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A 20-Year Nationwide Analysis of the Epidemiology and Mechanisms of Hockey-Associated Eye Injuries

Anjum Koreishi

anjum.koreishi@northwestern.edu

Northwerstern University, Feinberg School of Medicine

Ethan James

Northwestern University Feinberg School of Medicine

Anya Kornfeld

Northwerstern University, Feinberg School of Medicine

Kamraan Siddique

Raphael Tinio

Eric Kim

Rukhsana Mirza

Northwestern University Feinberg School of Medicine https://orcid.org/0000-0003-1351-5874

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Abstract

Background/Objectives:

To define national temporal and mechanism-specific patterns of hockey-associated ocular injuries presenting to U.S. emergency departments, with particular emphasis on differences by age and form of hockey.

Subjects/Methods:

We performed a retrospective cross-sectional analysis of the National Electronic Injury Surveillance System from 2006 through 2025. Annual weighted national estimates and population-adjusted incidence rates were calculated. Temporal trends were assessed using linear regression. Multivariable logistic regression was used to identify factors associated with puck/ball versus hockey-stick injury.

Results

A total of 193 cases were identified, corresponding to an estimated 6,003 injuries nationally (95% CI, 3,687-8,320). Neither weighted national estimates (P = 0.207) nor population-adjusted incidence (P = 0.114) changed significantly over time. Paediatric patients accounted for 66.8% of cases. Hockey-stick impacts were the most common mechanism (53.4%), followed by puck/ball impacts (30.6%). In multivariable analysis, each 10-year increase in age was associated with greater odds of puck/ball rather than stick injury (adjusted OR, 1.36; 95% CI, 1.05–1.77; P = 0.021). Street/floor/indoor hockey was also strongly associated with puck/ball injury relative to ice hockey (adjusted OR, 17.80; 95% CI, 3.13-101.38; P = 0.001).

Conclusions

The population burden of hockey-associated ocular injury remained stable over two decades, but the mechanisms underlying these injuries varied substantially by age and form of play. These findings support a more targeted approach to ocular injury prevention based on the specific hazards encountered across hockey populations.

Plain Language Summary

Hockey-related eye injuries can result from sticks, pucks, balls, and other aspects of play. Using a national U.S. emergency department database, we examined 20 years of hockey-associated eye injuries to determine how often they occurred and whether their causes differed across patients and forms of hockey. The overall rate of injury remained stable over time. However, the pattern of injury varied substantially. Stick injuries were most common overall and were particularly prominent among younger patients, whereas puck or ball injuries became more likely with increasing age. Puck or ball injuries were also more strongly associated with street, floor, or indoor hockey than with ice hockey. These findings suggest that hockey-related eye injuries do not arise from a single mechanism and that prevention strategies may be more effective when tailored to the specific risks faced by different groups of players.

Introduction

Ocular trauma is a leading cause of visual morbidity and places a substantial burden on emergency care in the United States. Between 2006 and 2011, an estimated 4.3 million patients presented to U.S. emergency departments (EDs) with eye injuries, accounting for more than one-third of all ED visits for ophthalmic conditions.[1] Sports participation is an important contributor to this burden, with approximately 30,000 sports-related eye injuries presenting to U.S. EDs annually.[2] Many of these sports-related ocular injuries are preventable, yet they continue to cause serious and sometimes permanent visual impairment.[3] Effective prevention depends on understanding the mechanisms and distribution of injury within specific sports, knowledge that remains incomplete for many high-risk activities.

Hockey presents a particular risk for ocular trauma due to the combination of high-velocity projectiles, elevated sticks, and close-contact play.[4] Although injury patterns in both ice and field hockey have been described, much of the published literature has focused on musculoskeletal, head, and facial trauma broadly, with less attention to ocular injury.[5,6] Prior studies that have examined ocular trauma have focused on narrow populations or levels of play. Keshen et al., for example, identified stick penetration through facemask openings as the mechanism underlying ocular and facial injuries among National Hockey League (NHL) goaltenders,[7] and others have demonstrated lower rates of ocular injury with visor or protective eyewear use in organised ice and field hockey.[8,9] Together, these findings suggest that the mechanisms and circumstances of ocular trauma may differ substantially according to the form of hockey played and the equipment involved. Yet, these differences have not been systematically characterised across the broader population of hockey players.

More recently, Meller et al. used the National Electronic Injury Surveillance System (NEISS) to characterise hockey-related ocular trauma presenting to U.S. EDs from 2004 through 2023.[4] Their analyses, which focused primarily on injury severity and location, protective eyewear use, and differences by age and sex, demonstrated that most injuries occurred in male and paediatric patients and that a clinically important proportion were vision-threatening. However, national patterns of specific injury mechanisms, particularly hockey-stick versus puck or ball trauma, and how these mechanisms differ according to age and hockey subtype remain less well characterised. Differences in injury setting, seasonality, and age-specific population-adjusted temporal trends are likewise not well established. Prior NEISS studies of other sports have demonstrated the utility of combining narrative-based mechanism classification with national and population-adjusted temporal analyses to identify sport-specific injury patterns, an approach that has yet to be applied to hockey-related ocular trauma.[10,11]

The present study used the NEISS database to characterise hockey-related ocular injuries presenting to U.S. EDs from 2006 through 2025. We aimed to evaluate national and population-adjusted temporal trends overall and by age group, classify specific mechanisms of injury, and compare demographic and injury patterns across hockey subtypes. Additionally, we sought to examine factors associated with puck or ball trauma versus stick trauma to identify patterns that may inform a more targeted, personalised approach to ocular injury prevention and care.

Materials and Methods

NEISS Search Strategy

A retrospective cross-sectional study was conducted using NEISS - a publicly available database maintained by the U.S. Consumer Product Safety Commission. NEISS collects de-identified injury data from a stratified probability sample of approximately 100 U.S. EDs. Each case is assigned a statistical weight, primary sampling unit, and stratum, permitting calculation of national injury estimates. The NEISS database was queried for hockey-related ocular injuries presenting to EDs from January 2006 through December 2025. Cases were identified using the NEISS product codes for ice hockey (1279), field hockey (1295), street/floor/indoor hockey (3245), unspecified hockey (3272), and roller hockey (5032), in combination with the body-part code for the eyeball (77). Cases were categorised according to hockey subtype.

Data Collection and Coding

For descriptive analyses, the variables age, sex, race, treatment date, injury location, diagnosis, ED disposition, and accompanying injury narrative were collected. Patients were categorised by age: 0 to 12 years, 13 to 17 years, 18 to 65 years, and older than 65 years. For age-specific incidence and temporal analyses, patients were classified as paediatric (< 18 years) or adult (≥ 18 years). Injury dates were used to assign the season in which the injury occurred: spring (March-May), summer (June-August), autumn (September-November), or winter (December-February).

Case narratives were manually reviewed using a prespecified framework to classify the immediate mechanism of ocular injury. Categories of injury included hockey stick impact, puck/ball impact, player or body contact, collision with fixed equipment or the environment, fall, foreign body or environmental exposure, other specified mechanism, or unknown/insufficient detail. When multiple events were described, the immediate cause of ocular trauma was used for classification. Cases in which the causative mechanism could not be determined were categorised as unknown.

Statistical Analysis

Descriptive statistics were used to characterise demographic and injury-related variables. Categorical characteristics were compared across hockey subtypes using Pearson χ^2 testing when assumptions were satisfied and Monte Carlo permutation testing for sparse contingency tables. One-way analysis of variance (ANOVA) was used to compare mean age across hockey subtypes.

NEISS sampling weights and survey-design variables were used to calculate annual national injury estimates and 95% confidence intervals (CIs). Annual population-adjusted incidence rates were calculated using U.S. Census Bureau population estimates and expressed as injuries per 1 million persons. Age-specific Census population estimates were used to calculate separate annual incidence rates for paediatric (< 18 years) and adult (≥ 18 years) patients.

Simple linear regression was used to evaluate temporal trends in NEISS-weighted national estimates and population-adjusted incidence rates, both overall and for each hockey subtype. Separate regression models were also constructed for paediatric and adult incidence, and an interaction term between year and age group was used to assess whether temporal trends differed between paediatric and adult patients.

To evaluate factors associated with the mechanism of injury, a multivariable logistic regression model was constructed among patients with a clearly identified hockey-stick or puck/ball mechanism. Puck/ball injury was

modelled as the outcome, with age, sex, and hockey subtype included as predictors. Age was modelled as a continuous variable, with odds ratios expressed per 10-year increase. Roller hockey was excluded from the multivariable model because all roller hockey injuries with a known mechanism were puck/ball related, resulting in complete separation. Adjusted odds ratios (ORs) with 95% CIs were reported.

All statistical analyses were performed using Python (version 3.14.7; Python Software Foundation, Wilmington, DE, USA) within JupyterLab (version 4.6.2; Project Jupyter). All statistical tests were 2-sided, and $P < 0.05$ was considered statistically significant. Because NEISS data are publicly available and de-identified, this study was exempt from institutional review board (IRB) approval. The study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Incidence and Temporal Trends

Between 2006 and 2025, 193 hockey-related ocular injuries were identified in the NEISS, corresponding to an estimated 6,003 injuries nationally (95% CI, 3,687-8,320). Hockey type was unspecified in 128 cases (66.3%), while 22 (11.4%) were associated with street/floor/indoor hockey, 21 (10.9%) with ice hockey, 18 (9.3%) with field hockey, and 4 (2.1%) with roller hockey.

Annual NEISS-weighted national estimates fluctuated throughout the study period, with no significant overall temporal trend (slope, -9.19 injuries/year; 95% CI, -23.92 to 5.55; $R^2 = 0.087$; $P = 0.207$). Population-adjusted incidence similarly did not change significantly over time (slope, -0.037 injuries per million/year; 95% CI, -0.083 to 0.010; $R^2 = 0.133$; $P = 0.114$) (Fig. 1, Table 1). No significant temporal trends in either national estimates or population-adjusted incidence were observed for ice, field, street/floor/indoor, or roller hockey. Among cases with unspecified hockey type, population-adjusted incidence decreased significantly over the study period (slope, -0.039 injuries per million/year; 95% CI, -0.073 to -0.005; $R^2 = 0.241$; $P = 0.028$), although the corresponding decline in weighted national estimates did not reach statistical significance ($P = 0.051$).

Table 1

Temporal trends in hockey-related ocular injuries in U.S. emergency departments

Group	National estimate slope/year (95% CI)	R^2	P value	Incidence slope/year per 1 million (95% CI)	R^2	P value
Overall	-9.19 (-23.92 to 5.55)	0.087	0.207	-0.037 (-0.083 to 0.010)	0.133	0.114
Ice hockey	2.87 (-0.95 to 6.68)	0.122	0.132	0.008 (-0.004 to 0.020)	0.100	0.174
Field hockey	0.66 (-2.84 to 4.17)	0.009	0.696	0.001 (-0.009 to 0.012)	0.004	0.798
Street/floor/indoor hockey	-2.35 (-5.91 to 1.22)	0.096	0.184	-0.008 (-0.020 to 0.003)	0.115	0.144
Roller hockey	0.42 (-1.71 to 2.55)	0.009	0.683	0.001 (-0.005 to 0.008)	0.008	0.705
Hockey, not specified	-10.79 (-21.65 to 0.06)	0.195	0.051	-0.039 (-0.073 to -0.005)	0.241	0.028
Paediatric (< 18 years)	-6.64 (-14.21 to 0.93)	0.159	0.082	-0.087 (-0.190 to 0.016)	0.148	0.094
Adult (≥ 18 years)	-2.55 (-13.13 to 8.03)	0.014	0.619	-0.017 (-0.060 to 0.026)	0.039	0.407

Age-Specific Trends and Demographics

Paediatric patients younger than 18 years accounted for 129 injuries (66.8%), while 64 (33.2%) occurred in adults. Population-adjusted incidence was higher among paediatric patients than adults in 17 of the 20 study years (Fig. 2). However, neither group demonstrated a significant temporal change in incidence. Paediatric incidence decreased at an estimated rate of 0.087 injuries per million/year (95% CI, -0.190 to 0.016; P = 0.094), while adult incidence decreased by 0.017 injuries per million/year (95% CI, -0.060 to 0.026; P = 0.407). There was no significant difference between paediatric and adult temporal slopes (P = 0.200) (Table 1).

Overall, 150 patients (77.7%) were male. Sex distribution differed significantly across hockey subtypes (P < 0.001). All ice hockey and roller hockey injuries occurred in male patients, and 90.9% of street/floor/indoor hockey injuries occurred in males. In contrast, females accounted for 66.7% of field hockey injuries. Age-group and race distributions did not differ significantly across hockey subtypes (P = 0.529 and P = 0.541, respectively) (Table 2).

Table 2
Comparative epidemiology of hockey-related ocular injuries by hockey subtype

Characteristics	Ice hockey n (%)	Field hockey n (%)	Street/floor/indoor hockey n (%)	Roller hockey n (%)	Hockey, not specified n (%)	Total n (%)	P value
Sex							**< .001**
Male	21 (100.0)	6 (33.3)	20 (90.9)	4 (100.0)	99 (77.3)	150 (77.7)	
Female	0 (0.0)	12 (66.7)	2 (9.1)	0 (0.0)	29 (22.7)	43 (22.3)	
Age group							**0.529**
0–12 years	9 (42.9)	5 (27.8)	9 (40.9)	1 (25.0)	65 (50.8)	89 (46.1)	
13–17 years	2 (9.5)	6 (33.3)	4 (18.2)	1 (25.0)	27 (21.1)	40 (20.7)	
18–65 years	10 (47.6)	7 (38.9)	9 (40.9)	2 (50.0)	34 (26.6)	62 (32.1)	
> 65 years	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.6)	2 (1.0)	
Race							**0.541**
White	12 (57.1)	13 (72.2)	14 (63.6)	2 (50.0)	55 (43.0)	96 (49.7)	
Black/African American	0 (0.0)	1 (5.6)	3 (13.6)	1 (25.0)	16 (12.5)	21 (10.9)	
Asian	1 (4.8)	1 (5.6)	0 (0.0)	0 (0.0)	5 (3.9)	7 (3.6)	
American Indian/Alaska Native	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.5)	
Native Hawaiian/Pacific Islander	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Other	1 (4.8)	2 (11.1)	0 (0.0)	0 (0.0)	6 (4.7)	9 (4.7)	
Not stated	7 (33.3)	1 (5.6)	5 (22.7)	1 (25.0)	45 (35.2)	59 (30.6)	
Season							**< .001**
Spring	3 (14.3)	2 (11.1)	8 (36.4)	0 (0.0)	41 (32.0)	54 (28.0)	
Summer	2 (9.5)	2 (11.1)	1 (4.5)	4 (100.0)	22 (17.2)	31 (16.1)	
Autumn	11 (52.4)	9 (50.0)	6 (27.3)	0 (0.0)	22 (17.2)	48 (24.9)	

Characteristics	Ice hockey n (%)	Field hockey n (%)	Street/floor/indoor hockey n (%)	Roller hockey n (%)	Hockey, not specified n (%)	Total n (%)	P value
Sex							**< .001**
Winter	5 (23.8)	5 (27.8)	7 (31.8)	0 (0.0)	43 (33.6)	60 (31.1)	
Injury setting							**0.004**
Sports/recreation place	19 (90.5)	7 (38.9)	9 (40.9)	1 (25.0)	39 (30.5)	75 (38.9)	
School	1 (4.8)	5 (27.8)	6 (27.3)	0 (0.0)	33 (25.8)	45 (23.3)	
Home	1 (4.8)	1 (5.6)	0 (0.0)	1 (25.0)	11 (8.6)	14 (7.3)	
Street/highway	0 (0.0)	0 (0.0)	2 (9.1)	0 (0.0)	0 (0.0)	2 (1.0)	
Other public property	0 (0.0)	0 (0.0)	1 (4.5)	0 (0.0)	1 (0.8)	2 (1.0)	
Not recorded	0 (0.0)	5 (27.8)	4 (18.2)	2 (50.0)	44 (34.4)	55 (28.5)	
Injury mechanism							**0.085**
Hockey stick	12 (57.1)	8 (44.4)	3 (13.6)	0 (0.0)	80 (62.5)	103 (53.4)	
Puck/ball	4 (19.0)	6 (33.3)	14 (63.6)	4 (100.0)	31 (24.2)	59 (30.6)	
Player/body contact or player-worn equipment	0 (0.0)	0 (0.0)	1 (4.5)	0 (0.0)	1 (0.8)	2 (1.0)	
Boards/goal/fixed equipment or environment	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.5)	
Fall	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.6)	2 (1.0)	
Foreign body/environmental exposure	2 (9.5)	1 (5.6)	0 (0.0)	0 (0.0)	5 (3.9)	8 (4.1)	
Unknown/insufficient detail	3 (14.3)	3 (16.7)	4 (18.2)	0 (0.0)	8 (6.2)	18 (9.3)	
Diagnosis							**0.918**
Contusion/abrasion	9 (42.9)	10 (55.6)	8 (36.4)	1 (25.0)	63 (49.2)	91 (47.2)	
Foreign body	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)	4 (3.1)	5 (2.6)	

Characteristics	Ice hockey n (%)	Field hockey n (%)	Street/floor/indoor hockey n (%)	Roller hockey n (%)	Hockey, not specified n (%)	Total n (%)	P value
Sex							**< .001**
Laceration	2 (9.5)	1 (5.6)	1 (4.5)	0 (0.0)	5 (3.9)	9 (4.7)	
Haemorrhage	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.6)	3 (1.6)	
Dermatitis/conjunctivitis	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.5)	
Other/not stated	8 (38.1)	7 (38.9)	13 (59.1)	3 (75.0)	53 (41.4)	84 (43.5)	
Disposition							**0.416**
Treated and released	17 (81.0)	18 (100.0)	21 (95.5)	4 (100.0)	118 (92.2)	178 (92.2)	
Treated and transferred	3 (14.3)	0 (0.0)	1 (4.5)	0 (0.0)	2 (1.6)	6 (3.1)	
Treated and admitted/hospitalised	1 (4.8)	0 (0.0)	0 (0.0)	0 (0.0)	2 (1.6)	3 (1.6)	
Held for observation	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.5)	
Left without being seen/against medical advice	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (3.9)	5 (2.6)	
Total	**21**	**18**	**22**	**4**	**128**	**193**	

Season and Injury Setting

Seasonal distribution differed significantly across hockey subtypes (P < 0.001) (Table 2). Overall, injuries occurred most frequently during winter (31.1%), followed by spring (28.0%), autumn (24.9%), and summer (16.1%). Ice and field hockey injuries occurred most frequently in the autumn, accounting for 52.4% and 50.0% of injuries in each subtype, respectively. Street/floor/indoor hockey injuries were more evenly distributed, with the highest proportion occurring during spring (36.4%).

Injury setting also differed significantly by hockey subtype (P = 0.004). Sports and recreational facilities were the most documented setting overall (38.9%), followed by schools (23.3%). Ice hockey showed the most distinct distribution of settings, with 90.5% of injuries occurring at sports or recreational facilities. Among field hockey injuries, 38.9% occurred at sports or recreational facilities and 27.8% at schools, while 40.9% of street/floor/indoor hockey injuries occurred at sports or recreational facilities and 27.3% occurred at schools (Table 2).

Injury Mechanisms and Predictors of Puck/Ball Trauma

Hockey-stick impact was the most common mechanism of ocular injury, accounting for 103 cases (53.4%), followed by puck or ball impact in 59 (30.6%). Foreign body or environmental exposure accounted for 8 injuries (4.1%), while player/body contact, falls, and collision with fixed equipment or the environment were uncommon. Mechanism could not be determined from the case narrative in 18 cases (9.3%). Although the overall distribution of mechanisms did not differ significantly across hockey subtypes (P = 0.085), distinct subtype-specific patterns were observed. Hockey-stick impact accounted for 57.1% of ice hockey and 44.4% of field hockey injuries, whereas puck or ball impact accounted for 63.6% of street/floor/indoor hockey injuries and all four roller hockey injuries (Table 2).

Mechanism also differed by age. Hockey-stick injuries accounted for 60.5% (78/129) of paediatric injuries compared with 39.1% (25/64) of adult injuries, whereas puck or ball impacts accounted for 24.8% (32/129) of paediatric injuries and 42.2% (27/64) of adult injuries. Among cases with a known hockey-stick or puck/ball mechanism, adults had 2.63 times the odds of sustaining a puck/ball rather than stick-related injury compared with paediatric patients (95% CI, 1.33–5.21; P = 0.008).

In multivariable analysis of cases with a known stick or puck/ball mechanism, increasing age remained independently associated with the mechanism of injury. Each 10-year increase in age was associated with 36% greater odds of puck/ball rather than hockey-stick trauma (adjusted OR, 1.36; 95% CI, 1.05–1.77; P = 0.021). Compared with ice hockey, street/floor/indoor hockey was strongly associated with puck/ball rather than stick-related injury (adjusted OR, 17.80; 95% CI, 3.13-101.38; P = 0.001). Associations for field hockey (adjusted OR, 4.55; 95% CI, 0.80-25.97; P = 0.088), unspecified hockey (adjusted OR, 1.74; 95% CI, 0.49–6.20; P = 0.395), and female sex (adjusted OR, 0.44; 95% CI, 0.16–1.20; P = 0.107) were not statistically significant (Table 3).

Table 3
Multivariable predictors of puck/ball vs hockey-stick ocular injury

Predictor	Adjusted OR (95% CI)	P value
Field hockey vs ice hockey	4.55 (0.80-25.97)	0.088
Street/floor/indoor hockey vs ice hockey	17.80 (3.13-101.38)	0.001
Hockey, not specified vs ice hockey	1.74 (0.49–6.20)	0.395
Age, per 10-year increase	1.36 (1.05–1.77)	0.021
Female vs male	0.44 (0.16–1.20)	0.107

Diagnoses and Emergency Department Disposition

Contusions and abrasions were the most common NEISS-coded diagnoses, accounting for 91 injuries (47.2%). An additional 84 cases (43.5%) were categorised as other or not stated, while lacerations (4.7%), foreign bodies (2.6%), haemorrhages (1.6%), and dermatitis or conjunctivitis (0.5%) were less frequent. Diagnosis distribution did not differ significantly across hockey subtypes (P = 0.918) (Table 2).

Most patients were treated and released from the ED (178/193, 92.2%). Six patients (3.1%) were treated and transferred to another facility, 3 (1.6%) were admitted or hospitalised, 1 (0.5%) was held for observation, and 5 (2.6%) left without being seen by a care provider or against medical advice. ED disposition did not differ significantly by hockey subtype (P = 0.416) (Table 2).

Discussion

In this analysis of hockey-related ocular trauma, an estimated 6,003 injuries presented to U.S. emergency departments between 2006 and 2025. Despite two decades of evolving equipment standards and protective eyewear mandates, the overall burden of these injuries remained relatively stable, with no significant change in either national estimates or population-adjusted incidence. Importantly, this overall stability masked meaningful differences in how these injuries occurred. Paediatric patients accounted for approximately two-thirds of cases, hockey-stick impacts were the predominant mechanism overall, and the relative likelihood of puck or ball trauma increased with age.

During the development of this manuscript, Meller et al. published a national NEISS analysis of hockey-related ocular trauma from 2004 through 2023.[4] Consistent with our findings, most injuries occurred in male and paediatric patients, and they provided a detailed description of injury severity, anatomic involvement, and protective eyewear use. Our analysis corroborates these epidemiologic observations while extending them in several ways. By including data through 2025 and stratifying injuries by mechanism, age, and hockey subtype, we were able to identify patterns that would otherwise be obscured in aggregate analyses. This distinction is important because prevention depends not only on the overall burden of injury, but also on understanding which mechanisms predominate in specific populations and forms of play. We additionally characterised population-adjusted temporal trends, setting, and seasonality. Meller et al. noted a decline in estimated injuries through 2018 followed by an increase in the most recent five-year period, whereas our year-by-year analyses did not identify a significant long-term change in either national estimates or population-adjusted incidence. Taken together, the two studies suggest that hockey-related ocular trauma continues to be a persistent source of injury despite considerable year-to-year variation.

The mechanism-specific findings were among the most notable results of this study. Hockey-stick impacts accounted for more than half of all injuries and were particularly common among paediatric patients, whereas the relative likelihood of puck or ball trauma increased with age. Each 10-year increase in age was associated with 36% greater odds of puck or ball rather than stick-related injury. This pattern is consistent with observations from earlier hockey-related ocular injury literature. Pashby identified sticks and pucks as the major causes of ocular injury in Canadian amateur hockey, with younger players accounting for a large proportion of those injured.[12,13] At the professional level, by contrast, Micieli et al. found that direct or deflected pucks accounted for 37% of eye and orbital injuries compared with 28% caused by high sticks,[8] and Pradeep et al. later reported greater time lost from play after direct puck injuries than after stick injuries.[14] The strong association between street, floor, or indoor hockey and puck or ball trauma in our cohort also fits with observations from related stick-and-ball sports. In floorball, direct ball impact is a common cause of ocular injury,[15] while collegiate field hockey studies have implicated both elevated balls and sticks in head, face, and eye trauma.[16] These distinctions are difficult to appreciate when all equipment-related injuries are grouped together and support considering stick and projectile trauma as distinct mechanisms in future surveillance and prevention efforts.

Hockey subtype also appeared to shape the broader epidemiologic context of injury. Nearly all ice, street, floor, indoor, and roller hockey injuries occurred in male patients, whereas most field hockey injuries occurred in female patients. A recent NEISS analysis of craniofacial injuries across four hockey variants reported a similar distribution, with marked differences in sex across ice, field, street, and roller hockey.[17] Prior paediatric and athlete-based studies have likewise shown that injury patterns vary substantially according to hockey type, age,

sex, and level of competition.[18,19] These differences may reflect participation patterns and should not be interpreted as evidence of greater biologic susceptibility in one group or another. The predominance of paediatric injuries in our cohort is also consistent with broader studies of sports-related ocular trauma.[2,20,21] Most patients were treated and released from the ED, and contusions or abrasions were the most common diagnoses. Similar findings have been reported in other national studies, although relatively minor initial diagnoses do not exclude important ophthalmic morbidity. Leivo et al., for example, found that sports-related ocular trauma could be associated with serious retinal findings and permanent functional impairment despite contusion being the most common diagnosis.[22]

The mechanism-specific differences observed here are also relevant to prevention. In the NHL, visor use has been associated with substantially lower odds of eye and orbital injury,[8] and Stuart et al. found a greater risk of eye injury among Junior A players without facial protection and no eye injuries among players wearing full facial protection.[23] Prospective data from collegiate ice hockey have similarly shown fewer facial injuries with full rather than half facial shields without a corresponding increase in concussion or neck injury.[24] Protective eyewear has also been proven effective outside ice hockey. In female high school field hockey, implementation of mandatory eye protection was associated with a lower incidence of eye and orbital injury and a 67% reduction in severe injuries.[9] The present findings extend this literature by demonstrating that the relative importance of stick and projectile trauma differs across age groups and forms of hockey. Prevention strategies may, therefore, be most effective when tailored to the specific hazards encountered in each setting rather than treating all hockey-related eye injuries as arising from a single mechanism.

Several limitations should be considered. NEISS captures injuries evaluated in participating emergency departments and does not include injuries treated exclusively in ophthalmology clinics, urgent care centres, athletic facilities, or other outpatient settings. Detailed ophthalmic information, including visual acuity, intraocular pressure, laterality, imaging findings, treatment after discharge, and long-term visual outcomes, is also unavailable. Mechanism classification depended on brief injury narratives and may have been limited when the circumstances of injury were incompletely documented. Hockey subtype was unspecified in 66.3% of cases, and several of the specified subtypes contained relatively few unweighted cases, resulting in wide confidence intervals for some estimates. NEISS also does not provide hockey participation or athlete-exposure denominators, so the population-adjusted rates reported here should not be interpreted as the risk of injury to an individual player. These limitations are shared by other national studies using NEISS to examine hockey and sports-related ocular trauma.[4,17,18,20,21]

Even with these limitations, the present study is an important contribution to sport-related ocular injury literature, as our analysis highlights that hockey-related ocular injuries do not occur through a single pattern, but are rather multifactorial. Stick trauma predominated among younger patients, while puck or ball trauma became more prominent with increasing age and in street, floor, or indoor hockey. Recognising these differences may help better align protective equipment, injury-prevention education, and other safety efforts with the circumstances in which these injuries occur.

Declarations

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Data Availability Statement: The data analysed in this study are publicly available from the U.S. Consumer Product Safety Commission National Electronic Injury Surveillance System (NEISS). The analytic dataset was derived from these publicly available data using the eligibility and classification criteria described in the Methods.

Author Contribution Statement: EJ conceived and designed the study with input from AK, KS, RT, EJK, RGM, and AFK. EJ had full access to the study data and takes responsibility for the integrity of the data and the accuracy of the analyses. EJ, AK, KS, and EJK contributed to data acquisition, analysis, and interpretation and participated in drafting the manuscript. EJ performed the statistical analyses and prepared the presentation of the results. RT, RGM, and AFK critically reviewed the manuscript for important intellectual content and provided substantive feedback. EJK and RGM provided supervision and strategic oversight. AFK provided senior mentorship, editorial guidance, and critical review throughout the study.

Conflict of Interest: The authors declare that they have no conflict of interest.

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Figures

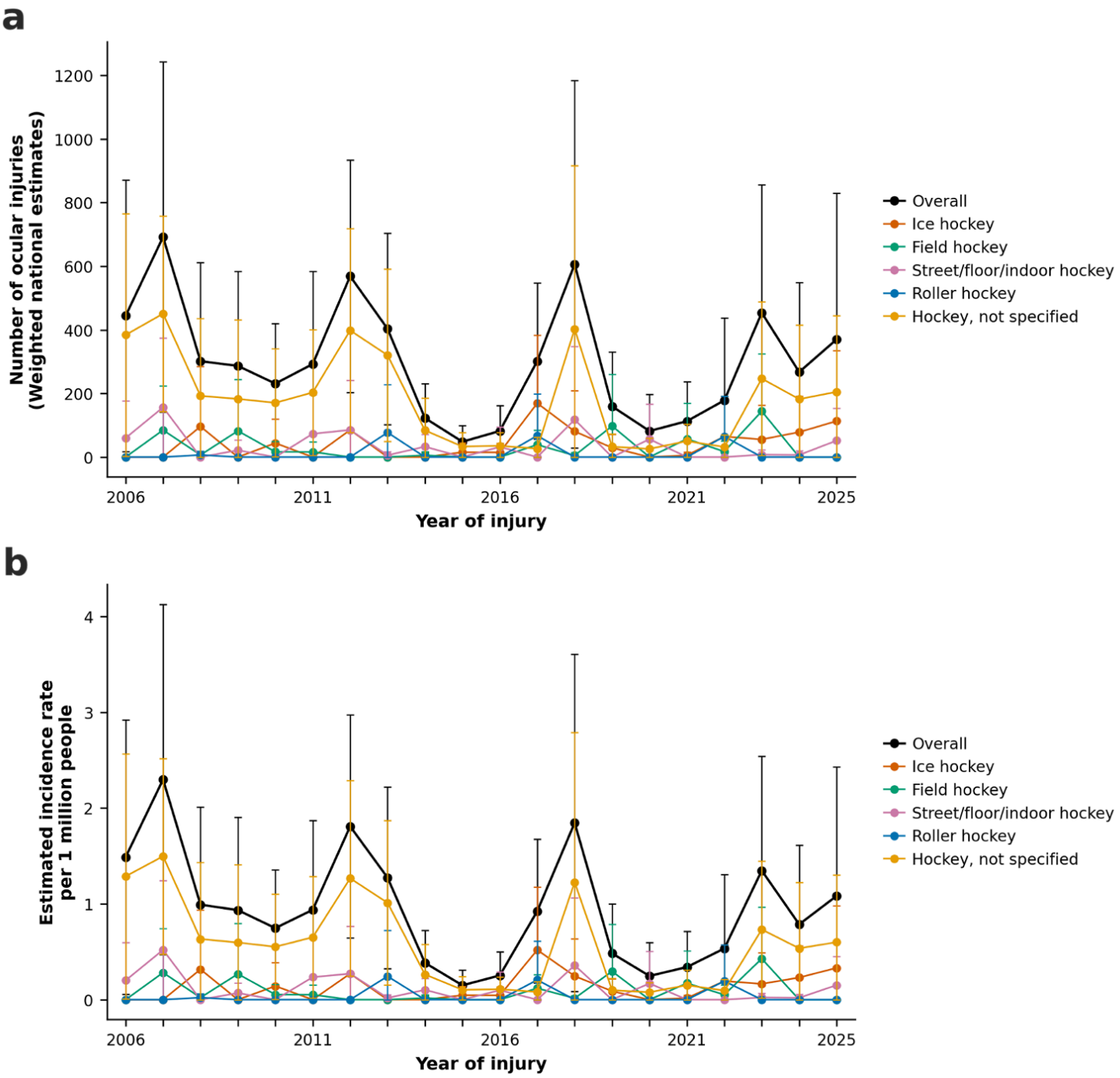

Figure 1

National estimates and population-adjusted incidence of hockey-related ocular trauma in U.S. emergency departments. (a) Annual NEISS-weighted national estimates of hockey-related ocular injuries overall and by hockey subtype. **(b)**Corresponding annual population-adjusted incidence rates per 1 million U.S. residents. Error bars represent 95% CIs.

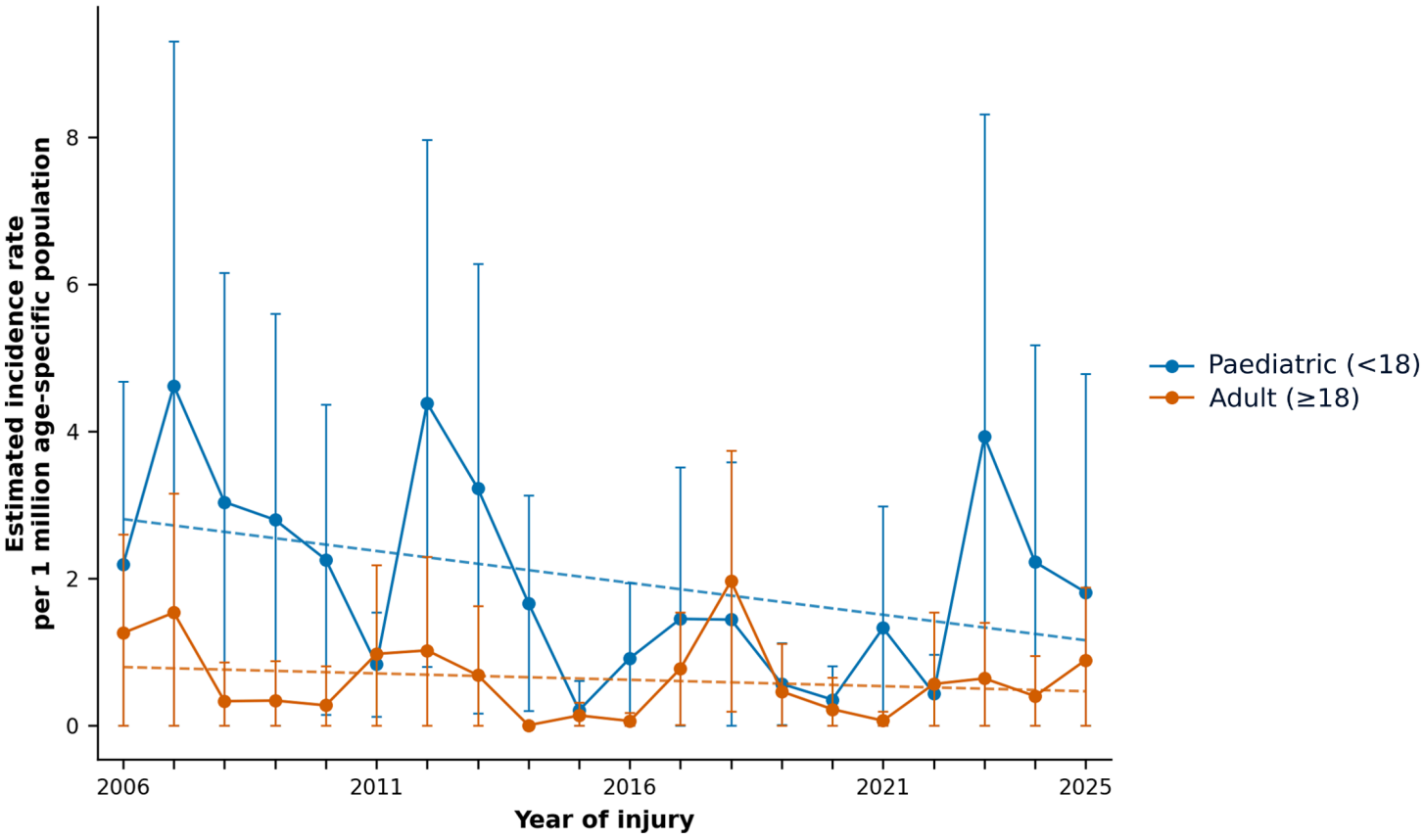

Figure 2

Population-adjusted incidence of hockey-related ocular trauma by age group. Annual estimated incidence rates of hockey-related ocular injuries per 1 million age-specific U.S. residents among paediatric versus adult patients. Error bars represent 95% CIs.