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Characteristics of ocular trauma in the United States

Características de trauma ocular nos Estados Unidos

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ABSTRACT | Purpose: We aimed to study the characteristics of ocular trauma, an important but largely preventable global cause of blindness, in the United States. **Methods:** Retrospective chart review of the National Trauma Data Bank (2008-2014) was performed. All patients with ocular trauma were identified using ICD-9CM codes. The collected data were statistically analyzed with student's t-test, Chi-squared test, and logistic regression analysis performed using the SPSS software. The significance was set at $p<0.05$. **Results:** It was found that 316,485 (5.93%) of the 5,336,575 admitted trauma patients had ocular injuries. Their mean (SD) age was 41.8 (23) years, and most of them were men (69.4%). Race/ethnicity distribution was White 66.1%, Black 15.1%, and Hispanic 12.3%. The common injuries were orbital 39.5% and eye/adnexa contusions 34%. Associated traumatic brain injury was present in 58.2%. The frequent mechanisms were falls 25.5%, motor vehicle accident--occupant 21.8%, and struck by/against 17.6%. Patients <21 years of age had higher odds of cut/pierce injuries (OR=3.29, 95%CI=3.07-3.51) than the other age groups, those aged 21-64 years had higher odds of motor vehicle accident-cyclist (OR=4.95, 95%CI=4.71-5.19), and those >65 years had higher odds of falls (OR=16.75, 95%CI=16.39-17.12); $p<0.001$. The Blacks had a greater likelihood of firearm injuries (OR=3.24, 95%CI=3.10-3.39) than the other racial/ethnic groups, the Hispanics experienced more of cut/pierce injuries (OR=2.01, 95%CI=1.85-2.18), and the Whites experienced more of falls (OR=2.3, 95%CI=2.3-2.4); $p<0.001$. The Blacks (OR=3.41, 95%CI=3.34-3.48) and Hispanics (OR=1.75, 95%CI=1.71-1.79) mostly suffered assaults, while the Whites suffered unintentional injuries (OR=2.78 95%CI=2.74-2.84); $p<0.001$. Optic nerve/visual pathway injuries had the greatest association with very severe injury severity scores (OR=3.27, 95%CI=3.05-3.49) and severe Glasgow Coma Scores (OR=3.30, 95%CI=3.08-3.54); $p<0.001$. The mortality rate was 3.9%. **Conclusions**: Male preponderance and falls, motor vehicle accident-occupant, and struck by/against mechanisms agree with the previous reports. The identified demographic patterns underscore the need to develop group-specific preventive measures.

Keywords: Eye injuries; Blindness/prevention & control; United Sates/epidemiology

RESUMO | Objetivo: O trauma ocular é uma causa importante e amplamente evitável de cegueira em todo o mundo. Nosso objetivo é estudar suas características nos EUA. **Métodos:** Revisão retrospectiva do *National Trauma Data Bank* (2008-2014). Todos os pacientes com trauma ocular foram identificados com códigos CID-9CM. Os dados coletados foram analisados estatísticamente e o teste t de student foi utilizado. As análises qui-quadrado e de regressão logística foram realizadas com o software SPSS. A significância foi estabelecida em $p<0,05$. **Resultados:** 316.485 (5,93%) de 5.336.575 pacientes internados com trauma, apresentaram lesões oculares. A média (DP) de idade foi de 41,8 (23) anos. A maioria era do sexo masculino (69,4%). A distribuição raça/etnia foi branca: 66,1%, negra; 15,1% e hispânica: 12,3%. As lesões comuns foram orbitárias: 39,5% e contusões dos olhos/anexos: 34%. A maioria (58,2%) teve lesão cerebral traumática. Os mecanismos frequentes foram: quedas: 25,5%, acidente com veículos motorizados: 21,8% e acidentes atingidos por algo/contra algo: 17,6%. Os pacientes <21 anos apresentaram chance aumentada de lesões com corte/perfuração (RC=3,29; IC95% = 3,07-3,51) do que outras faixas etárias, aqueles entre 21-64 anos responderam por acidente automobilístico-ciclista: (RC=4,95; IC95% = 4,71-5,19) e aqueles > 65 anos foram vítimas de quedas (RC=16,75; IC 95% = 16,39-17,12); $p<0,001$. Os negros apresentaram maior probabilidade de lesões por arma de fogo (RC=3,24; IC95% =

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3,10-3,39) do que outras raças/etnias e os hispânicos tiveram mais lesões de corte/perfuração (RC=2,01; IC95%= 1,85-2,18) enquanto os brancos tiveram mais quedas: (RC=2,3; IC95%= 2,3-2,4); p<0,001. Os negros (RC=3,41; IC95% = 3,34-3,48) e os hispânicos (RC=1,75; IC95% = 1,71-1,79) sofreram principalmente agressões e os brancos tiveram lesões não intencionais (RC=2,78; IC95% 2,74-2,84); p<0,001. Lesões do nervo óptico/via visual apresentaram maior associação com escore de gravidade de lesão muito grave (RC=3,27; IC95%= 3,05-3,49) e escores graves de Coma de Glasgow (RC=3,30; IC95%= 3,08-3,54); p<0,001. A taxa de mortalidade foi de 3,9%. **Conclusões:** Houve preponderância masculina a quedas, a acidentes com veículo motorizado atingidos por algo/contra algo conforme os relatos anteriores. Os padrões demográficos identificados realçam a necessidade de desenvolver medidas de prevenção específicas para os diferentes grupos.

Descritores: Traumatismo ocular; Cegueira/prevenção & controle; Estados Unidos/epidemiologia

INTRODUCTION

Globally, ocular trauma is a major cause of unilateral blindness and visual impairment[1-3]. Prevent Blindness America estimated the total economic burden of visual impairment to be $139 billion (2011)[4], and approximately 2.4 million annual US emergency department visits are related to ocular injuries[5]. Analyzing the contributing factors of ocular trauma are likely to be beneficial in developing preventive measures[3,6].

Ocular trauma data are region specific, and hence, interventions need to be appropriately tailored. Differences may result from regional occupations and activities/exposures such as agriculture[7,8], construction[8], or exposure to firecrackers in China[9], outdoor activities in the Mediterranean[10], and assaults in urban areas[11,12]. Previous epidemiological studies have identified the patient characteristics and mechanisms of injury associated with blindness and visual impairment[3,6,13]. While studies in the US have focused on inpatient populations[14], others have concentrated on ocular injuries resulting in permanent visual impairment[3,6,15] or have studied small populations[1,16]. Studies utilizing large databases have included patients presenting with ocular injuries to emergency department (ED)[5] and outpatient settings[13]; however, few have used a large database to evaluate ocular trauma in the setting of the major trauma admissions[17]. To this end, this study made use of the National Trauma Data Bank (NTDB), which contains the largest collection of trauma data in the United States and is under the auspices of the American College of Surgeons[18]. Ocular trauma is a significant cause of morbidity, and can result in lifelong disabilities that profoundly impact psychosocial development, employment potential, and independence[19,20]. Analysis of a large sample could help identify at-risk demographic groups and specific settings for injuries. Such information would be helpful in formulating policies aimed at preventing future ocular trauma.

METHODS

This retrospective database-sourced study used de-identified data from the NTDB (2008-2014) following approval by the Institutional Review Board of Albert Einstein College of Medicine. Patients with ocular trauma were identified with reference to the Internal Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). The included codes were as follows: open wound of ocular adnexa (870.0, 870.1, 870.2, 870.3, 870.4, 870.8, 870.9), open wound of eyeball (871.0, 871.1, 871.2, 871.3, 871.4, 871.5, 871.6, 871.7, 871.9), superficial injury (918.0, 918.2, 918.9), contusion of eye and adnexa (921.0, 921.1, 921.2, 921.3, 921.9, 364.41, 364.0, 364.3), foreign body on external eye (930.0, 930.1, 930.2, 930.8, 930.9), intraocular foreign body (360.59), burn confined to eye and adnexa (940.0, 940.1, 940.2, 940.3, 940.4, 940.5, 940.9), orbital injury (802.6, 802.7, 802.8, 802.9, 376.32, 376.33), injury to optic nerve and pathways (950.0, 950.1, 950.2, 950.3, 950.9), injury to other associated cranial nerves-III, IV, V, VI, VII, and shaken baby - (951.0, 951.1, 951.2, 951.3, 951.4, 951.9, 995.55), retinal injuries (362.81, 921.3, 361.00-361.33, 361.10, 363.63), vitreous hemorrhage (379.23), avulsion of globe (871.3), and hyphema (364.41). The mechanisms and circumstances of trauma were categorized using the following E codes: railway accidents (E800-E807), motor vehicle (E810-E29), water transport accidents (E830) air/space transport accidents (E840-E845), vehicle accidents not elsewhere classifiable (E846-E848), accidental poisoning (E850-E858, E860-E869), during surgical and medical care (E860-E876, E878-E879), accidental falls (E880-E888), other accidents (E890-929), drugs (E930-E949), self-inflicted or suicide (E950-E959), inflicted by other persons or assault (E960-E969), legal intervention (E970-E978), terrorism (E979), undetermined (E980-E989), and operations of war (E990-E999). Supplemental E codes were used to determine the external circumstances. Injury Severity Scores (ISS) and Glasgow Coma Scores (GCS) recorded by the ED and locations of all injuries were also documented. The ISS is a numeric stratification system that

categorizes the degree of injury severity (range:1-75) and represents a spectrum from minor injury to increased risk of death. The mortality rate was determined by detailing dispositions including, home, facility transfer, nursing home, rehabilitation, hospice, death on discharge, left against medical advice, and unknown.

Statistical analysis

The data collected included demographic information, type and mechanism of injury, intent and location, ISS, and GCS. Mean, median, and interquartile range were calculated for the continuous variables. The variables were categorized for logistic regression. The age groups were categorized into <21 years, 21-64 years, and >65 years, and the ocular injuries were categorized according to the ICD9-CM groups. Both ISS and GCS were classified according to the NTDB conventions: ISS: 1-8 (minor); 9-15 (moderate); 16-24 (severe); and >24 (very severe); GCS: 13-15 (mild traumatic brain injury [TBI]), 9-12 (moderate TBI), ≤8 (severe TBI). The association between the variables was determined using student's t-test and Chi-squared test or Fisher's exact test, as appropriate. Logistic regression analysis and determination of odds ratios and confidence intervals were performed to gauge the relative strength of the associations between the variables. The data were analyzed using SPSS software (Statistical Package for Social Science, IBM Corp, Armonk, NY), and graphs and tables were generated using Microsoft Excel (Microsoft Corp., Redmond, WA). All the *p*-values were two-tailed, and statistical significance was set at $p<0.05$.

RESULTS

It was noted that 316,485 (5.93%) of the 5,336,575 admitted patients had ocular trauma. Their mean (SD) age was 41.8 (23) years, and a large proportion (61.7%) belonged to the economically active population of 21-64 years. Men were injured more frequently (69.4%) than women (30.6%); besides, the men were younger, with a mean (SD) of 39.2 (20.5) years, when compared with the women, with a mean (SD) of 47.9 (27) years. In all the age groups, except for those >80 years of age, men outnumbered the women (Figure 1). The Whites were more frequently injured (66.1%) than the Blacks (15.1%) and "other" races (18.9%). The Hispanics constituted 12.3%. Level 1 trauma centers (38.5%) and the South (36.7%) reported the most of cases and the mean annual frequency was 45,212 (range: 37,218-52,891) (Table 1).

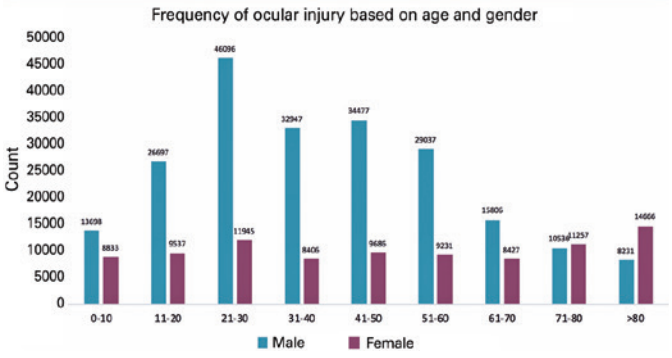
Most ocular trauma was blunt (82.5%). The intentions, in descending order, were unintentional (73.2%), assault (19.8%), and self-inflicted (1.2%). The frequent mechanisms were falls (25.5%), motor vehicle traffic-occupant (MVT-occupant) (21.8%), and struck by/against (SBA) (17.6%) (Figure 2). The most common injuries were orbital (39.5%), eye/adnexal contusions (34%), and open ocular adnexal wounds (23.4%) (Figure 3). Open eyeball wounds (9.4%) and optic nerve/pathway injuries (1.3%) were infrequent. However, associated TBI was documented in 58.2%. The mean (SD) ISS was 12.9 (10.4), and most of the patients (67.6%) sustained minor-to-moderate injuries. The mean (SD) GCS was 13.1 (3.8), and mild TBI was the largest sub-group (47.1%).

The most common locations were the street (40.8%) and home (27%). When broken into the four census regions, 36.7% injuries were reported from the South, 21.9% from the West, 20.7% from the Midwest, and 18.6% from the Northeast. In work-related injuries such as those sustained in industries, mine, or farm locations, eye protection was used in 1.8% of the cases, and in recreational activities, it was used in only 0.4% of the cases (total, 2.2%). Substance abuse was associated with 10% of the injuries. The mortality rate was 3.9% (Table 1).

Comparative analysis

Differences in demographic and regional patterns

Logistic regression analysis of the three broad age groups revealed that the youngest group (<21 years) had greater odds than the other age groups for cut/pierce mechanism of injury (OR=3.29, 95%CI=3.07-3.51), and recreational locations (OR=2.87, 95%CI=2.77-2.98); p<0.001. On the other hand, those in the age group of 21-64 years were more prone to MVT motorcyclist



Most ocular injuries occurred in the 21-64-year-old age group and men outnumbered women in all groups, except for those aged >80 years.
Figure 1. Frequencies of Ocular Trauma by Age and Gender, NTDB (2008-2014).

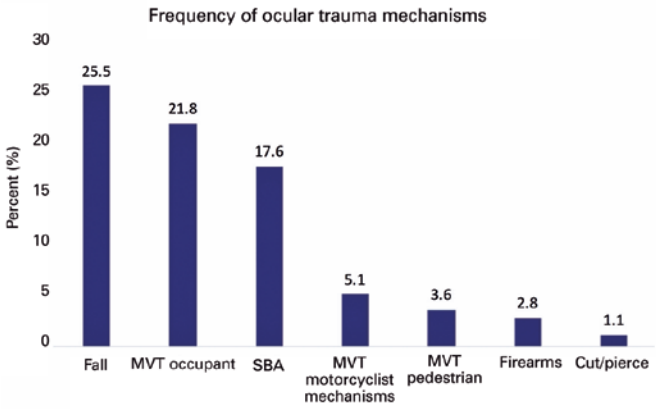
Table 1. Descriptive characteristics and demographic data of all patients with ocular trauma, National Trauma Data Bank (2008-2014)

Characteristics	Number	Percentage (%)	Characteristic	Number	Percentage (%)	Mean (SD)	Median (IQR)
Gender			Age (Years)			41.8 (23)	40.0 (23-58)
Male	219624	69.4	0-20	58765	18.6		
Female	96861	30.6	21-64	195156	61.7		
Race			>65	55592	17.6		
White	47660	15.1	Injury severity score			12.9 (10.4)	10 (5-17)
Black	209115	66.1	1-8 (Mild)	118501	37.4		
Other	59710	18.9	9-15 (Moderate)	86960	27.5		
Ethnicity			16-24 (Severe)	56576	17.9		
Hispanic	38884	12.3	>24 (Very severe)	40644	12.8		
Year of injury			Glasgow coma score			12.9 (3.7)	15.0 (13-15)
2008	37218	11.8	≤8	39517	12.5		
2009	41583	13.1	9-12	12507	4		
2010	43044	13.6	13-15	235535	74.4		
2011	44082	13.9	Unknown	28926	9.1		
2012	49041	15.5	Hospital stay (days)			6.2 (10.0)	3 (1-6)
2013	48626	15.4	1 day	79107	25		
2014	52891	16.7	2-3 days	95102	30		
Common injuries types			4-6 days	62900	19.9		
Contusion eye/adnexa	107582	34	>6 days	78809	24.9		
Orbital fractures	124887	39.5	Locations of injury				
Open wound adnexa	73963	23.4	Street	129154	40.8		
Superficial	35056	11.1	Home	85442	27		
Open wound eyeball	29905	9.4	Public building	17323	5.5		
Optic nerve/Visual pathway	4045	1.3	Industry	6444	2		
Related cranial nerves (III, IV, V, VI, VII and shaken baby)	7023	2.2	Recreation	12155	3.8		
			Residential institution	10947	3.5		
Traumatic brain injury	184124	58.2	Farm	1753	0.6		
Intention of injury			Mine	162	0.1		
Unintentional	231638	73.2	Other	15897	5		
Assault	62595	19.8	Unspecified/Unknown	37208	11.8		
Self-inflicted	3955	1.2	Region in USA				
Undetermined	1496	0.5	Midwest	65591	20.7		
Unknown	16675	5.3	Northeast	58868	18.6		
Mechanisms			South	116131	36.7		
Falls	80678	25.5	West	69270	21.9		
MVT-occupant	68966	21.8	Not applicable	1257	0.4		
Struck by/against	55580	17.6	Unknown	5368	1.7		
MVT motorcyclist	16148	5.1	Level of trauma center				
MVT pedestrian	11500	3.6	Level 1	121714	38.5		
Other Transport	8715	2.8	Level 2	58311	18.4		
Firearms	3587	1.1	Level 3	6557	2.1		
Cut/peirce	14431	4.6	Level 4	654	0.2		
Pedal cyclist	3237	1	Not Applicable	129249	40.8		
Hot object	1396	0.4	Eye Protection - Work	148 (of 8359)	1.8		
Nature/environment	1472	0.5	Eye Protection - Recreation	46 (of 12155)	0.4		
Other	50,775	16.0	Substance abuse (Alcohol/Drugs)	31,604	9.98		
Unknown	16675	5.3					
Type of injury			Mortality	12233	3.9		
Penetrating	12361	3.9					
Blunt	261186	82.5					
Other	26263	8.3					
Unknown	16675	5.3					

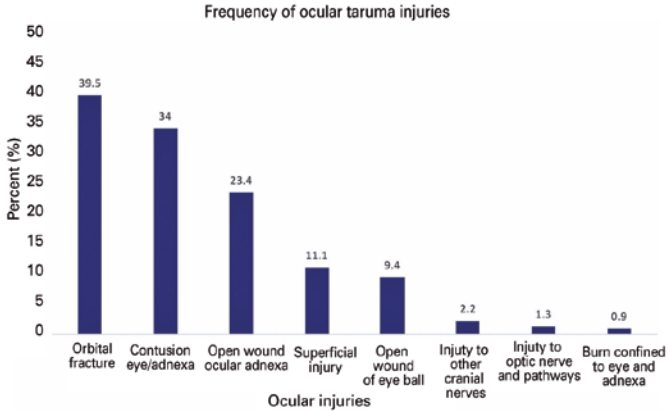
N/A= not applicable; SD= standard deviation; IQR= interquartile range.

injuries (OR=4.95, 95%CI=4.71-5.19) and industrial locations (OR=6.27, 95%CI=5.76-6.83); p<0.001. The elderly (>65 years) had the greatest odds of falling (OR=16.75, 95%CI=16.4-17.12) and sustaining injury in residential institutions (OR=4.57, 95%CI=4.38-4.76) and home locations (OR=3.80, 95%CI=3.73-3.88); p<0.001) (Figure 4A). The intentions varied with age; those in the 21-64 age group had greater odds of assault (OR=3.50, 95%CI=3.43-3.58), while those in the <21 (OR=1.37, 95%CI=1.34-1.40) and >65 age groups (OR=8.84, 95%CI=8.48-9.22) had the greatest odds of unintentional injury; p<0.001.

Men had greater odds of SBA injuries (OR=3.38, 95%CI=3.94-3.47) and industrial location (OR=7.87, 95%CI=7.06-8.77), while women had greater odds of sustaining falls (OR=2.94, 95%CI=2.89-2.99) and being injured at home (OR=2.07, 95%CI=2.03-2.10);



Frequent mechanisms were falls, MVT-occupant and stuck by or against injuries. MVT= motor vehicle traffic; SBA= struck by or against.
Figure 2. Mechanisms of Ocular Trauma, NTDB (2008-2014).



Common of ocular injuries were orbital injuries, contusions of the eye or adnexa, and open wound ocular adnexa.
Figure 3. Types of Ocular Injuries, NTDB (2008-2014).

p<0.001. Men were most likely to suffer assault injuries (OR=3.05, 95%CI=2.98-3.12), and women were most likely to suffer unintentional injuries (OR=3.02, 95%CI=2.95-3.08); p<0.001.

Analysis based on race/ethnicity revealed that the Blacks were more likely to sustain injury from firearms (OR=3.24, 95%CI=3.1-3.39), and in the streets (OR=1.11, 95%CI=1.08-1.13); p<0.001. In contrast, the Whites had greater odds of falls (OR=2.32, 95%CI=2.28-2.37; p<0.001). Although the Whites had the greatest odds of farm location (OR=3.67, 95%CI=3.19-4.24; p<0.001) when compared with other races/ethnicities, they also had higher odds of mines, home, recreation, and residential institution locations than the Blacks and Hispanics. The Hispanics had the greatest odds of cut/pierce injuries (OR=2.01, 95%CI=1.85-2.18) and industrial locations (OR=2.25, 95%CI=2.12-2.38); p<0.001, (Figure 4B). With respect to intentions, the Whites were most likely to be injured unintentionally (OR=2.79, 95%CI=2.74-2.84), while the Blacks (OR=3.41, 95%CI=3.34-3.48) and Hispanics (OR=1.75, 95%CI=1.71-1.8) were most likely to face assault injuries; p<0.001. The Whites suffered more from self-inflicted injuries than those from other races/ethnicities (OR=1.74, 95%CI=1.61-1.87; p<0.001).

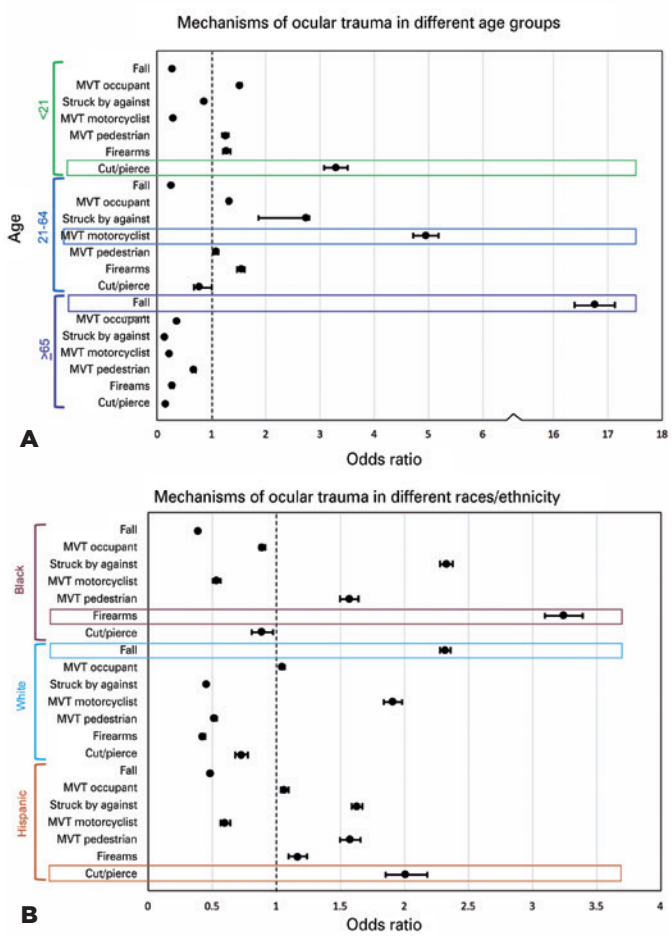
Of the 31,604 cases of substance abuse (alcohol/drugs)-associated injuries, most were men (78.7%), Whites (61.4%), in the 21-64 age group (83.9%), and unintentional trauma (63.9%). For the entire group, substance abuse was more associated with SBA (OR=1.64, 95%CI=1.55-1.75; p<0.001) than other injuries. However, the association with mechanisms differed between the demographic groups. For the groups most associated with substance abuse, men were more commonly injured by MVT-occupant (OR=1.39, 95%CI=1.33-1.45; p<0.001) than other mechanisms, the 21-64 age group by MVT-pedestrian (OR=1.40, 95%CI=1.29-1.53; p<0.001), and Whites by MVT-motorcycling trauma (OR=1.89, 95%CI=1.76-2.02; p<0.001).

The patients from the Northeast had greater odds of falls (OR=1.99, 95%CI=1.95-2.03), the Midwest, SBA (OR=1.07, 95%CI=1.05-1.10), the South, MVT-occupant (OR=1.46; 95%CI=1.43-1.48), and the West, MVT-pedestrian (OR=1.53, 95%CI=1.47-1.6); p<0.001. Additionally, firearm injuries were most likely to occur in the South (OR=1.3; 95%CI=1.24-1.36; p<0.001), and in this region, the Whites had a greater likelihood of firearm injuries than any other race/ethnic group (OR=1.09; 95%CI=1.0-1.19; p=0.05).

Severity of ocular trauma

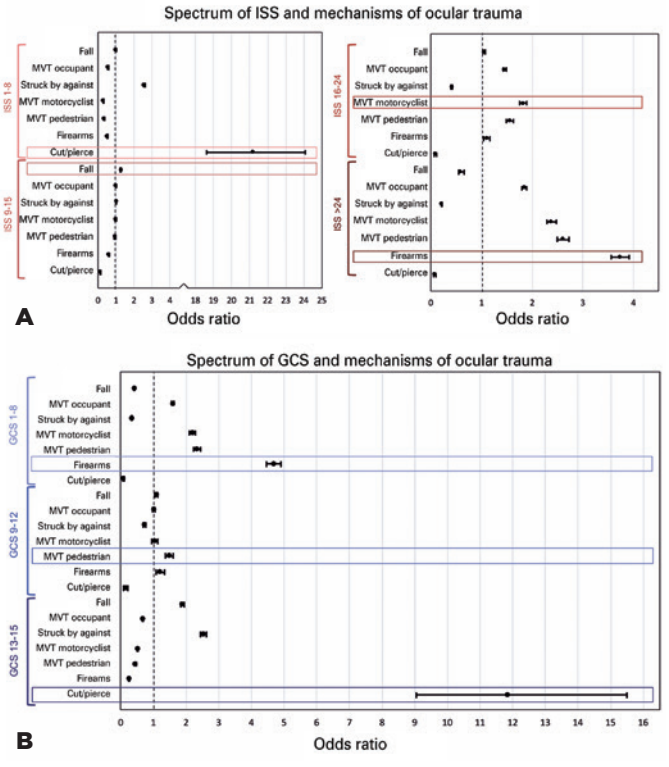
The mechanisms with the highest odds of very severe injury severity (ISS) were firearms (OR=3.73, 95%CI=3.56-3.91), followed by MVT-pedestrian (OR=2.61, 95%CI=2.49-2.72) and MVT motorcyclist (OR=2.38, 95%CI=2.29-2.47); p<0.001. Those with the lowest ISS were cut/pierce (OR=21.83, 95%CI=18.63-21.09) and SBA (OR=2.57, 95%CI=2.52-2.62); p<0.001. Although pedal cyclists had the greatest odds of sustaining TBI (OR=2.13, 95%CI=2.01-2.25; p<0.001), when broken down to the levels of TBI as reflected by the GCS, the mechanisms were different. Firearms (OR=4.77, 95%CI=4.47-4.89) and MVT-pedestrian (OR=2.33, 95%CI=2.23-2.43) had the greatest odds of severe TBI. Like ISS, cut/pierce (OR=11.84, 95%CI=9.04-15.49) and SBA (OR=2.53, 95%CI=2.45-2.61) had the greatest odds of mild TBI (Figure 5).

Burns confined to the eye and adnexa were most associated with the lowest ISS (OR=6.14, 95%CI=5.61-6.72; p<0.001). Open wounds of the adnexa (OR=1.36, 95%CI=1.33-1.39) and open globe injuries (OR=1.29, 95%CI=1.25-1.34) were associated with the mildest TBI; p<0.001. However, optic nerve/visual pathway injuries had the greatest odds of very severe ISS (OR=3.27, 95%CI=3.05-3.49) and severe TBI (OR=3.30, 95%CI=3.08-3.54); *p*<0.001. Self-inflicted injuries had the greatest odds of TBI (OR=2.39, 95%CI=2.22-2.58; p<0.001). These patients had the greatest odds of dying from their injuries (OR=7.66, 95%CI=7.09-8.27; p<0.001).



(A) Falls were the most common mechanism and most likely to occur in the oldest age group, while MVT-cyclist and struck by or against most likely to occur in the 21-64-year-old age group and cut/pierce in the youngest group, when compared to the other groups. (B) Falls were the most likely to occur in white patients, firearms in black patients, and cut/pierce injuries in Hispanic patients.

Figure 4. Summary of Regression Analysis of Mechanisms Association with (A) Age group and (B) Race/Ethnicity, NTDB (2008-2014).



(A) Cut/pierce injuries were most associated with mild injury severity and firearms, the most severe injury severity. (B) Similarly, cut/pierce injuries were most associated with the mild levels of TBI and firearms, the most severe level of TBI. ISS= injury severity score; GCS= Glasgow coma score; TBI= traumatic brain injury.

Figure 5. Summary of Regression Analysis of Mechanisms Association with (A) Injury Severity Score and (B) Glasgow Coma Score, NTDB (2008-2014).

DISCUSSION

Approximately 6% of the admitted trauma patients had ocular trauma. Most patients were young, men, Whites, and from the South. The common mechanisms, in descending order, were falls, MVT-occupant, and SBA. The common locations were the street and home. The frequent injuries were orbital and eye/adnexal contusions. Although most were considered mild, the majority of injuries were associated with TBI. Orbital injuries were most associated with severe ISS, while optic nerve/visual pathway injuries were most associated with very severe ISS and severe GCS.

The mechanisms, locations, intentions, and levels of ISS and GCS varied with age, gender, and race/ethnicity. Those in the youngest age group (<21 years) had greater odds of sustaining minor injuries, cut/pierce mechanisms, and at home location. In contrast, the working age group (21-64 years) had greater odds of very severe injuries, MVT motorcyclist mechanism, and the street location. Finally, the elderly (>65 years) sustained moderate and severe injuries, falls mechanism and home location. These differences were also noted between races/ethnicities. The Blacks suffered more from firearm injuries and street location, Whites from falls and farming location, and Hispanics from cut/pierce injuries and industry location when compared with other races/ethnicities. With respect to intention, the Blacks and Hispanics were most likely to be assaulted, and the Whites were most likely to suffer unintentional injury. Our findings regarding the mechanisms and intentions agree with the results from previous studies, which had also noted propensities to assault among the Hispanics and Blacks[13,21-23].

Previous studies have evaluated the types of injuries and mechanisms of ocular trauma and have related them to demographic details[3,5,6,17,23]. Scruggs et al.[17] used weighted NTDB (National Sample Program) data to evaluate 28,340 cases. Similar to our findings, they also identified that the most common injuries were orbital; a young age and male preponderance were also established. However, the mean age was younger (38.2 years), and the most frequent mechanisms were related to motor vehicles. Falls were most frequent in our study. Although these disparate findings might have resulted from the use of different databases, they may also indicate that fall-related injuries are increasing in the aging US population[23]. Haring et al.[5], using a different weighted database (Nationwide ED Sample, NEDS), evaluated 4,317,164 cases and found a similar male preponderance but a younger age (33.8 years) than our study (41.8 years). Furthermore, their most common mechanisms were foreign bodies, followed by falls. Again, the difference from our findings can be attributed to the variations in sourcing the data and in the populations. Haring's study of ED patients included conditions that are routinely dealt with on an outpatient basis, while our study focused on admitted major trauma patients. Using logistic regression, they found that men, older patients, SBA injuries, and multiple injuries were most associated with inpatient admission[5].

The analyses performed in this study revealed that locations were also associated with demographic groups. May et al.[3], in their study of serious eye injuries using the United States Eye Injury Registry, found that the most common location of injury was the home, followed by industry. Streets and recreation/sport tied for the third place. This study determined that the street was the most common location, followed by home and public buildings. May's study identified that the street accounted for only 9%, while our study found motor vehicle/cycle or pedestrian accidents accounted for about 40% of the injuries. Their finding of poor compliance with regulations regarding eye-protective glasses in the workplace and recreation (2%) agreed well with our finding of 2.2% compliance. This observation has implications for focusing on campaigns that promote eye safety compliance in the workplace and during sports activities.

Our study used regression models to elucidate the patterns of association between mechanisms, locations, intent, severity indices (ISS and GCS), and demographics. To our knowledge, these have previously not been reported in largescale ocular trauma studies (Figures 4 and 5). The mechanisms of ocular injury have been analyzed in earlier studies using frequencies[5,17,23]. The frequencies of intent of ocular injury have been reported previously[5,6]; however, our analyses unearthed demographic differences in the intentions of injury. Assaults were more likely in the working age group (21-64 years) and Blacks and Hispanics. Unintentional injuries were most likely in Whites and in the youngest (<21 years) and oldest (>65 years) age groups. Self-inflicted injuries were most likely in Whites and were most commonly associated with optic nerve/visual pathway injuries, very severe ISS, and severe TBI. Consequently, the Whites suffered the highest inpatient mortality.

This study has several strengths, not the least of which is its scope. We identified the at-risks groups and the demographically associated circumstances of their

injuries, including mechanisms, substance abuse relations, locations, and intention, which could be used to create guidelines for preventive strategies. TBI is known to be associated with ocular trauma[24-27], which was confirmed in this study. The concurrence of TBI may manifest in multiple ways and contribute to short- and long-term disability. These complications must be considered during post-discharge multidisciplinary care and rehabilitation. Additionally, we considered the impact of intention; few reports have evaluated the impact of intention on the severity of injury using ISS and TBI and the resulting mortality. In a report of intentions in pediatric ocular injuries using the same NTDB data, Gise et al.[28] also noted a stronger association of self-inflicted injury with TBI and mortality than the other intentions. These outcomes likely reflect the associations that can be generated using similar analytical models for all trauma. Indeed, Deng et al., in their studies of firearms, related the TBI using weighted NTDB (NSP) data (2003-2012) and likewise found that self-inflicted injuries had the highest levels of TBI and ISS, and consequently, higher rates of mortality[29,30].

This study also has some limitations, the most important one being its retrospective design and database sourcing. The results can only reflect the integrity of the submitted data. Furthermore, detailed ophthalmic findings and outcomes were not available, which makes comparison with population-based reports difficult. The data used were not the weighted NTDB (NSP) and may hence represent variable annual trauma center and regional contributions. Moreover, the full scope of ocular trauma, especially minor injuries that are encountered in outpatient settings, are not represented. This issue might lead to an underestimation of the ocular trauma in the US, while focusing on patients with major injuries alone. Lastly, NTDB (2008-2014) used ICD-9CM codes, which are less precise than the current ICD-10CM codes.

This study confirmed that young and male patients were disproportionally affected by ocular trauma and most patients were in the economically active age group. We identified demographic variations in mechanisms, location, association with substance abuse, intention of injury, and association between intention and types of ocular injuries and indices of severity. An analysis of more current datasets that confirm our results could provide a foundation for the design and implementation of focused interventional measures.

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REFERENCES

1. Katz J, Tielsch JM. Lifetime prevalence of ocular injuries from the Baltimore eye survey. Arch Ophthalmol. 1993;111(11):1564-8.
2. Thylefors B. Epidemiological patterns of ocular trauma. Aust N Z J Ophthalmol. 1992;20(2):95-8.
3. May DR, Kuhn FP, Morris RE, Whitherspoon CD, Danis RP, Matthews GP, et al. The epidemiology of serious eye injuries from the United States Eye Injury Registry. Graefe's Arch Clin Exp Ophthalmol. 2000;238(2):153-7.
4. Wittenborn J, Rein D. Cost of vision problemas: the economic burden of vision loss and eye disorders in the United States. [Internet]. Chicago: University of Chicago; 2013.[cited 2018 Nov 27]. Available from: https://www.preventblindness.org/sites/default/files/national/documents/Economic Burden of Vision Final Report_130611_0.pdf
5. Haring RS, Canner JK, Haider AH, Schneider EB. Ocular injury in the United States: Emergency department visits from 2006-2011. Injury. 2016;47(1):104-8.
6. Kuhn F, Morris R, Witherspoon CD, Mann L. Epidemiology of blinding trauma in the United States Eye Injury Registry. Ophthalmic Epidemiol. 2006;13(3):209-16.
7. Krishnaiah S, Nirmalan PK, Shamanna BR, Srinivas M, Rao GN, Thomas R. Ocular trauma in a rural population of southern India: The Andhra Pradesh Eye Disease Study. Ophthalmology. 2006;113:1159-64.
8. Khatry SK, Lewis AE, Schein OD, Thapa MD, Pradhan EK, Katz J. The epidemiology of ocular trauma in rural Nepal. Br J Ophthalmol. 2004;88(4):456-60.
9. Qi Y, Zhang FY, Peng GH, Zhu Y, Wan GM, Wang WZ, et al. Characteristics and visual outcomes of patients hospitalized for ocular trauma in central China: 2006-2011. Int J Ophthalmol. 2015;8(1):162-8.
10. Cillino S, Casuccio A, Di Pace F, Pillitteri F, Cillino G. A five--year retrospective study of the epidemiological characteristics and visual outcomes of patients hospitalized for ocular trauma in a Mediterranean area. BMC Ophthalmol. 2008;8(1):6.
11. Desai P, Morris DS, Minassian DC, MacEwen CJ. Trends in serious ocular trauma in Scotland. Eye (Lond). 2015;29(5):611-8.
12. Soliman MM, Macky TA. Pattern of ocular trauma in Egypt. Graefe's Arch Clin Exp Ophthalmol. 2008;246(2):205-12.
13. McGwin Jr G, Xie A, Owsley C. Rate of eye injury in the United States. Arch Ophthalmol. 2005;123(7):970-6.
14. Klopfer J, Tielsch JM, Vitale S, See LC, Canner JK. Ocular trauma in the United States: eye injuries resulting in hospitalization, 1984 Through 1987. Arch Ophthalmol. 1987;110(6):838-42.
15. Kuhn F, Mester V, Berta A, Morris R. [Epidemiology of serious ocular trauma. The United States Eye Injury Registry (USEIR) and the Hungarian Eye Injury Registry (HEIR)]. Ophthalmologe. 1998;95(5):332-43. German.
16. Wong TY, Klein BEK, Klein R. The prevalence and 5-year Incidence of Ocular Trauma. The Beaver Dam Eye Study. Ophthalmology. 2016;107(12):2196-202.

17. Scruggs D, Scruggs R, Stukenborg G, Netland PA, Calland JF. Ocular injuries in trauma patients: An analysis of 28,340 trauma admissions in the 2003-2007 National Trauma Data Bank National Sample Program. J Trauma Acute Care Surg. 2012;73(5):1308-12.
18. Fantus RJ, Nance ML..TDB data points: Annual report 2015: regional trauma. Bull Am Coll Surg. 2016;101(1):74-5.
19. Sherrod CE, Vitale S, Frick KD, Ramulu PY. Association of vision loss and work status in the United States. JAMA Ophthalmol. 2014;132(10):1239-42.
20. Zhang H, Huang J, Long C. Influence of psychological intervention before emergent ocular trauma surgery on patients' negative emotions. Eye Sci. 2014;29(2):74-7.
21. Chikani V, Brophy M, Vossbrink A, Blust RN, Benkert M, Salvino C, et al. Racial/Ethnic disparities in rates of traumatic injury in Arizona, 2011-2012. Public Health Rep. 2016;131(5):704-10.
22. Crutcher 2nd CL, Fannin ES, Wilson JD. Racial disparities in cranial gunshot wounds: intent and survival. J Racial Ethn Health Disparities. 2016;3(4):687-91.
23. Enderlin C, Rooker J, Ball S, Hippensteel D, Alderman J, Fisher SJ, et al. Summary of factors contributing to falls in older adults and nursing implications. Geriatr Nurs. 2015;36(5):397-406.
24. Ventura RE, Balcer LJ, Galetta SL. The neuro-ophthalmology of head trauma. Lancet Neurol. 2014 Oct; 13(10):1006-16. Comment in: Lancet Neurol. 2015;14(2):136-7; Lancet Neurol. 2015;142(2):137.
25. Chopra N, Gervasio KA, Kalosza B, Wu AY. Gun trauma and ophthalmic outcomes. Eye (Lond). 2018;32(4):687-92.
26. Gise R, Truong T, Poulsen DM, Soliman Y, Parsikia A, Mbekeani JN. Pediatric traumatic brain injury and ocular injury. J AAPOS. 2018;22(6):421-5.e3.
27. Guly CM, Guly HR, Bouamra O, Gray RH, Lecky FE. Ocular injuries in patients with major trauma. Emerg Med J. 2006;23(12):915-7.
28. Gise R, Truong T, Parsikia A, Mbekeani JN. A comparison of pediatric ocular injuries based on intention in patients admitted with trauma. BMC Ophthalmol. 2019;19(1):37.
29. Deng H, Yue JK, Winkler EA, Dhall SS, Manley GT, Tarapore PE. Adult firearm-related traumatic brain injury in United States Trauma Centers. J Neurotrauma. 2019;36(2):322-37.
30. Deng H, Yue JK, Winkler EA, Dhall SS, Manley GT, Tarapore PE. Pediatric firearm-related traumatic brain injury in United States trauma centers. J Neurosurg Pediatr. 2019:1-11.