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ABSTRACT. Objective. Ice hockey, a popular sport in some regions, has potential for injury due to the velocities of players, pucks, and sticks. Previous studies conducted worldwide have shown that the rate of injury increases as the size and the speed of players increase, as well as when checking is allowed. However, national data about the annual number and types of injuries among ice hockey players are lacking. Data from previous studies were collected from regional tournaments, collegiate teams, local emergency departments (EDs), and different countries. The purpose of this article is to examine ice hockey injuries using a national US database to determine the age distribution of total injuries, injury types, and body regions injured, with a particular focus on ice hockey players <18 years old.

Methods. Data regarding ice hockey–related injuries treated in US EDs between January 1, 2001, and December 31, 2002, were extracted from the National Electronic Injury Surveillance System (NEISS). Data considered included age, gender, race, injury diagnosis, and body region injured. Ice hockey–related injury cases were identified using the consumer product code for ice hockey and the narrative description of the incident in NEISS.

Results. An estimated 32 750 individuals with ice hockey–related injuries were treated in US EDs in 2001–2002, including >19 000 youths <18 years old. The number of injuries peak through adolescence (ages 12–17; 47% of all injuries). Males experienced 90% of all injuries. A very small percentage of individuals were hospitalized after injury (1.2% of individuals <18 years old; 0.5% of individuals ≥18 years old). The incidence of head injuries increased as age decreased, although the trend was not statistically significant. The upper extremity (44%) accounted for the highest total percentages of body regions injured for youths <18 years old, and trunk (14%) and facial injuries (10%) represented the smallest total percentages. Players ≥18 years old had significantly more lacerations than younger players (38% of injuries for 18- to 24-year-olds; 25% for 25- to 34-year-olds; 50% for 35- to 44-year-olds compared with 19% for 6- to 11-year-olds and 14% for 12- to 17-year-olds).

Conclusions. Adolescents had the greatest number of ice hockey–related injuries treated in NEISS hospital EDs in 2001–2002; thus, ongoing efforts to develop injury prevention strategies should focus on this age group. Players ≤17 years old had a lower percentage of lacerations compared with all older players and a higher percentage of upper extremity injuries. The percentage of individuals hospitalized after injury was very low, yet youths <18 years old had twice the percentage of hospitalization after injury compared with individuals ≥18 years old. Males experienced the vast majority of all ice hockey–related injuries, with females representing a higher percentage of injuries among youths than among adults. Children and adults alike can reap the physical fitness and social benefits from ice hockey, when they are able to avoid predictable and preventable injuries.

Ice hockey has been depicted as a game played with “clubs (hockey sticks), knives (skates), and bullets (pucks).”1,2 The risk of injury is high, with players traveling up to 30 mph and pucks exceeding 100 mph.3 Previous studies conducted worldwide have shown that the rate of injury increases as the size and the speed of players increase, as well as when checking is allowed.4–12 As standards for helmets and face masks evolved to cover more surface area and to improve safety design, the number of head, eye, and dental injuries decreased; however, the number of spinal cord injuries increased.13–17 This increase is explained by studies on injury risk perception that have shown up to 55% of youth ice hockey players believe that brain and/or spinal cord injury is impossible while wearing the required protective gear.17–19 Overall, strains, sprains, lacerations, and contusions remain the most common types of ice hockey injuries.3–18

In the United States, ice hockey is a popular sport, with >530 000 registered players, including 370 458 youths,20 yet no study has evaluated ice hockey–related injuries in the United States using a nationally representative database. Data from previous studies1–19,21 were collected from regional tournaments, collegiate teams, local emergency departments (EDs), and different countries. Some studies collected data only on male ice hockey players,17,22,23 although registration data shows that females account for almost 10% of all ice hockey players in the United States.
United States. The purpose of this article is to examine ice hockey injuries using a national US database to determine the age distribution of total injuries, injury types, and body regions injured. This new information will inform players, coaches, and administrators about the patterns of ice hockey–related injuries in the United States.

METHODS

Data Source

The National Electronic Injury Surveillance System (NEISS) is operated by the US Consumer Product Safety Commission (CPSC) to provide timely data on consumer product–related and sports activity–related injuries that are treated in EDs in the United States and its territories. The NEISS receives data from a network of 98 hospitals that represent a stratified probability sample of 6100 hospitals with at least 6 beds and a 24-hour ED. At all 98 hospitals, every ED medical record is reviewed by a professional NEISS coder, and any event involving a traumatic injury is entered into the NEISS database. The database is updated daily and includes information for each injury event on the patient’s age, gender, race, injury diagnosis, body part injured, product(s) involved, treatment received, and a brief narrative of the incident. Each year, NEISS provides data on 500,000 injury-related ED visits and provides statistical weights to estimate the number and epidemiology of such events for the entire nation. Data used in this study were ice hockey–related injury cases that were treated in EDs in all NEISS hospitals between January 1, 2001, and December 31, 2002.

Variables

Ice Hockey Injury

Ice hockey–related injury cases were identified using the consumer product code for ice hockey and the narrative description of the incident in NEISS. An ice hockey–related injury was defined as a traumatic injury event that occurred to an individual while playing ice hockey. Cases were excluded on the basis of the narrative description if ice hockey equipment was involved but the patient was not playing ice hockey at the time of injury (eg, ice hockey sticks were used as fighting tools at home).

Body Region

The body part injured provided by NEISS was classified into broader body regions to allow meaningful comparison. “Upper extremity” includes the upper arm, shoulder, elbow, lower arm, wrist, hand, and finger. “Lower extremity” includes the upper leg, knee, lower leg, ankle, foot, and toe. “Head” refers to the head only. “Face” captures the ear, eyeball, face, and mouth. “Trunk” encompasses the neck, upper trunk, lower trunk, and pubic region.

Injury Diagnosis

Injury diagnoses presented are directly from injury diagnoses codes provided by NEISS data with 2 exceptions. We created a category “traumatic brain injury” (TBI) for the NEISS injury diagnosis codes for concussions and for internal organ injuries with “head” as the body part injured. The category “fracture” represents both fractures and avulsions.

Statistical Analysis

Data analyses were conducted using SAS (version 8.02; SAS Institute, Inc, Cary, NC) and SUDAAN (version 8.0.2, Research Triangle Institute, Research Triangle Park, NC) software to account for the weighting structures of NEISS-AIP. Experts at the CPSC provide statistical weights for NEISS data that adjust for the inverse probability of selection for each injury episode on the basis of the volume of the specific ED involved and other factors built into the complex survey design. NEISS was designed to project national estimates of injuries for product types; therefore, CPSC experts advise entering these statistical weights into statistical software for all analyses and data presentation.

The actual sample size is an unweighted number and is specified when presented; all other numbers are national estimates calculated with the statistical weights. National estimates of ice hockey–related injuries were calculated by age, gender, and race. National estimates, percentages, and 95% confidence intervals were calculated by injury diagnosis and body region injured. Injury diagnosis–specific information is provided only for diagnoses that represent at least 5% of total injuries for at least 1 age group. Diagnosis-specific groups that total <5% (dislocation, hematomata, and dental injury) were moved into the “other” category and detailed in a footnote. This study was approved by the Institutional Review Board of the Columbus Children’s Research Institute and Children’s Hospital.

RESULTS

Number of Injuries

Based on data collected by the NEISS, an estimated 32,750 individuals with ice hockey–related injuries were treated in US EDs in 2001–2002, including >18,000 youths who were <18 years old. The distribution of these patients by age group, gender, and race is shown in Table 1 and by age and gender in Fig 1. Injuries peaked during adolescence ($n = 15,482$ for ages 12–17 years compared with $n = 3,327$ for ages 6–11 years down to $n = 923$ for ages ≥18 years). Male individuals experienced 90% of injuries overall. Among those with recorded race, white players sustained 97% of injuries. For youths <18 years old, only 1.2% were hospitalized after the injury ($n = 225$); only 0.5% of individuals ≥18 years old were hospitalized after injury ($n = 63$).

Body Region Injured

The number and percentage of injuries by body region are presented in Fig 2 for youth <18 years old. The upper extremity (44%) accounted for the highest percentage of youth injuries overall. In contrast, trunk (14%) and facial injuries (10%) represented the smallest percentage of total youth injuries. By age group, 12- to 17-year-olds had a significantly higher percentage of upper extremity injuries (47% of all injuries) compared with all other age groups (27% for 6- to 11-year-olds; 26% for 18- to 24-year-olds; 30% for 25- to 30-year-olds; 28% for 35- to 44-year-olds; Table 2). Although not statistically significant, the percentage of head injuries decreased as age increased.

| Table 1. Demographics for Actual Sample and National Estimates of Ice Hockey Injuries |
|------------------------------------------|-----------------|
| **Age, y** | **National Estimates*** |
| 6–11 | 101 | 3327 |
| 12–17 | 359 | 15,482 |
| 18–24 | 119 | 6053 |
| 25–34 | 86 | 3975 |
| ≥35 | 65 | 2993 |

**Gender**

| Male | 677 | 29,458 |
| Female | 73 | 3296 |

**Race**

| White | 505 | 19,689 |
| Minority | 19 | 529 |
| Unknown | 226 | 12,535 |


* National estimates are calculated with statistical weights as advised by experts at the CPSC to account for the inverse probability of selection for each injury episode.
creased (21% of all injuries for 6- to 11-year-olds decreasing to 10% of all injuries for people ≥45 years old).

**Injury Diagnosis**

The percentage of injury diagnoses for youth <18 years old is presented in Fig 3. All players ≥18 years old had significantly more lacerations than younger players (38% of injuries for 18- to 24-year-olds; 25% for 25- to 34-year-olds; 50% for 35- to 44-year-olds compared with 19% for 6- to 11-year-olds and 14% for 12- to 17-year-olds; Table 2). Consistent with body part injured, the percentage of TBIs decreased as age increased (19% of all injuries for 6- to 11-year-olds decreasing to 10% of all injuries for people ≥45 years old). Contusions or abrasions (27%) represented the largest percentage of injuries to youths <18 years old.

**DISCUSSION**

Adolescents had the greatest number of ice hockey–related injuries treated in NEISS hospital EDs in 2001–2002; thus, ongoing efforts to develop injury prevention strategies should focus on this age group. Players <18 years old had a lower percentage of lacerations compared with all older players and a higher percentage of upper extremity injuries. The percentage of individuals hospitalized after injury was very low, yet youths <18 years old had twice the percentage of hospitalization after injury compared with individuals ≥18 years old. Males experienced the vast majority of all ice hockey–related injuries, with females representing a higher percentage of injuries among youth than among adults. It is interesting that the percentage of TBIs increased as age decreased.

Consistent with previous local findings,15,27 our national data show that the number of injuries peak dramatically during adolescence (ages 12–17). For injuries of any cause, rates tend to be higher for adolescents and for males.28–33 This age group has numerous ice hockey participants, 90% of which are male, and checking is allowed in most leagues.20,34 Checking is a controversial issue in youth ice hockey and may be a contributing factor to these injuries,4,8,12,17,35 although NEISS does not record this variable specifically. One study of a Minnesota youth hockey league showed that 86% of all injuries involved checking.17 Studies of individual teams have shown that few youth ice hockey players receive training in how to properly give and receive body checks and that young players frequently overestimate the protection provided by the required protective gear.17–19,23 Some researchers have further raised concern about variable enforcement of checking regulations.18,36 Our findings on the high incidence of injuries in adolescents highlight the need for in-
increased education and prevention strategies that target (1) officials to consistently enforce existing gameplay rules, (2) coaches to universally train players how to properly give and receive checks, and (3) players to recognize limitations of protective gear.

Consistent with previous research, our ED data showed that lacerations, contusions, and abrasions accounted for almost half of all injuries. It is interesting that studies have reported strains and sprains to be the most frequent injury, representing up to 5-fold the percentage of fractures, yet in our study of injuries that were treated in the ED, fractures account for a similar percentage of injuries as strains and sprains. This is likely related to the severity of injuries presenting to an ED compared with overall patterns of injury. The body region most frequently injured for youths <18 years old was the upper extremity, and adolescents injured this body region significantly more than all other age groups. Previous research found that the face was the most common body region injured, representing up to 29.2% of all injuries. Our lower percentage of youth facial injuries (10%) likely reflects the effects of helmet and full facial mask requirements implemented before our data collection but after that of earlier research. Other recent studies that evaluated the effects of these guidelines found the incidence of facial injuries to be as low as 4% of all injuries, a rate of 14.9 per 1000 player-game hours. The higher incidence of facial injury to players ≥18 years old in our data may be explained by popular league regulations that allow players ≥18 years old the option to select a half face shield or no visor, whereas players <18 years old are required to wear a full face shield and visor. Thus, our data support the growing research base documenting the effectiveness of these regulations in reducing facial injuries. For overall injuries, international research has demonstrated that lacerations, contusions, sprains, and strains are the most common types of injury in ice hockey. Many studies have described the incidence of brain and spinal cord injuries in ice hockey. Our data are consistent with their findings. We investigated further looking at the distribution by age and found an interesting (although not statistically significant) trend toward increasing incidence of TBI as age decreased. Some emerging data suggest that younger athletes are more susceptible to TBI than older athletes. Our observed trend may be related to traits of an older, more experienced athlete, including less aggressive play, less illegal contact, a realistic view of protective gear, and a higher incidence of properly fitted equipment in good condition. In addition, the younger players might be newer skaters and fall more frequently, hitting their heads with resulting TBI despite protection and without body checking. Clearly, additional research is needed beyond the variables captured by NEISS to detail the age-specific circumstances of the injury events that result in TBI, especially in the wake of national recommendations and rules against checking in youth ice hockey because checking has been shown to cause most TBIs. In this research, it will be important to distinguish between proper checking that uses positioning to control the puck and illegal checking, such as checking from behind, checking after the play, and cross-checking.

Several methodologic limitations exist in our study. First, NEISS tracks only injuries that are treated in an ED. Our findings may not be representative of injuries that are treated in other health care settings or injuries that do not receive medical attention. In addition, NEISS codes only the most severe injury. Thus, the frequency of additional minor injuries might be underrepresented in our data. Last, we could not calculate injury rates because we found no accurate, comprehensive national estimates of participants in ice hockey. USA Hockey is the national governing body for the sport of ice hockey in the United States and offers membership statistics by division, yet its database does not capture every single player in organized and informal ice hockey and offers only registration reports by division, not by specific age.

In summary, our analyses demonstrate that adolescents experience a significant number of ice hockey–related injuries that require treatment in hospital.

<table>
<thead>
<tr>
<th>Body region injured</th>
<th>6–11 Years</th>
<th>12–17 Years</th>
<th>18–24 Years</th>
<th>25–34 Years</th>
<th>35–44 Years</th>
<th>45 Years and Older</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper extremity</td>
<td>907 (27.3)</td>
<td>7327 (47.3)</td>
<td>1556 (25.7)</td>
<td>1194 (30.0)</td>
<td>804 (27.8)</td>
<td>381 (41.3)</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>523 (15.7)</td>
<td>2506 (16.2)</td>
<td>1099 (18.2)</td>
<td>895 (22.5)</td>
<td>518 (17.9)</td>
<td>244 (26.5)</td>
</tr>
<tr>
<td>Head</td>
<td>695 (20.9)</td>
<td>2360 (15.2)</td>
<td>766 (12.7)</td>
<td>574 (14.5)</td>
<td>329 (11.4)</td>
<td>90 (9.8)</td>
</tr>
<tr>
<td>Face</td>
<td>487 (14.7)</td>
<td>1402 (9.1)</td>
<td>1915 (31.6)</td>
<td>876 (11.5)</td>
<td>767 (12.2)</td>
<td>408 (11.1)</td>
</tr>
</tbody>
</table>

| Injury diagnosis    | 645 (19.4) | 2228 (14.4) | 1186 (19.6) | 943 (12.7)  | 517 (12.1)  | 395 (11.0)        |
| Laceration          | 807 (24.2) | 2725 (17.4) | 1915 (31.6) | 843 (11.9)  | 517 (12.1)  | 408 (11.1)        |
| Contusion or abrasion| 523 (15.7) | 2175 (12.6) | 1341 (22.0) | 617 (9.0)   | 483 (10.1)  | 395 (11.0)        |
| Fracture            | 590 (16.8) | 1935 (12.4) | 363 (6.0)   | 281 (4.7)   | 217 (4.1)   | 134 (1.9)         |
| Strain of spine     | 103 (0.4)  | 134 (0.5)   | 83 (0.7)    | 59 (0.4)    | 36 (0.5)    | 24 (0.3)          |

EDs. Annually, injuries account for 15% of total medical spending for people 1 to 19 years of age51; thus, our findings underscore the importance of injury prevention programs that focus on this high-risk population and support interventions, such as the USA Hockey rules on fair play and facial protection. Additional research is needed to investigate factors that contribute to the large percentage of TBIs among young players. Children and adults alike can reap the physical fitness and social benefits from ice hockey when they are able to avoid predictable and preventable injuries.

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