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ORIGINAL RESEARCH

Incidence and Characteristics of Orbital Hemorrhages in the United States from 2006 to 2018

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Purpose: To determine the incidence, characteristics, and costs associated with orbital hemorrhages presenting to US EDs.

Patients and Methods: This was a retrospective, longitudinal study of the Nationwide Emergency Department Sample, 2006 to 2018. Medical records from patients presenting to participating hospital-owned EDs and diagnosed with primary or secondary orbital hemorrhage were examined to determine incidence, demographics, clinical characteristics, mechanism, disposition and related risk factors, and costs.

Results: From 2006 to 2018, an estimated 20,762 US ED visits included an orbital hemorrhage diagnosis. Most primary diagnosis patients were elderly (35%) and male (51%), and incidence increased from 1.1 (95% CI: 0.8–1.4) to 3.1 per million (95% CI: 2.5–3.7, $p < 0.0001$). Fall was the most common mechanism (21.6%), particularly among the elderly (39.9%). Fall-related diagnoses increased from 0.03 (95% CI: −0.01–0.07) to 1.0 per million (95% CI: 0.7–1.3, $p < 0.0001$), while overall falls increased by only 7%. Assault-related orbital hemorrhage increased from 0.1 (95% CI: 0.0–0.2) to 0.6 per million (95% CI: 0.4–0.7, $p < 0.0001$), while overall assaults decreased by 22%. Annual total ED costs increased from $463,220 (95% CI: 233,993–692,446) to $6,117,320 (95% CI: 4,665,403–7,569,237, $p < 0.001$). Inpatient admission was uncommon (9.0%), but related costs totaled $18.9 million (95% CI: 13.3–24.5). Odds of admission were lower in fall- and objects-related injuries and higher with certain concurrent injuries.

Conclusion: Orbital hemorrhages are becoming more frequent and costly. A disproportionately large increase in fall- and assault-related diagnoses highlights the need for targeted injury prevention strategies to reduce cost and morbidity.

Keywords: orbital trauma, ocular trauma, epidemiology, cost

Introduction

Most literature on orbital hemorrhage (OH) concentrates on orbital compartment syndrome, which can cause irreversible vision loss after just 100–120 minutes[1–3] by decreased perfusion and direct compression.[4] Fortunately, the existing literature on OH suggests that this potentially blinding condition occurs relatively infrequently, found in only 0.45–3.6% of orbital fracture and trauma patients.[3,5,6] Incidence in post-operative fracture repair has been reported at an even lower rate.[7] OHs can also occur spontaneously, generally in patients with predisposing anatomical abnormalities; however, these cases are rare.[8] Orbital hemorrhage can be diffuse, either intraconal and/or extraconal, or localized as in subperiosteal hemorrhage. Bleeding diatheses (primary or drug-induced), post-adnexal (blepharoplasty, especially if patient is on anticoagulant or antiplatelet agents) or sinus surgery, and rarely severe Valsalva (eg childbirth) are minor causes of OH.[8] In contrast, most OHs occur in male trauma patients, most commonly related to assault, motor vehicle accident, or fall.[5,6,9]

The present literature on OH is based on either single institution samples or a systematic review of the literature, both of which are inherently limited and subject to bias. We are unaware of previous reports of true national-level investigation in the United States (US) or elsewhere regarding the incidence, characteristics, and cost of orbital hemorrhage diagnoses and could find no references involving a nationwide investigation in a computerized search (PubMed, Google

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Scholar). Noting the pattern of increasing cost and incidence of orbital fractures,[10] there exists a significant chance that the same pattern exists for orbital hemorrhages. Physicians must be aware of the costs incurred by this condition and the factors playing into these costs as the first step in identifying ways to mitigate economic burden in an already overdrawn US healthcare economy. An understanding of OH characteristics and incidence would also help physicians to identify which preventive measures may be most helpful to decrease patient morbidity.

Although eye injuries are often addressed by outpatient ophthalmologists, most eye and orbital injuries are treated first in emergency departments (EDs).[11] We utilized a nationally representative sample of ED visits to examine the incidence, characteristics, and cost of OHs presenting to EDs across the US over a 13-year period.

Materials and Methods

Study Design

We conducted a retrospective, longitudinal study using the National Emergency Department Sample (NEDS) to identify all ED visits in the sample from 2006 to 2018 with a diagnosis of OH, which were then examined for main outcome measures of incidence, demographics, clinical characteristics, mechanism, disposition and related risk factors, and cost. International Classification of Diseases [ICD] codes used to isolate these cases are included in Supplementary Table S1 (table detailing ICD codes). External cause of injury codes were used to categorize mechanism of injury and are detailed in Supplementary Table S2 (table detailing cause of injury codes). The Current Procedural Terminology (CPT), ICD-9 procedure, and ICD-10 procedure codes for lateral canthotomy used to ascertain if this procedure was performed are detailed in Supplementary Table S3 (table detailing lateral canthotomy procedure codes). ED cost was defined as the total charge to the patient for the ED visit, whereas inpatient cost was defined as the total of hospital charges for an inpatient stay.

Institutional Review Board approval was obtained prospectively (exempt status given de-identified database, Johns Hopkins Medicine IRB). This study adheres to the tenets of the Declaration of Helsinki and is also in accordance with HIPAA regulations. The NEDS does not contain direct patient identifiers, so informed consent was not required. To maintain adherence with the Healthcare Cost and Utilization Project data user agreement, estimates for any characteristics with 10 or fewer visits are not reported here to maintain patient confidentiality.

Data Set

The Nationwide Emergency Department Sample (NEDS) is the US' largest all-payer ED database, developed as part of the Healthcare Cost and Utilization Project and sponsored by the US Federal Agency for Healthcare Research and Quality. This database is used to calculate national estimates of ED visits and represents a stratified sample consisting of over 25–30 million ED visits annually from nearly 1000 hospital-owned EDs in the US. To calculate national estimates, sample data are weighted to reflect the portion of all hospital-reported EDs in the AHA Annual Survey Database that they compose. Stratification is based on geographic region, trauma designation, urban versus rural location, teaching status, and hospital control/ownership. Patient characteristics and diagnoses (using ICD-9 from 2006 through September 30, 2015 and ICD-10 from October 1, 2015 onward) are included in the database. The primary diagnosis for an encounter is the diagnosis primarily responsible for presentation to care, while secondary diagnoses are any other accompanying diagnoses. More information can be found at https://www.hcup-us.ahrq.gov/db/nation/neds/nedsdbdocumentation.jsp.

Data Collection and Analysis

National estimates were calculated using NEDS-supplied sampling weights. US Census Bureau data were used to calculate incidence of orbital hemorrhage. Age was grouped into the following categories: children (10 years and younger), adolescents (11–20 years), young adults (21–44 years), adults (45–64 years), and elderly (65 years and older). Descriptive statistics were calculated for hospital characteristics, patient demographics, and concomitant ocular/ facial injuries. ED and inpatient charges were inflation-adjusted based on the 2021 US dollar using the Consumer Price Index for Hospital Services from the US Bureau of Labor Statistics. Linear regression was used to estimate trends in incidence and mean ED charge per visit. Univariate and multivariate logistic regression were used to assess factors associated with inpatient admission. Stata version 15 (StataCorp LLC, College Station, Texas, USA) was used for all statistical analyses.

Results

Incidence

Estimated incidence of ED visits with a primary or secondary OH diagnosis increased by more than 4.3-fold from 2.7 per million (95% confidence interval [CI]: 2.2–3.3) in 2006 to 11.8 per million (95% CI: 10.4–13.1, $p<0.0001$) in 2018. Primary OH diagnoses alone increased about 2.9 times, from 1.1 per million (95% CI: 0.8–1.4) in 2006 to 3.1 per million (95% CI: 2.5–3.7, $p<0.0001$). Total OH diagnoses increased most precipitously from 2015 to 2016, jumping 74% from 6.0 per million (95% CI: 5.0–7.0) to 10.5 per million (95% CI: 8.9–12.0, $p<0.0001$). Over the same interval, primary OH diagnoses increased 116% from 1.43 per million (95% CI: 1.1–1.76) to 3.1 per million (95% CI: 2.5–3.7, $p<0.0001$) (Figure 1A).

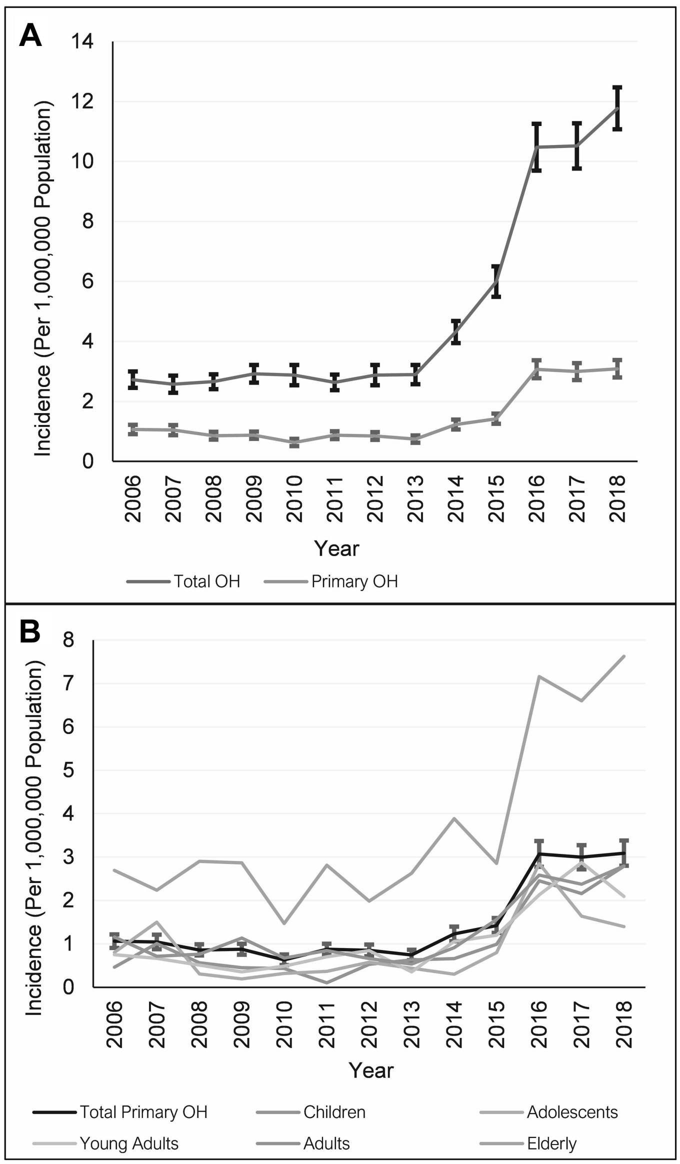

Figure 1 Orbital hemorrhage diagnoses in US emergency departments. (**A**) This plot displays the incidence of emergency department visits with orbital hemorrhage diagnoses (total and primary) from 2006–2018 (with standard error). (**B**) This plot displays the age-specific incidence of emergency department visits with primary orbital hemorrhage diagnoses from 2006–2018 (with standard error for total incidence).

All groups but adolescents had a statistically significant increase in age-specific primary OH incidence over the study period (Figure 1B). Primary OH increased about six-fold in children (0.5 [95% CI: 0.0–0.9] to 2.8 per million [95% CI: 1.7–3.9, p<0.0001]), and between two- to three-fold in young adults, adults, and the elderly. There was otherwise a trend toward fewer orbital hemorrhages in January and February in any given year (data not shown), though this did not reach statistical significance.

Demographics

The mean age of OH patients presenting to the ED was 49.2 (standard error = 0.8) years. The elderly made up the largest proportion of OH patients (33.6%) (Table 1). The majority of OH patients were male (51.0%), though elderly patients were predominantly female (64.0%) (Table 1). The most common primary expected payer overall was Medicare, with 85.0% of the elderly covered in this way, though a significant portion of young adults (33.1%) were self-pay (Table 1). These and all demographic results can be examined in Table 1.

Mechanism of Injury

The most common overall mechanism of injury reported was fall (21.6%), followed by assault (15.9%). Young adults and the elderly were overwhelmingly injured by assaults (40%) and falls (40%), respectively (Supplementary Figure S1, figure detailing mechanisms of injury across age groups). All examined mechanisms increased in incidence, with fall-related OHs increasing to the greatest extent (Supplementary Figure S2, figure detailing overall incidence of mechanisms of injury). While the incidence of assault-related OHs increased by nearly 7-fold from less than 0.1 (95% CI: 0.0–0.2) to 0.6 per million (95% CI: 0.4–0.7, p<0.0001), fall-related OHs increased by over 34-fold from 0.03 (95% CI: −0.01–0.07) to 1.0 per million (95% CI: 0.7–1.3, p<0.0001) (Figure 2). From 2006 to 2018, overall fall incidence in the NEDS increased by only 7% from 276.6 (95% CI: 264.9–288.3) to 295.0 per 10,000 population (95% CI: 281.1–309.2, p=0.0015). Overall assault incidence decreased by 22% from 43.3 (95% CI: 40.6–46.0) to 33.7 per 10,000 population (95% CI: 31.5–35.9, p<0.001) (Supplementary Figure S3, figure detailing overall assault and fall incidence 2006–2018).

Associated Ocular Injuries and Procedures

The most common primary OH-associated ocular injury was contusion (6.3%), with nasal fracture nearly as common in young adults (5.7%) and low vision notable in the elderly (4.0%) (Supplementary Table S4, table detailing most common associated ocular injuries across age groups). Lateral canthotomy was coded in only 3.3% of primary OH cases and 3.8% of total OH cases. However, 20.9% of admitted primary OH cases had undergone lateral canthotomy, and odds of admission increased by over 16-fold if this procedure was performed (Odds Ratio [OR] 16.07, 95% CI: 8.01–32.26).

ED Costs

Total inflation-adjusted ED cost for primary OH cases from 2006 to 2018 was $24.8 million (95% CI: 22.0–27.7), with annual adjusted ED costs increasing over 13-fold from $463,220 (95% CI: 233,993–692,446) to $6,117,320 (95% CI: 4,665,403–7,569,237, p<0.001) (Figure 3A). Mean inflation-adjusted per-visit ED cost increased slightly less than 4-fold, from $1,883 (95% CI: 1,143–2,623) to $6,974 (95% CI: 5,861–8,087, p<0.0001) (Figure 3B).

Disposition and Factors Associated with Admission

The vast majority (80.7%) of primary OH patients were seen in and discharged from the ED (routine disposition). Only 9.0% were admitted to the presenting hospital. Though admission was relatively rare, the total inflation-adjusted inpatient charge for primary OH 2006–2018 was notable at $18.9 million (95% CI: 13.3–24.5), with mean inpatient cost per patient of $35,726 (95% CI: 28,193–43,258).

The largest fraction of admitted patients were elderly, with low admission rates particularly among younger patients (Table 2). Both fall- (OR 0.45, p=0.009) and object-related (OR 0.24, p=0.015) injuries were associated with decreased odds of admission, while long-term anticoagulant or antiplatelet use was associated with increased odds (OR 2.75, p=0.001), as were certain concurrent injuries (Table 2).

Table 1 Demographics of National Emergency Department Sample (NEDS) Patients with Primary Diagnosis of Orbital Hemorrhage 2006 to 2018[a]

Characteristic	Children (≤10) (N = 589) n (%)	Adolescent (11–20) (N = 488) n (%)	Young Adult (21–44) (N = 1423) n (%)	Adult (45–64) (N = 1370) n (%)	Elderly (≥65) (N = 2083) n (%)	Total (N = 5953) n (%)	X^2	p
Sex								
Female	186 (31.6)	183 (37.4)	556 (39.1)	657 (48.0)	1333 (64.0)	2915 (49.0)	795.1	<0.001
Male	403 (68.4)	305 (62.6)	867 (60.9)	713 (52.0)	750 (36.0)	3038 (51.0)		
Primary Expected Payer (Uniform)								
Medicare	–[b]	27 (5.6)	54 (3.8)	239 (17.5)	1775 (85.0)	2100 (35.3)	9499	<0.001
Medicaid	264 (44.8)	187 (38.6)	369 (26.0)	281 (20.6)	35 (1.7)	1136 (19.1)		
Private Insurance	243 (41.2)	184 (38.0)	444 (31.3)	487 (35.7)	222 (10.6)	1580 (26.6)		
Self-Pay	38 (6.4)	72 (14.9)	470 (33.1)	234 (17.2)	27 (1.3)	841 (14.1)		
No Charge	–[b]	–[b]	18 (1.3)	–[b]	–[b]	27 (0.4)		
Other	40 (6.8)	14 (2.9)	63 (4.4)	115 (8.4)	29 (1.4)	261 (4.4)		
Household Income Quartile								
First	203 (35.1)	119 (24.5)	556 (40.5)	451 (33.8)	505 (24.4)	1835 (31.4)	306	0.01
Second	165 (28.5)	144 (29.5)	302 (21.9)	350 (26.3)	506 (27.4)	1527 (26.1)		
Third	109 (18.8)	133 (27.4)	278 (20.2)	295 (22.2)	546 0.26.4)	1363 (23.3)		
Fourth	102 (17.6)	91 (18.7)	239 (17.4)	236 (17.7)	451 (21.8)	1119 (19.2)		
Hospital Region								
Northeast	121 (20.5)	69 (14.1)	287 (20.2)	314 (22.9)	416 (19.9)	1207 (20.2)	199	0.23
Midwest	137 (23.3)	136 (27.9)	349 (24.5)	291 (21.2)	624 (29.9)	1537 (25.8)		
South	254 (43.1)	173 (35.5)	532 (37.4)	470 (34.3)	735 (35.2)	2164 (36.3)		
West	77 (13.1)	110 (22.5)	255 (17.9)	295 (21.5)	313 (15.0)	1050 (17.6)		
Hospital Teaching Status								
Metropolitan Non-teaching	133 (22.5)	145 (29.8)	391 (27.5)	421 (30.7)	716 (34.3)	1807 (30.3)	121	0.33
Metropolitan Teaching	360 (61.1)	249 (51.1)	841 (59.1)	764 (55.7)	1072 (51.4)	3287 (55.2)		
Non-metropolitan	96 (16.3)	93 (19.1)	190 (13.4)	186 (13.6)	299 (14.3)	865 (14.5)		
Trauma Level Designation								
Non-Trauma	248 (44.3)	207 (43.7)	651 (50.1)	645 (52.2)	1152 (59.8)	2903 (52.9)	286	0.04
1	168 (29.9)	130 (27.4)	355 (27.6)	269 (21.7)	325 (16.9)	1247 (22.7)		
2	96 (17.2)	58 (12.3)	146 (11.3)	155 (12.5)	236 (12.3)	692 (12.6)		
3	49 (8.7)	79 (16.6)	137 (10.6)	167 (13.5)	213 (11.1)	645 (11.8)		

Notes: [a]Numbers and percentages in each category may not sum to the same total or to 100%, respectively, due to extrapolation from a sample (NEDS) and rounding error; [b]10 or fewer patients reported in this category, number excluded to preserve anonymity of data.

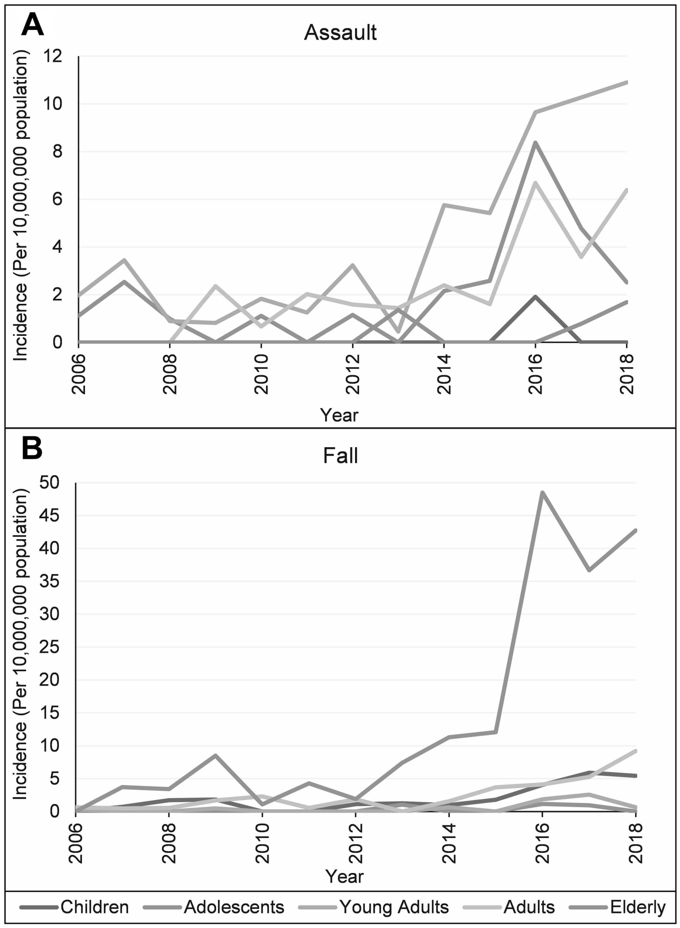

Figure 2 Assault- and fall-related orbital hemorrhage diagnoses. This plot displays the age-specific incidence of (**A**) assault-related and (**B**) fall-related injury leading to primary orbital hemorrhage from 2006 to 2018.

Discussion

Orbital hemorrhage is a potentially devastating ophthalmic emergency that may require urgent intervention in the rare case of compartment syndrome. Despite its clinical importance, there is little data assessing national epidemiologic trends in OH. Our study used a nationally representative sample to investigate incidence, demographics, clinical characteristics, and economic burden associated with OHs presenting to US EDs from 2006 to 2018. Key findings were a rising incidence of OH, particularly those caused by fall and assault, as well as substantial increases in inflation-adjusted ED costs. A minority of patients with primary OH had secondary injuries, required canthotomy/cantholysis, or warranted hospital admission.

Although incidence and cost of OH visits increased substantially between 2006 and 2018, the greatest increase occurred from 2015 to 2016. This sharp increase coincided with the switch from ICD-9 to ICD-10, which may have induced a shift toward more complete coding, possibly because of greater number and detail of codes in the ICD-10.[12] Moreover, seasonality of OH cases, though not statistically significant in our investigation, is consistent with lower volumes of traumatic injuries[13] and orbital fractures[10] observed in winter months.

Mean cost per primary OH ED visit increased fairly steadily over the study period, exceeding the approximately 68% increase in overall national health expenditures over the same period.[14] This relatively greater increase in spending on OH could partly stem from frequent use of imaging in trauma evaluations. The temporary spike in cost per visit in 2010 did not coincide with any major shifts in coding or treatment and remains unexplained. Conversion to ICD-10 did not acutely affect payment per ED visit, consistent with a prior report analyzing effects of this conversion on an outpatient ophthalmology practice.[15]

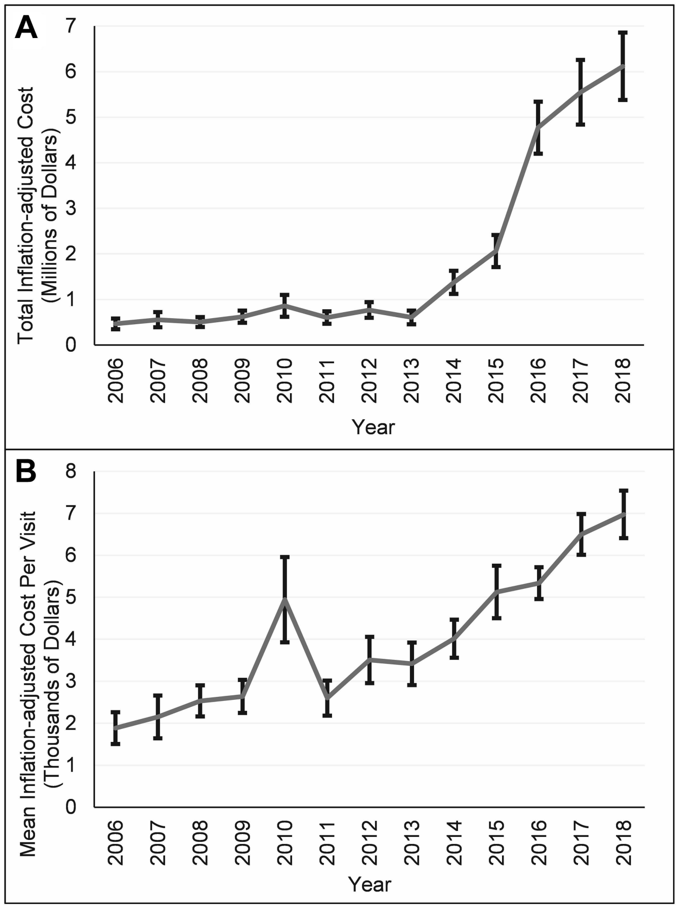

Figure 3 Emergency department costs related to orbital hemorrhage diagnoses. (**A**) This plot displays the estimated total annual inflation-adjusted emergency department costs for visits with a primary orbital hemorrhage diagnosis from 2006 to 2018 (with standard error). (**B**) This plot displays the mean per-visit inflation-adjusted ED cost for visits with a primary OH diagnosis from 2006 to 2018 (with standard error).

The distribution of demographics and mechanisms of injury in our analysis of OH in the NEDS was consistent with data previously reported in patients with OH and orbital fractures.[5,6,9,16] In particular, a recent analysis of orbital floor fractures found a high rate of orbital trauma from falls in the elderly, particularly elderly women, and we noted a similar trend.[10] This trend is consistent with the higher rate of non-fatal, unintentional falls in elderly women compared to elderly men.[17] We also observed a precipitous increase in fall- and assault-related primary OHs. The increase in fall-related primary OHs began prior to conversion from ICD-9 to ICD-10 and was 17 times higher than the 2-fold increase in fall-related orbital floor fractures from 2006 to 2017 noted by Iftikhar et al.[10] The rise in fall-related OH was spearheaded by the elderly, though this increase is only partially accounted for by the 34% increase in the US elderly population from 2007 to 2017.[18] Fall-related injury, therefore, represents an increasing threat to the elderly,[19] perhaps because of increasing lifespans[20] and more active lifestyles.[21] Comorbid diabetes, heart failure, and/or systemic hypotension in elderly patients increase this threat even further, as these patients would be at a greater risk to develop ocular ischemia as a complication of orbital hemorrhage. As such, fall prevention is an area in particular need of strategies to mitigate injury. Seeing as the elderly are more likely to fall and most likely to be admitted with OH, efforts to decrease falls would cut not only ED costs, but also inpatient costs.

Though the elderly should be a major focus of fall prevention, this age group made up a variable but not growing fraction of the age-specific incidence of fall-related OH throughout the study. Therefore, these injuries are increasing for other age groups as well. Also quite concerning about the rate of increase of fall-related OH is how dramatically it outpaced the rate of increase in incidence of falls in general (only 7%) during the study period, which may be related to known increases in anticoagulant use leading to increased severity of bleeding injuries.[22,23] Increasing anticoagulant use

Table 2 Risk Factors Associated with Admission in Primary Orbital Hemorrhage

Characteristic	Admitted[a] (N = 533) n (%)	Univariate Regression		Multivariate Regression	
		Odds Ratio (95% CI)	p	Odds Ratio (95% CI)	p
Age					
Children	35 (6.5)	Reference	–	Reference	–
Adolescent	36 (6.8)	1.30 (0.41–4.14)	0.66	1.06 (0.31–3.55)	0.929
Young Adult	106 (19.9)	1.29 (0.50–3.32)	0.59	1.05 (0.37–2.98)	0.927
Adult	121 (22.7)	1.56 (0.59–4.10)	0.37	1.16 (0.39–3.47)	0.794
Elderly	235 (44.0)	2.03 (0.82–5.02)	0.12	1.7 (0.52–5.58)	0.379
Sex					
Female	222 (41.6)	0.72 (0.49–1.05)	0.089	0.71 (0.44–1.14)	0.152
Male	312 (58.4)	Reference	–	Reference	–
Primary Expected Payer					
Medicare	218 (41.3)	Reference	–	Reference	–
Medicaid	102 (19.3)	0.85 (0.50–1.46)	0.56	1.31 (0.51–3.34)	0.576
Private Insurance	128 (24.3)	0.76 (0.47–1.24)	0.28	0.85 (0.41–1.79)	0.676
Self-Pay	50 (9.4)	0.54 (0.27–1.07)	0.078	0.67 (0.23–1.96)	0.463
No Charge	–[b]	0.64 (0.07–5.73)	0.69	0.83 (0.06–10.9)	0.885
Other	28 (5.3)	1.03 (0.43–2.44)	0.95	1.35 (0.4–4.55)	0.625
Household Income Quartile					
First	131 (24.9)	Reference	–	Reference	–
Second	118 (22.4)	1.09 (0.62–1.93)	0.77	1.11 (0.56–2.19)	0.773
Third	158 (30.0)	1.70 (1.01–2.85)	0.044	1.72 (0.97–3.04)	0.063
Fourth	120 (22.7)	1.45 (0.86–2.80)	0.15	1.11 (0.52–2.35)	0.783
Hospital Region					
Northeast	122 (22.9)	Reference	–	Reference	–
Midwest	89.3 (16.7)	0.55 (0.27–1.11)	0.096	0.55 (0.23–1.31)	0.179
South	200 (37.4)	0.90 (0.50–1.63)	0.73	1.27 (0.67–2.41)	0.47
West	122 (22.9)	1.17 (0.61–2.22)	0.64	1.02 (0.47–2.21)	0.953
Hospital Teaching Status					
Metropolitan Non-teaching	137 (25.7)	Reference	–	Reference	–
Metropolitan Teaching	359 (67.2)	1.50 (0.93 −2.30)	0.10	1.41 (0.75–2.63)	0.283
Non-metropolitan	38 (7.0)	0.55 (0.24 −1.26)	0.16	0.59 (0.24–1.48)	0.262

(Continued)

Table 2 (Continued).

Characteristic	Admitted[a] (N = 533) n (%)	Univariate Regression		Multivariate Regression	
		Odds Ratio (95% CI)	p	Odds Ratio (95% CI)	p
Trauma Level Designation					
Non-Trauma	195 (42.7)	Reference	–	Reference	–
1	164 (35.9)	2.10 (1.18 −3.73)	0.012	1.67 (0.75–3.71)	0.209
2	80 (17.6)	1.82 (1.00–3.33)	0.051	1.24 (0.59–2.6)	0.568
3	17 (3.8)	0.38 (0.15–0.99)	0.048	0.33 (0.11–1.03)	0.057
Mechanisms[c]					
Motor Vehicle Accident	15 (2.9)	0.49 (0.28–2.63)	0.80	0.64 (0.16–2.65)	0.542
Fall	96 (18.0)	0.78 (0.49–1.25)	0.31	0.45 (0.25–0.82)	0.009
Assault	67 (12.5)	0.74 (0.41–1.32)	0.31	0.47 (0.21–1.07)	0.073
Objects	19 (3.5)	0.39 (0.14–1.06)	0.066	0.24 (0.07–0.76)	0.015
Other	69 (13.0)	2.50 (1.38–4.53)	0.002	0.42 (0.14–1.3)	0.132
Drug Use[c]					
Long Term Anti-Coagulant and/or Anti-Platelet Use	125 (24.0)	2.86 (1.78–4.59)	<0.001	2.75 (1.51–5.00)	0.001
Associated Ocular Injuries[c]					
Open Globe	16 (3.0)	7.3 (1.69–31.4)	0.008	11.00 (2.25–53.77)	0.003
Vitreous Hemorrhage	–[b]	9.84 (1.36–71.3)	0.024	6.39 (0.69–58.99)	0.102
Open Wound of Adnexa	27 (5.1)	2.43 (1.0–5.92)	0.050	2.52 (0.8–7.92)	0.114
Superficial Eye Injury	–[b]	0.51 (0.07–3.70)	0.51	0.85 (0.13–5.74)	0.866
Contusion of Eye/Adnexa	66 (12.4)	2.33 (1.17–4.63)	0.016	3.6 (1.48–8.73)	0.005
Orbital Fracture	18 (3.3)	2.41 (0.77–7.53)	0.13	1.54 (0.29–8.07)	0.609
Nasal Fracture	28 (5.2)	2.22 (0.77–6.39)	0.14	1.84 (0.42–8.03)	0.416
Maxillary Fracture	–[b]	18.56 (1.66 −207.60)	0.018	23.51 (1.92–287.88)	0.013
Low Vision	43 (8.1)	5.95 (2.54–13.93)	<0.001	3.95 (1.34–11.66)	0.013
Optic Neuropathy	–[b]	8.36 (0.52–134.94)	0.134	–[d]	–[d]
Diplopia	27 (5.1)	8.79 (2.71–28.45)	<0.001	23.74 (6.4–88.11)	<0.001
Orbital Edema	–[b]	4.26 (0.40–46.36)	0.230	–[d]	–[d]
Orbital Cellulitis	16 (3.0)	–[e]	–[e]	–[d,e]	–[d,e]

Notes: [a]Numbers and percentages in each category may not sum to the same total or to 100%, respectively, due to extrapolation from a sample (National Emergency Department Sample) and rounding error; [b]10 or fewer patients reported in this category, number excluded to preserve anonymity of data; [c]reference is patients without this mechanism/associated injury/factor; [d]omitted from multivariate regression due to collinearity; [e]all patients with a primary orbital hemorrhage diagnosis and secondary orbital cellulitis diagnosis were admitted.
Abbreviation: CI, confidence interval.

may also at least in part explain the much greater increase in fall-related OHs than fractures, as mentioned above. Many investigators have examined possible interventions to reduce falls, including vitamin D supplementation,[24] exercise with or without additional education or martial arts training,[25,26] interdisciplinary assessment and referral,[27] environmental modification,[28] addressing physical issues (vision,[29] foot care[30]), and dedicated medication review.[31] These methods have individually demonstrated efficacy, but results in meta-analyses are mixed.[32,33] Studies on fall prevention are also far from standardized, which remains an area for much needed improvement in future investigations.

Otherwise, assault as an etiology of OH increased nearly 7-fold in incidence from 2006 to 2018, which was out of proportion to changes in assault incidence noted in the literature[34,35] and estimated from the NEDS database (22% decrease) over the same period. This disparity may suggest that even if assaults are decreasing, at least a subset of these are becoming more violent. However, increased incidence could otherwise be an artifact of a known increased use of CT imaging in the ED[36] or an artifact of more complete coding. As with falls, many groups have examined different programs to reduce violence, especially among youth. Effective methods have included mentorship;[37] information sharing programs;[38] brief hospital-based interventions;[39] case management;[40] and pre-school programs providing family support and education.[41] Though there is no consensus currently on the best method to prevent youth violence, it appears that more effective strategies in general involve various stakeholders, including youth, community, school, family, etc.[42] One group has also demonstrated the likely cost-effectiveness of a hospital-based intervention program, which when combined with our results provides quite an impetus for broad initiation of effective prevention strategies.[43]

Regarding hospital admission, patients with long-term anticoagulant/antiplatelet use were significantly more likely to be admitted, perhaps because of more severe bleeding, which aligns with past reports of similar rate of bleeding injury for patients regardless of anticoagulant status but a greater mortality from bleeding in the anticoagulated.[22] This trend reinforces the importance of fall prevention to decrease healthcare costs, especially as the use of oral anticoagulants has increased.[22] Subjects on oral anticoagulants also run an additional risk for prolonged duration of a compartment syndrome, should this severe complication arise, as active orbital bleeding may not stop. The risk of repeat falls should be weighed against the risk of stroke when deciding to continue these medications after a fall,[22] and in patients where novel anticoagulant use is clinically appropriate, use of proper doses of dabigatran or apixaban has demonstrated a possibly lower risk for intracranial hemorrhage than warfarin and should be considered.[44] Furthermore, certain concomitant injuries were associated with greater odds of admission, which is not surprising as a more severe mechanism necessitating a higher level of care is likely to cause other injuries than just OH. Fall- and object-related primary OHs were less likely to be admitted, which may be the case because patients who fell or were injured by objects in a severe enough manner to be admitted also had other more severe diagnoses than OH that were instead coded as the primary diagnosis.

Moreover, lateral canthotomy was coded at an overall low but variable rate. Prior work has suggested that orbital hemorrhage occurs relatively infrequently, at a rate of 0.45–3.6% in orbital fracture/trauma,[3,5,6] of which only a fraction lead to compartment syndrome. As such, it is not surprising that our observed rate of lateral canthotomy is rather low. However, the possibility for underestimation exists in cases in which the anatomic cause of the hemorrhage (for instance, facial fracture) or a more serious nearby injury takes precedence as the primary diagnosis. Regardless, lateral canthotomy significantly increased odds of admission, consistent with greater injury severity one would expect to lead to vision-threatening hemorrhage.

In conclusion, we characterized demographics, cost, and inpatient admission trends in patients presenting to EDs across the US with OH diagnoses, which though it was retrospective allowed for a larger and more broadly representative sample than could likely be organized prospectively on a national level. Strengths of our study include our use of a nationally representative sample over more than a decade and inclusion of both primary and secondary OH diagnoses. Our study is limited by the potential for coding errors or omissions, which could limit our identification of all OH cases. Also, the coding artifact of the ICD-9 to ICD-10 transition is not insignificant, but the increase in orbital hemorrhage incidence over the study period had begun even before this transition and was far more than seen, for instance, with orbital fractures in another examination of the NEDS.[10] As such, our conclusions do not appear to be critically limited by coding artifact, and our finding of a rising prevalence of OH emphasizes the continued importance of recognition and treatment of this entity by ophthalmologists and emergency medicine physicians alike. The notable increases in fall- and assault-related OHs, along with exponentially rising costs, further inform public health efforts for the mitigation of facial trauma.

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Disclosure

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