number and rate per 10,000 soccer participants 7 to 17 years of age treated in US EDs for soccer-related injuries by year and age group, 1990–2014.

associated with concussion among high school players.<sup>8,25</sup> The US Soccer Federation implemented new guidelines in January 2016 that eliminate heading for children  $\leq 10$  years of age and limit the amount of heading in practice for children 11 to 13 years of age.<sup>26</sup> Concussions among youth athletes can have serious consequences. Young athletes recover more slowly from concussions and repeat concussions than their college counterparts.<sup>27–29</sup> They are at risk for second-impact syndrome if they return to play prematurely, and repetitive concussions over years may put them at risk for other neurobehavioral and cognitive changes, including chronic traumatic encephalopathy.<sup>30,31</sup>

Sprain or strain and fracture were the most common diagnoses, a finding that is consistent with previous studies.<sup>4–6,14</sup> As others have previously reported,<sup>10,32,33</sup> sprains or strains occurred commonly to the ankles and knees, probably because of the cutting and pivoting maneuvers that are common in soccer and because of uneven playing fields. Older patients (12–17 years of age) and girls were more likely to sustain a sprain or strain than younger patients and boys. The

higher incidence of knee injuries, and anterior cruciate ligament injuries specifically, among female soccer players has been previously reported.<sup>32,34–37</sup> The effectiveness of prevention interventions on anterior cruciate ligament injury rates in soccer is inconsistent.<sup>38</sup> In contrast, 7- to 11-year-old patients and male patients were more likely to sustain a fracture than patients who were older or female. In part this difference may be due to more physical play by boys and to the fact that young children commonly fall forward onto outstretched arms, which often results in upper extremity fractures. Indeed, in this study patients 7 to 11 years were more likely to sustain an injury to the hand or finger or another part of the upper extremity than older patients. Fractures were among the most serious injuries in this study; patients with a fracture were  $>5$  times more likely to be admitted to the hospital than patients with other diagnoses. Fractures accounted for  $>60\%$  of hospital admissions.

The increasing number and rate of soccer-related injuries, especially concussions/CHIs, demonstrated in this study underscore the need for increased injury prevention

efforts. Education of players, coaches, referees or officials, and parents about the importance of following the rules of the game, and enforcement of those rules, are critical first steps.<sup>12,34,39</sup> One study found that 12% of all soccer competition injuries were related to illegal activity, and of these 25% were concussions.<sup>4</sup> Concussion prevention should focus on reducing player-to-player contact, some of which results from illegal activity. Protective headgear and ball heading are areas that deserve continued research and review.<sup>40</sup> Return-to-play and concussion management guidelines should be followed. Low neck strength has been shown to be associated with increased risk of concussion among high school athletes.<sup>41</sup> Preseason neck strength screening and neck muscle strengthening interventions may be of benefit in preventing concussions. More research is needed in these areas and on the effect of state sports-related concussion laws.<sup>42</sup>

There are several limitations to this study. Only cases treated in EDs were included in this study. Patients treated in non-ED health care settings, and those not seeking treatment, are not captured by the NEISS database. Therefore, the number of soccer-related injuries was underestimated in this study, and study findings may not be representative of all soccer-related injuries. Furthermore, NEISS case information is limited by the information documented in ED records and NEISS case narratives. NEISS case narratives did not consistently contain detailed information about the mechanism of injury and factors contributing to the injury event. Although rates and patterns of injuries associated with practice and competition differ,<sup>43</sup> we were unable to determine during which of these activities the injuries included in this study occurred. Some injuries also may have involved soccer equipment, but not soccer

activity, such as tripping on a soccer ball on the ground. NEISS does not have a variable for injury severity, and the use of hospital admission as a proxy measure of severity is a limitation of this study because factors other than injury severity can influence the decision to admit to the hospital. Soccer participation data were not available by gender, which precluded calculation of gender-specific injury rates. Despite these limitations, the strength of this study lies in its use of a large, nationally

representative sample over a period of 25 years and its calculation of injury rates based on soccer participation data.

## CONCLUSIONS

This study is the first to comprehensively investigate soccer-related injuries and calculate injury rates based on soccer participation data among children at the national level. The increasing number and rate of pediatric

soccer-related injuries, especially concussions/CHIs, underscore the need for increased efforts to prevent these injuries.

## ABBREVIATIONS

CHI: closed head injury  
CI: confidence interval  
ED: emergency department  
NEISS: National Electronic Injury Surveillance System  
RR: relative risk

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## REFERENCES

1. Koutures CG, Gregory AJ; American Academy of Pediatrics. Council on Sports Medicine and Fitness. Injuries in youth soccer. *Pediatrics*. 2010;125(2):410–414
2. American Academy of Pediatrics. Committee on Sports Medicine and Fitness. Injuries in youth soccer: a subject review. *Pediatrics*. 2000;105(3 pt 1):659–661
3. US Youth Soccer. Key Statistics: US Youth Soccer Annual Registration of Players. Available at: [www.usyouthsoccer.org/media\\_kit/keystatistics/](http://www.usyouthsoccer.org/media_kit/keystatistics/). Accessed May 23, 2016
4. Yard EE, Schroeder MJ, Fields SK, Collins CL, Comstock RD. The epidemiology of United States high school soccer injuries, 2005–2007. *Am J Sports Med*. 2008;36(10):1930–1937
5. Leininger RE, Knox CL, Comstock RD. Epidemiology of 1.6 million pediatric soccer-related injuries presenting to US emergency departments from 1990 to 2003. *Am J Sports Med*. 2007;35(2):288–293
6. Esquivel AO, Bruder A, Ratkowiak K, Lemos SE. Soccer-related injuries in children and adults aged 5 to 49 years in US emergency departments from 2000 to 2012. *Sports Health*. 2015;7(4):366–370
7. Emery CA, Meeuwisse WH. Risk factors for injury in indoor compared with outdoor adolescent soccer. *Am J Sports Med*. 2006;34(10):1636–1642
8. Comstock RD, Currie DW, Pierpoint LA, Grubenhoff JA, Fields SK. An evidence-based discussion of heading the ball and concussions in high school soccer. *JAMA Pediatr*. 2015;169(9):830–837
9. Kerr ZY, Collins CL, Fields SK, Comstock RD. Epidemiology of player–player contact injuries among US high school athletes, 2005–2009. *Clin Pediatr (Phila)*. 2011;50(7):594–603
10. Emery CA, Meeuwisse WH, Hartmann SE. Evaluation of risk factors for injury in adolescent soccer: implementation and validation of an injury surveillance system. *Am J Sports Med*. 2005;33(12):1882–1891
11. Pickett W, Streight S, Simpson K, Brison RJ. Head injuries in youth soccer players presenting to the emergency department. *Br J Sports Med*. 2005;39(4):226–231, discussion 226–231
12. Junge A, Rösch D, Peterson L, Graf-Baumann T, Dvorak J. Prevention of soccer injuries: a prospective intervention study in youth amateur players. *Am J Sports Med*. 2002;30(5):652–659
13. Tournay C, Sangnier S, Cotte T, Langlois R, Coquart J. Epidemiologic study of young soccer player's injuries in U12 to U20. *J Sports Med Phys Fitness*. 2014;54(4):526–535
14. Adams AL, Schiff MA. Childhood soccer injuries treated in US emergency departments. *Acad Emerg Med*. 2006;13(5):571–574
15. US Consumer Product Safety Commission. The NEISS Sample (Design and Implementation) From 1979 to 1996. Available at: [www.cpsc.gov/PageFiles/106606/2001d010-6b6.pdf](http://www.cpsc.gov/PageFiles/106606/2001d010-6b6.pdf). Accessed May 23, 2016
16. US Consumer Product Safety Commission. The NEISS Sample (Design and Implementation) From 1997 to Present. Available at: [www.cpsc.gov/PageFiles/106617/2001d011-6b6.pdf](http://www.cpsc.gov/PageFiles/106617/2001d011-6b6.pdf). Accessed May 23, 2016
17. National Sporting Goods Association. ProQuest Statistical Abstract of the US Online Edition: Participants in Selected Sports Activities. 2013–2015. Available at: <http://statabs.proquest.com/sa/index.html>. Accessed May 23, 2016
18. National Sporting Goods Association. Statistical Abstract of the US: Participants in Selected Sports Activities. 1990–2012. Available at: [www.census.gov/library/publications/time-series/statistical\\_abstracts.html](http://www.census.gov/library/publications/time-series/statistical_abstracts.html). Accessed May 23, 2016
19. Bayt DR, Bell TM. Trends in paediatric sports-related injuries presenting to US emergency departments, 2001–2013. *Inj Prev*. 10.1136/injuryprev-2015-041757



20. Bakhos LL, Lockhart GR, Myers R, Linakis JG. Emergency department visits for concussion in young child athletes. *Pediatrics*. 2010;126(3). Available at: [www.pediatrics.org/cgi/content/full/126/3/e550](http://www.pediatrics.org/cgi/content/full/126/3/e550)
21. Rosenthal JA, Foraker RE, Collins CL, Comstock RD. National high school athlete concussion rates from 2005–2006 to 2011–2012. *Am J Sports Med*. 2014;42(7):1710–1715
22. Buzas D, Jacobson NA, Morawa LG. Concussions from 9 youth organized sports: results from NEISS hospitals over an 11-year time frame, 2002–2012. *Orthop J Sports Med*. 2014;2(4):2325967114528460
23. Jacobson NA, Buzas D, Morawa LG. Concussions from youth football: results from NEISS hospitals over an 11-year time frame, 2002–2012. *Orthop J Sports Med*. 2013;1(7):2325967113517860
24. National Conference of State Legislatures. Traumatic Brain Injury Legislation. 2015. Available at: [www.ncsl.org/research/health/traumatic-brain-injury-legislation.aspx](http://www.ncsl.org/research/health/traumatic-brain-injury-legislation.aspx). Accessed May 23, 2016
25. Meehan WP III, d'Hemecourt P, Comstock RD. High school concussions in the 2008-2009 academic year: mechanism, symptoms, and management. *Am J Sports Med*. 2010;38(12):2405–2409
26. United States Soccer Federation. US Soccer Concussion Guidelines. 2015. Available at: [www.ussoccer.com/about/recognize-to-recover/concussion-guidelines](http://www.ussoccer.com/about/recognize-to-recover/concussion-guidelines). Accessed May 23, 2016
27. Field M, Collins MW, Lovell MR, Maroon J. Does age play a role in recovery from sports-related concussion? A comparison of high school and collegiate athletes. *J Pediatr*. 2003;142(5):546–553
28. Castile L, Collins CL, McIlvain NM, Comstock RD. The epidemiology of new versus recurrent sports concussions among high school athletes, 2005–2010. *Br J Sports Med*. 2012;46(8):603–610
29. Covassin T, Elbin RJ, Harris W, Parker T, Kontos A. The role of age and sex in symptoms, neurocognitive performance, and postural stability in athletes after concussion. *Am J Sports Med*. 2012;40(6):1303–1312
30. Stern RA, Riley DO, Daneshvar DH, Nowinski CJ, Cantu RC, McKee AC. Long-term consequences of repetitive brain trauma: chronic traumatic encephalopathy. *PM R*. 2011;3(10 suppl 2):S460–S467
31. Wetjen NM, Pichelmann MA, Atkinson JL. Second impact syndrome: concussion and second injury brain complications. *J Am Coll Surg*. 2010;211(4):553–557
32. Swenson DM, Collins CL, Best TM, Flanigan DC, Fields SK, Comstock RD. Epidemiology of knee injuries among US high school athletes, 2005/2006–2010/2011. *Med Sci Sports Exerc*. 2013;45(3):462–469
33. Swenson DM, Collins CL, Fields SK, Comstock RD. Epidemiology of US high school sports-related ligamentous ankle injuries, 2005/06–2010/11. *Clin J Sport Med*. 2013;23(3):190–196
34. Caine DJ, Maffulli N. Epidemiology of children's individual sports injuries. An important area of medicine and sport science research. *Med Sport Sci*. 2005;48:1–7
35. Fernandez WG, Yard EE, Comstock RD. Epidemiology of lower extremity injuries among US high school athletes. *Acad Emerg Med*. 2007;14(7):641–645
36. Joseph AM, Collins CL, Henke NM, Yard EE, Fields SK, Comstock RD. A multisport epidemiologic comparison of anterior cruciate ligament injuries in high school athletics. *J Athl Train*. 2013;48(6):810–817
37. Monfort SM, Comstock RD, Collins CL, Onate JA, Best TM, Chaudhari AM. Association between ball-handling versus defending actions and acute noncontact lower extremity injuries in high school basketball and soccer. *Am J Sports Med*. 2015;43(4):802–807
38. Dai BY, Mao DW, Garrett WE, Yu B. Anterior cruciate ligament injuries in soccer: loading mechanisms, risk factors, and prevention programs. *J Sport Health Sci*. 2014;3(4):299–306
39. Collins CL, Fields SK, Comstock RD. When the rules of the game are broken: what proportion of high school sports-related injuries are related to illegal activity? *Inj Prev*. 2008;14(1):34–38
40. Delaney JS, Al-Kashmiri A, Drummond R, Correa JA. The effect of protective headgear on head injuries and concussions in adolescent football (soccer) players. *Br J Sports Med*. 2008;42(2):110–115, discussion 115
41. Collins CL, Fletcher EN, Fields SK, et al. Neck strength: a protective factor reducing risk for concussion in high school sports. *J Prim Prev*. 2014;35(5):309–319
42. Gessel LM, Fields SK, Collins CL, Dick RW, Comstock RD. Concussions among United States high school and collegiate athletes. *J Athl Train*. 2007;42(4):495–503
43. Rechel JA, Yard EE, Comstock RD. An epidemiologic comparison of high school sports injuries sustained in practice and competition. *J Athl Train*. 2008;43(2):197–204

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