Prevalence and risk factors associated with work-related eye injuries in Bosnia and Herzegovina

Nina Jovanovic[1,2], Corinne Peek-Asa[2], Amanda Swanton[2], Tracy Young[2], Jasmina Alajbegovic-Halimic[3], Semra Cavaljuga[4], Faruk Nisic[3]

[1]Department of Ophthalmology, Canton Hospital Zenica, Zenica, Bosnia and Herzegovina, [2]Injury Prevention Research Center (IPRC), College of Public Health, University of Iowa, Iowa City, IA, USA, [3]Eye Clinic, Clinical Center University of Sarajevo, Sarajevo, Bosnia and Herzegovina, [4]Department of Epidemiology and Biostatistics, School of Medicine, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Background: Eye injuries are a prevalent workplace injury and cause substantial disability when vision is impaired.
Objective: To examine work-relatedness of demographic, injury, and clinical characteristics of eye injuries in a large clinic in Bosnia and Herzegovina.
Methods: We performed a nine-year retrospective study of patients admitted with an eye injury to the Canton Hospital in Zenica, Bosnia and Herzeogvina. Controlling for age and sex, we used logistic regression to examine the influence of work-relatedness on patient and injury characteristics and clinical outcomes.
Results: Of 258 patients, 71 (27.5%) had work-related and 180 (69.8%) had non-work-related eye injuries. Work-related eye injury was associated with age, education, occupation, and injury type. Agricultural workers were eight times more likely to experience work-related eye injury (95%CI = 1.21–152.0) compared to manual workers. Work-relatedness of injury did not predict final visual acuity or length of hospital stay.
Conclusion: Promotion of eye safety is needed countrywide. Occupational eye protection is a priority due to the relatively proportion of eye injuries and the workplace being a relatively controlled environment.

Keywords: Occupational injury, Eye injury

Introduction

One aim of The World Health Organization's (WHO) "Right to Sight Vision 20/20" program is to prevent vision loss caused by modifiable risk factors before 2020.[1] Prevention of ocular trauma requires identifying the epidemiologic distribution and risk factors, developing and evaluating prevention steps, and disseminating effective prevention approaches. In low- and middle-income countries, a focus on cost effective prevention strategies is especially critical.

Globally, visual impairment and complete visual loss are common resulting from ocular injury. A review conducted for the WHO Program for the Prevention of Blindness estimates that 55 million eye injuries that restrict normal activity occur each year, resulting in 750,000 hospital admissions and 1.6 million cases of trauma-induced total blindness.[2] Causes of eye injury vary throughout the world. The WHO reported in 2007 that low- and middle-income countries had particularly high rates of occupational eye injuries, especially in agriculture and in cottage and unregulated industries.[3]

Bosnia and Herzegovina has a unique socioeconomic and geopolitical position within Europe as a result of conflict and the current transition to a period of socioeconomic development. Neighboring countries include highly industrialized European Union (EU) countries and countries transitioning to EU status, all of which have established modern labor laws and regulations under the supervision of EU Agencies.[4] In contrast, Bosnia and Herzegovina currently has laws and regulations from the former Yugoslavia. Although labor regulations and policies are being updated as the country develops, the majority have been in place since 1990 or before. The International Labor Organization[4] published several reports from Bosnia and Herzegovina that identified future challenges, including inactivity in policy development, high unemployment, high outbound migration, and lack of new reform or updated labor laws, and safety at work laws. According

Correspondence to: Injury Prevention Research Center (IPRC), College of Public Health, University of Iowa, Iowa City, IA, USA. Email: Corinne-peek-asa@uiowa.edu

Institutions to which the work should be attributed: Injury Prevention Research Center (IPRC), College of Public Health, University of Iowa, Iowa City, Iowa, USA; Canton Hospital Zenica, Zenica, Bosnia and Herzegovina

DOI 10.1080/10773525.2016.1243081

to the *Report on Occupational Safety and Health in the Federation of Bosnia and Herzegovina* published in 2007,[5] occupational safety and health in the Federation of Bosnia and Herzegovina is primarily regulated by the *Law on Work/Occupational Safety* and the *Law on Labor*.[6] Neither of these laws has been updated since 1990 and they date from the period of socialism. Lack of progress in occupational safety is in part due to outdated policies but is also due to the high cost of creating safe work environments. In countries with low resources, high unemployment, and high emigration of the skilled and educated workforce, governments may be challenged to prioritize safety. Knowledge about the burden of occupational injuries may be helpful in advocating for increased attention to safety.

Eye injuries, both work- and non-work-related, are a neglected area of research and prevention in Bosnia and Herzegovina. Many studies have examined ocular injuries, but no studies to our knowledge have been published from Bosnia and Herzegovina despite the high risk for decreased quality of life following visual impairment.[1–3] Surveillance and epidemiologic studies are a critical component of advocacy efforts to increase ocular trauma prevention.[7]

Given occupational exposure to eye injuries, particularly in low- and middle-income countries, the objective of the study was to conduct an epidemiological analysis of the frequency and demographic and clinical characteristics of work-related vs. non-work related eye injuries treated in the Canton Hospital Zenica. We compared demographic and clinical characteristics of work-related and non-work related eye injuries. One outcome of this work was to establish an ocular trauma registry in the hospital to provide information about ocular morbidity in Zenica–Doboj Canton. Results from the study can be used to identify the burden of eye injury, to help educate stakeholders in the impact of eye injury, and to identify priorities for eye protection programs.

Methods

Study design and population

This is a retrospective, epidemiological study of patients treated for eye injuries from 1 January 2006 through 31 December 2014 at the Canton Hospital in Zenica, Bosnia and Herzegovina, a secondary level referral center. Canton Hospital Zenica is the main health institution in the region, serving a population of 654,477 (399,485 inhabitants of Zenica Doboj Canton and 254,922 inhabitants of Central-Bosnian Canton) with a catchment area of approximately 6532 km^2. The hospital serves as the main trauma and emergency center in this region.

Subjects

Medical records of patients admitted to the Ophthalmology Service were screened for eligibility. Inclusion criteria included a diagnosis of a mechanical, chemical or physical acute eye injury, including open and closed injury of the eyeball, using the Birmingham Eye Trauma Terminology criteria and Ocular Trauma Classification Group.[8,9] Only patients whose injury required immediate hospital treatment and were admitted to the hospital were included. Children younger than four years old were excluded due to lack of initial and final visual acuity data. All patients' data were collected with adherence to the guidelines of the Declaration of Helsinki, and an IRB approval for this study was obtained from Cantonal Hospital Zenica.

Procedure

A total of 258 medical records met inclusion criteria. All 258 patients were first admitted and treated at the Cantonal Hospital Zenica. Of these patients, 11 (4.26%) needed additional treatment for posterior segment surgery (Pars Plana Vitrectomy or Foreign Intraocular Body extraction) and were transferred to Clinical Center. Sarajevo, a third Level Ocular Trauma Center. For these 11 patients, data from both hospitals were included in the study.

Eligible medical records were reviewed by the principal investigator. Study data were obtained and entered on an Initial Report Questionnaire, a modified version of the United States Eye Injury Register Initial Report.[10] Medical records often had outdated terminology (for example, penetrating injuries were misdiagnosed as perforating injuries or rupture) and limited coding of diagnosis and treatment (for example, neither International Statistical Classification of Diseases and Related Health problems were applied (ICD-10 or 9)), despite the availability of complete medical notes. Thus, individual review was necessary to provide accurate mechanism and diagnosis codes. Additionally, all patients' data received a corrected diagnosis using the Birmingham Eye Trauma Terminology and Ocular Trauma Classification System.[8,9] These data represent the first complete and modern case series of eye injuries in Bosnia and Herzegovina.

Study variables

Information collected from the medical record included the demographic variables: sex, age, level of education, occupation, employment status, and whether the injury was work-related. Age was categorized into: 4–17, 18–65, more than 65 years. Education included the categories: less that college, college and higher, students & children, and other. The "other" category includes individuals over 65 years of age who by standard policy are retired and were not asked to report an educational level. Occupations were collapsed into four main categories that were created to describe only occupations represented among the injured patients: manual workers (e.g. craftsman, driver, bricklayer, carpenter, locksmith), fire and explosion hazard workers (e.g. miner, electrician, mechanic, fireman), agricultural workers (e.g. farmer, lumberjack, forest engineer), and not working (e.g. senior, student, unemployed, housewife, child). Work was defined as any activity conducted for pay, either monetary or non-monetary (such as in exchange for specific goods or

services). Information about number of hours worked was not collected. Information regarding work-relatedness was categorized as yes or no based on an official "Occupational Injury Note" that was provided by the licensed family practitioner at the first follow-up appointment after the injury. This Occupational Injury Note was part of patient's medical record, and these data were obtained during data collection and classification for this study.

Information about the injury included: season of injury (spring, summer, fall, winter) and place of injury (industrial premises and mine; farm and forest; home; school and university; recreation and sport; street and highway; public place). Mechanism of injury was coded into five categories: *blunt force object* included blunt wooden and metal object, fall or other blunt object; *sharp force object* included nail or other sharp object; *road injuries and fire* included road accidents, firework and burn, fire and explosion; *biologic or organic material* included coal or plant and lawn material; and, *other,* which was primarily comprised of other working equipment. Information on the use of eye protection was available for work-related injuries only and was coded as yes or *no* based on information in the Occupational Injury Note. Time from injury to hospital arrival was categorized as: less than 24 h; 24–48 h; 3–6 days, 7–13 days; and 14 or more days. Length of hospital stay was categorized as 1–6 days; 7–13 days; 14–20 days; and 21 days or more.

Eye injury variables include the type of injury categorized as closed vs. open globe injuries. The Ocular Trauma Score (categories 1; 2; 3; 4; 5),[11] and the Final Visual Acuity measure (categories 1; 2; 3; 4; 5, category 0) were used to assess the severity and outcome of injury. The OTS was calculated for every patient using standard protocol of assigning an ordinal scale from one to five with one representing the least favorable visual prognosis and five the most favorable.[11] Next, the OTS score was dichotomized for the purpose of further statistical analysis. Based on clinical evaluation of the severity of the injured eye reported in the original Ocular Trauma Score study,[11] categories: one, two, and three were collapsed into category 1 (low Ocular Trauma Score), and categories four and five were collapsed into category 2 (high Ocular Trauma Score). Previous studies have used other categorizations with no standardized reporting, although the creation of these categories aligns with the concepts of high and low from previous studies.[12,13] Final Visual Acuity was assessed twice, first at the hospital release and next at the 4 or 6 month-follow-up using Snellen chart. Results were collapsed into five ordinal categories based on standards for the score: no light sense and projection; only light sense and projection (LP/HM); 1/200-19/200; 20/200-20/50; ≤20/40, but for the purpose of statistical analysis we dichotomized them into category 1 (NPL, LP/HM and 1/200-19/200) and category 2 (20/200-20/50 and more than or 20/40).[12,13]

Data analysis

Contingency tables were used to compare the frequency of demographic, injury, and clinical characteristics of patients with work-related eye injuries to those with non-work-related eye injuries. These initial comparisons included data from the entire sample of patients for whom work-relatedness was known ($n = 251$). Fisher's exact test was used to test the association between work-relatedness and all other variables ($\alpha = 0.05$).

For the remainder of the analyses, the sample was restricted to the patients that were deemed *at risk* for work-related injuries. Therefore, children and youth age less than 18 and seniors (age ≥65) were excluded because they were not of working age. This yielded a new sample of 188 patients (age 18–65). We included individuals in this age range who were categorized as unemployed because many people work in unregistered businesses. The associations between select demographic and injury characteristics, including sex, age, occupation, source of injury, and season, were tested using simple logistic regression models ($\alpha = 0.05$). First, each variable was used individually to predict work-relatedness (crude odds ratios). Next, multivariable models were used to adjust each comparison for the effects of sex and age (adjusted odds ratios). When assessing the season, the original four seasons were grouped (collapsed) into two categories (spring/summer and fall/winter). When examining occupation, housewives and unemployed categories were excluded, resulting in a sample size of 120 employed patients.

Simple logistic regression models were used to examine the association between the clinical characteristics, including Final Visual Acuity, Ocular Trauma Score, hospital admittance, and time of hospitalization with work-relatedness. Due to small numbers of cases in certain cells, the original categories were grouped into broader groupings for this analysis. FVA and OTS were dichotomized as described previously. Length of admission was categorized as 48 h and less vs. more than 48 h, and time of hospitalization had three categories (1–6 vs. 7–13 vs. 14 and more days). As above, initially each clinical variable was used individually to predict work-relatedness (crude odds ratio) and then we performed a multivariable analysis for each characteristic adjusting for age and sex (adjusted odds ratio). All analyses were performed using RStudio Version 0.99.451 (© 2009–2015 RStudio, Inc., Boston, MA).

Results

Among the 258 patients with eye injuries in the study, 71 (27.5%) were work-related, 180 (69.8%) were non-work-related, and 7 (2.7%) had unknown work status. These seven were not included in further analyses. Nearly 85% of eye injuries were among males, and a higher proportion of males (30.3%) than females (15.2%) had work-related injuries (Table 1). Eye injuries were less frequent among children aged 4 through 17 (15.5%) and older adults aged

Table 1 Demographic characteristics of eye injuries (N = 251)

	Work-related	Non-work-related	*p*-value *	Total
Demographic characteristics	*N* (%)**	*N* (%)**		*N*
Gender			0.096	
Male	66 (30.38)	152 (69.7)		218
Female	5 (15.2)	28 (84.9)		33
Age			<0.001	
4–17	0 (0.00)	40 (100.00)		40
18–65	70 (36.37)	123 (63.7)		193
65+	1 (5.6)	17 (94.4)		18
Education			<0.001	
Less than collage	58 (48.7)	61 (51.3)		119
College or higher	8 (53.3)	7 (46.7)		15
Students and children	2 (3.8)	51 (96.2)		53
Other	3 (4.8)	61 (95.3)		64
Occupation				
Manual force workers			<0.001	
Craftsman	11 (37.9)	18 (62.1)		29
Driver	9 (75.0)	3 (25.0)		12
Bricklayer	3 (60.0)	2 (40.0)		5
Other	13 (44.8)	16 (55.2)		29
Carpenter	3 (50.0)	3 (50.0)		6
Locksmith	7 (63.6)	4 (36.4)		11
Fire and explosion hazards workers				
Miner	7 (77.8)	2 (22.2)		9
Electrician	1 (33.3)	2 (66.7)		3
Mechanic	4 (40.0)	6 (60.0)		10
Agricultural workers				
Farmer/Lumberjack	8 (100.0)	0 (0.0)		8
Not working				
Senior	0 (0.0)	27 (100.0)		27
Student	2 (4.8)	40 (95.2)		42
Unemployed	3 (8.3)	33 (91.7)		36
Child	0 (0.0)	11 (100.0)		11
Housewife	0 (0.0)	13 (100.0)		13

*Fisher's exact test for testing independence between work and non-work-related groups ($\alpha = 0.05$).
**Percentages based on characteristics (row %'s).

65 and greater (7.0%) compared to adults aged 18–64 (74.8%). No injuries in children and only 5.6% of eye injuries among older adults were work-related, compared with 36.3% in adults.

Nearly half of the patients had less than a college education, and nearly half of these had work-related eye injuries. The highest proportion of work-related eye injuries was among those with more than a college education, in which 53.3% of the eye injuries were work-related. More than half of all eye injuries were work-related for the occupations of driver, bricklayer, miner, carpenter, locksmith, and farmer/lumberjack; all of the eye injuries among farmers/lumberjacks were work-related. Proportions of work-related eye injuries were significantly different for education and occupation ($p < 0.001$, Table 1).

A slightly higher but non-significant proportion of eye injuries were work-related in spring and summer (Table 2). The most common sources for eye injury were blunt wood or metal objects (22.5%), sharp objects (24.4%), other blunt objects (13.2%), and plant/lawn material (9.3%). The highest proportion of work-related injury sources was found with blunt wood or metal objects (39.6%), sharp objects (22/63%), fires (54.6%), machinery (80%), and coal (70%). More than a third of injuries occurred in the home, while farms and industrial settings each accounted for approximately one fifth of injuries. More than 95% of injuries in industrial settings were work-related (Table 2). Use of eye protection was assessed only for work-related injuries with complete data for eye protection. Just over 30% of work related eye injuries involved the use of eye protection.

Of all non-work-related injuries, 63.3% were seen in the hospital less than 24 h after injury, similar to the proportion of work-related injuries admitted within one day (73.2%, Table 3). Approximately, one fourth of all non-work-related injuries had a delay of 24–48 h between injury and arrival at the hospital. Of all patients with eye injuries, 4.4% waited more than seven days for in-hospital treatment. The association between work-relatedness and admittance time was not statistically significant. Length of hospitalization was almost equally distributed among work and non-work-related eye injuries, with insignificant *p*-value. Closed (49.3%) and open globe injuries (50.7%) were similarly frequent within work-related injury category, in contrast to non-work-related category in which closed globe injuries were more common (67.2%) (*p*-value = 0.0095, Table 3).

Among people 19–65 years old, males had nearly two times the odds of having a work-related eye injury as compared to non-work-related (OR = 1.96; 95%CI = 0.72–6.29), although this finding was not statistically significant. Patients over 40 had 37%

Table 2 Injury characteristics of work-related and non-work-related eye injuries (N = 251)

	Work-related	Non-work-related	*p*-value*	*N*
Injury characteristics	*N* (%)**	*N* (%)**		
Season			0.38	
Spring	21 (32.3)	44 (67.7)		65
Summer	23 (30.3)	53 (69.7)		76
Fall	12 (19.7)	49 (80.3)		61
Winter	15 (30.6)	34 (69.4)		49
Source of injury			0.07	
Blunt force object				
Blunt wooden or metal object	12 (20.7)	46 (79.3)		58
Fall	0 (0.0)	2 (100.0)		2
Other blunt object	6 (17.7)	28 (82.4)		34
Sharp force object				
Nail	3 (20.0)	12 (80.0)		15
Sharp object	19 (39.6)	29 (60.4)		48
Road injuries and fire				
Road accident	2 (25.0)	6 (75.0)		8
Firework and burn	1 (25.0)	3 (75.0)		4
Fire/explosion	6 (54.6)	5 (45.5)		11
Biologic/organic materials				
Coal	7 (70.0)	3 (30.0)		10
Plant and lawn material	6 (25.0)	18 (75.0)		24
Other materials			0.001	
Other working equipment	4 (80.0)	1 (20.0)		5
Other	5 (15.6)	27 (84.4)		32
Place of injury				
Industrial premises/mine	46 (95.8)	2 (4.2)		48
Farm/forest	13 (24.5)	40 (75.5)		53
Home	0 (0.0)	90 (100.0)		90
School, university	0 (0.0)	10 (100.0)		10
Recreation/sport	0 (0.0)	10 (100.0)		10
Street/highway	7 (33.3)	14 (66.7)		21
Public place	5 (26.3)	14 (73.7)		19
Use of protective eye wear				
Yes	17 (100.0)	0 (0.0)		17
No	44 (100.0)	0 (0.0)		44
Unknown	10 (100.0)	0 (0.0)		10

*Fisher's exact test for testing independence between work and non-work-related groups ($\alpha = 0.05$).
**Percentages based on characteristics (row %'s).

reduction in the odds of a work-related eye injury, also non-significant (OR = 0.63; 95%CI = 0.34–1.15, Table 4). Compared with manual workers (craftsman, driver, bricklayer, carpenter, locksmith), farmers had nearly eight times the odds for work-related eye injury (OR = 7.97; 95%CI = 1.21–152.0, Table 4). Compared to blunt sources of injury, organic material was significantly more likely to cause work-related injury (OR = 3.2; 95%CI = 1.21–8.71). No other sources were significantly associated with work-relatedness of the eye injury (Table 4).

Hospital admittance was used as a surrogate variable for response time from injury to the treatment. The analysis did not find any association between Final Visual Acuity, Ocular Trauma Score, hospital admittance, or the duration of hospitalization with work-relatedness (Table 5).

Discussion

This study from Bosnia and Herzegovina provides the first systematic analysis of eye injuries and work-related eye trauma in the country. Only hospitalized eye injuries were included, meaning that this sample represents more severe injuries as compared to injuries that did not require hospitalization. Of the 258 severe eye injuries in the nine year study period, 71 (27.5%) were work-related, indicating that work-related eye injury poses a considerable burden to eye trauma. The burden is likely higher, as outpatient injuries can also lead to visual impairments and contribute to missed work days and job loss.[1,2]

Prior studies have reported that the incidence and severity of eye injuries is higher in low- and middle-income countries compared to high-income countries.[14,15] However, the rate and frequency of occupational injury are associated with more than economic development including, the level of industrialization, characteristics of the working population, existing safety regulations and policies, and the level of enforcement. Rapid industrialization, in particular industrialization that out-paces advancements in occupational safety, can also lead to high rates.[1,16–21] In comparison to this study, which found that 27.5% of all eye injuries were work-related, studies of work-related eye injury found a frequency of approximately 43% in China and 50% in Thailand.[16,17] A higher proportion of work-related eye injuries were reported from lower income countries, especially those that are rapidly industrializing: 56% in India, 56% in Singapore, and 44% in Malaysia.[17–20] The United States Bureau of Labor Statistics

Table 3 Clinical characteristics of eye injuries

	Work-related	Non-work-related	*p*-value*
Clinical characteristics	***N* (%)****	***N* (%)****	
Time from injury to hospital admittance			0.4988
Less than 24 h	52 (73.2)	114 (63.3)	
24–48 h	10 (14.1)	42 (23.3)	
3–6 days	6 (8.5)	15 (8.3)	
7–13 days	1 (1.4)	2 (1.1)	
14 and more	2 (2.8)	7 (3.9)	
Length of hospitalization			0.4519
1–6 days	32 (45.1)	96 (53.3)	
7–13 days	34 (47.9)	76 (42.2)	
14–20 days	3 (4.2)	6 (3.3)	
21 and more	2 (2.8)	2 (1.1)	
Type of eye injury according to BETT			0.0095**
Closed globe injuries	35 (49.3)	121 (67.2)	
Contusion	18 (25.4)	60 (33.3)	
Lamellar laceration	5 (7.0)	16 (8.9)	
Both	12 (16.9)	45 (25.0)	
Open globe injuries	36 (50.7)	59 (32.8)	
Ocular Trauma Score			0.756
1 (poor visual prognosis)	5 (7.0)	9 (5.0)	
2	6 (8.5)	14 (7.8)	
3	15 (21.1)	36 (20.0)	
4	24 (33.8)	53 (29.4)	
5 (very good visual prognosis)	21 (29.6)	68 (37.8)	
Final visual acuity			0.6985
0 (removed eye)	2 (2.8)	1 (0.6)	
1 (NLP)	2 (2.8)	7 (3.9)	
2 (LP)	5 (7.0)	15 (8.3)	
3 (1/200–19/200)	4 (5.6)	7 (3.9)	
4 (20/200–20/50)	10 (14.1)	23 (12.8)	
5 (≤20/40)	48 (67.6)	127 (70.6)	

Note: BETT (Birmingham Eye Trauma Terminology), OTS (Ocular Trauma Score), NLP (no light projection), LP (light projection).
*Fisher's exact test for testing independence between work and non-work-related ($\alpha = 0.05$).
**OR = 0.475, 95%CI (0.26–0.86).

Table 4 Factors associated with work-related eye injuries* (N = 188)

Variables	Crude OR	[95%CI]	Adj. OR**	[95%CI]
Sex				
M	2.07	[0.77–6.57]	1.96	[0.72–6.29]
F	Ref		Ref	
Age				
19–39 years	Ref		Ref	
40–65 years	0.61	[0.33–1.12]	0.63	[0.34–1.15]
*Occupation****				
Manual workers (craftsmen, drivers, bricklayers, locksmith, other)	Ref		Ref	
Fire and electric hazard workers (miners, fire workers, mechanics, electricians)	1.15	[0.49–2.75]	1.31	[0.55–3.14]
Agricultural workers (farmers, lumber-jack)	7.0	[1.17–133.84]	7.95	[1.32–152.0]
Source of injury				
Blunt force (blunt wooden, metal object, fall, other blunt)	Ref		Ref	
Sharp force (sharp object, nail)	1.83	[0.85–3.98]	1.76	[0.81–3.88]
Road injuries and fire (road accident, firework, explosion, burn)	2.4	[0.83–6.93]	2.27	[0.77–6.70]
Other (other working equipment and other)	1.33	[0.44–3.77]	1.42	[0.47–4.09]
Biological/organic (plant, lawn material, coal)	3.15	[1.20–8.46]	3.2	[1.21–8.71]
Season				
Spring/Summer	Ref		Ref	
Fall/Winter	0.94	[0.50–1.73]	0.93	[0.49–1.74]

*Age 19–65 with outcome variable: work-related eye injury (*N* = 188).
**Controlled for age and sex.
***We excluded housewives and unemployed from the analysis (*N* = 120 for occupation category).

(US BLS) provides detailed characteristics of days away from work due to nonfatal work-related eye injuries.[21] The BLS reported a total of 23,730 days away from work for nonfatal occupational eye injuries the private, state, and local government sectors, with the incidence rate of 2.2. per 10,000 full-time workers.[22] This study does not have comparable data because there is no national work-related or eye injury registry to enumerate injuries, and the working population denominator is not well defined.

Age was not a risk factor for work-related eye injury in this study. Other studies report conflicting data; some report that workers age 20–34 or young workers had

Table 5 Injury outcomes and response time associated with work-related eye injuries* (N = 188)

Variables	Crude OR	[95%CI]	Adj. OR**	[95%CI]
Final visual acuity				
Poor vision	0.78	[0.34–1.70]	0.79	[0.34–1.72]
Good vision	Ref		Ref	
Ocular trauma score				
Low (Poor) score	1.15	[0.61–2.15]	1.17	[0.62–2.21]
High (Good) score	Ref		Ref	
Time from injury to hospital admittance				
≤48 h	Ref		Ref	
>48 h	0.94	[0.42–2.03]	1.14	[0.50–2.58]
Length of stay				
1–6 days	Ref		Ref	
7–13 days	1.27	[0.68–2.36]	1.3	[0.69–2.45]
14+ days	1.59	[0.43–5.67]	1.7	[0.45–6.21]

Note: FVA (final visual acuity), OTS (Ocular Trauma Score).
*Age 19–65 with outcome variable: work-related eye injury (*N* = 188).
**Controlled for age and sex.

higher risk for occupational eye injuries compared to older workers,[3,23] while other studies report greater injury risk for older workers.[24–26] Historically, reports tend to show a significantly higher proportion of work-related eye injuries in men. US data show that 81% of work-related eye injuries were among men,[21] and Serinken et al. reported that 95.3% of work-related eye injuries in Turkey were among men.[23] This study showed that men were more likely, but not significantly, to sustain work-related eye injury when compared with women. This may indicate that women, who are not as likely to be in the workforce, may have a high risk for eye injury. However, since the sample of women was so small, we cannot determine the basis for this finding. Based on these findings and those of other studies (e.g. Serinken et al.), future occupational eye safety programs should focus on specific tasks and occupations regardless of age or sex because these occupational exposures are stronger predictors of injury than demographic factors.[23]

Due to lack of strict safety protection regulations in many middle-income countries, open globe injuries occur more frequently within occupational settings in developing compared to developed countries. For example, the National Eye Trauma System Registry in the US reported that 22% of work-related eye injuries were open globe injuries, compared to 33% in India.[27] Results of this study are consistent, with 37.9% of open globe injuries found among work-related injuries ($p = 0.0095$). Of 71 work-related eye injuries, 62% of patients were not wearing eye protection when injured. Such high noncompliance with protective equipment may be related to the lack of occupational safety regulations mentioned earlier. Future aims for Bosnia and Herzegovina's legislature should include compliance with the objectives of the WHO: *Universal eye health: a global action plan 2014–2019*, which includes objectives that focus on development and implementation of integrated national eye health policies, plans, and programs.[28]

Bosnia and Herzegovina has a high rate of unemployment, which in 2014 was estimated at 43.6% of the population.[29] However, it is common for registered unemployed persons to work in unregistered businesses, especially among small businesses for the purposes of tax evasion. Unregistered businesses in Bosnia and Herzegovina work outside of the few existing occupational safety laws, and it is not known if these employers provide adequate personal protective equipment. In this research, there were several injured patients who reported work-related eye injury while being characterized as "unemployed" by the department administrator (information obtained from health insurance status record). However, they were included as work-related because the patient reported that the injury occurred during paid work. The authors could not assess if black market employment was a risk factor for work-related eye injuries, but this is a topic important for future intervention research.

Strengths and limitations of the study

This study examines eye injuries admitted to one of the largest trauma hospitals in the country, and thus represent more severe eye injuries. While this sample represents only one hospital, we have no reason to expect that trends and characteristics reported here differ substantially throughout the country. This retrospective study of medical records did not include detail about eye protection or about educational status for all patients, and a more comprehensive set of variables could have been collected prospectively.

Since this is a hospital study, a catchment population was not available to calculate population-based rates and to identify risk factors. Although the authors were able to control for age, gender, occupation, and educational status, information about socioeconomic status was not available, which could represent unmeasured confounding.

Conclusion

This study identified occupations and sources of eye injury that were more likely to lead to work-related eye trauma. Agricultural workers had nearly nine times the odds of work-related injury than other occupations. Organic

sources of injury were also significantly more likely to be work-related. Furthermore, among all work-related injuries, fewer than a third were wearing eye protection. Farmers, who often work alone and are not affiliated with a specific employer, may have poorer access to occupational safety and health information. Medical care providers can use these trends to recommend eye protection for workers in high risk occupations. Occupational safety and health stakeholders can use these data to prioritize workers and work environments, and these data indicate that agricultural and those working with machinery are a priority.

Although a larger, population-based study would be necessary to overcome limitations of the study, the study presents the first hospital-based report of the socio-demographic and clinical characteristics of work-related vs. non-work-related eye injuries from Bosnia and Herzegovina. The data presented here may serve as a scientific background for implementation and enforcement of the new Safety at Work Law that is currently in the process of preparation. Current laws in Bosnia and Herzegovina do not specify eye protection requirements for specific occupations or job descriptions, although some occupations are at high risk for eye injury. This study reports low use of eye protection, which implies a high burden on society. These data support the prioritization of safety and prevention programs, as well as the potential for policy approaches.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the University of Iowa NIH/Fogarty-funded International Trauma and Injury Prevention Training Program [grant number NIH 5D43TW007261; Peek-Asa, PI]; and the CDC/NCIPC-funded Injury Prevention Research Center [grant number NCIPC R49CE002108; Peek-Asa, PI].

ORCiD

Young Tracy http://orcid.org/0000-0002-7988-4245

References

1 The World Health Organization. Vision 2020 report. Geneva, Switzerland. [cited 2016 Feb]. Available from: www.who.int/blindness/partnerships/vision2020/en/
2 Negrel AD, Thylefors B. The global impact of eye injuries. Ophthalmic Epidemiol. 1998;5(3):143–169.
3 Xiang H, Stallones L, Chen G, Smith GA. Work-related eye injuries treated in hospital emergency departments in the US. Am J Ind Med. 2005;48:57–62.
4 International Labor Organization. Country profiles. Geneva, Switzerland; 2007. [cited 2016 Feb]. Available from: http://www.ilo.org/safework/countries/europe/bosnia/WCMS_187910/lang–en/index.htm
5 Report on Occupational Safety and Health in The Federation of Bosnia and Herzegovina. International Labor Organization Report, March 2007. Geneva, Switzwerland. [cited 2016 Feb]. Available from: http://www.ilo.org/wcmsp5/groups/public/—ed_protect/—protrav/—safework/documents/policy/wcms_187910.pdf
6 Act on Safety Labor, Federation of Bosnia and Herzegovina. Sarajevo, Bosnia and Herzegovina; 2015. [cited 2016 Feb]. Available from: http://www.uip-zzh.com/files/zakoni/rad/22-90.pdf
7 Time to end the eye health 'neglect' in Europe. -Report. European Coalition for Vision. Luxemburg; 2014 Apr. [cited 2015 Mar 20]. Available from: http://www.iapb.org/news/time-end-eye-health-neglect-europe
8 Kuhn F, Morris R, Witherspoon CD. Birmingham eye trauma terminology (BETT): terminology and classification of mechanical eye injuries. Ophthalmol Clin North Am. 2002;15:139–143.
9 Pieramici DF, Sternberg Jr. P, Aaberg Sr. TM, Bridges Jr. WZ, Capone Jr. A, Cardilloa JA, *et al*. A system for classifying mechanical injuries of the eye (globe). Am J Ophthalmol. 1997;123:820–831.
10 Kuhn F, Pieramici DJ. Ocular trauma; principles and practice. New York-Stuttgart: Thieme; 2002. p. 46.
11 Kuhn F, Maisiak R, Morris RE, Witherspoon CD. The ocular trauma score (OTS). Ophthalmol Clin North Am. 2002;15(2):163–5.
12 Han SB, Yu HG. Visual outcome after open globe injury and its predictive factors in Korea. J Trauma Injury Infect Crit Care. 2010;69(5):E66–E72.
13 Man CYW, Steel D. Visual outcome after open globe injury: a comparison of two prognostic models – the Ocular Trauma Score and the Classification and Regression Tree. Eye. 2010;24:84–89.
14 Chen SY, Fong PC, Lin SF, Chang CH, Chan CC. A case-crossover study on transient risk factors of work-related eye injuries. Occup Environ Med. 2009;66:517–522.
15 Yu TSI, Liu HJ, Hui K. A case-control study of eye injuries in the workplace in Hong Kong. Ophthalmology. 2004;111:70–74.
16 Cai M, Zhang J. Epidemiological characteristics of work-related ocular trauma in southwest region of China. Int J Environ Res Public Health. 2015;12:9864–9875.
17 Voraporn C, Thidarat L, Sabyasachi S. Work-related eye injuries: important occupational health problem in northern Thailand. Asia-Pacific J Ophthalmol. 2015;4(3):155–160.
18 Krishnaiah S, Nirmalan PD, 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;113:1159–1164.
19 Woo JH, Sundar G. Eye injuries in Singapore – don't risk it. Do more. A prospective study. Ann Acad Med Singapore. 2006;35:706–718.
20 Soong TK, Koh A, Subrayan V, Loo AV. Ocular trauma injuries: a 1-year surveillance study in the University of Malaya Medical Centre, Malaysia. 2008. Graefes Arch Clin Exp Ophthalmol. 2011;249:1755–1760.
21 U.S. Bureau of Labor Statistics (BLS). Workplace injuries involving the eyes. Washington, DC; 2008. Originally posted on 02/23/2011, [2015 Oct 9]. Available from: http://www.bls.gov/opub/mlr/cwc/workplace-injuries-involving-the-eyes-2008.pdf
22 Bureau of Labor Statistics U.S. Department of Labor (BLS). Nonfatal occupational injuries and illnesses requiring days away from work. Economic News release, Table 5, Washington, DC; 2014. Posted on 11/19/2015. [cited 2016 Jul 14]. Avaialble from: http://www.bls.gov/news.release/osh2.t05.htm
23 Serinken M, Turkcuer I, Cetin EN, Yilmaz A, Elicabuk H, Karcioglu O. Causes and characteristics of work-related eye injuries in western Turkey. Indian J Ophthalmol. 2013;61(9):497–501.
24 Baker RS, Wilson MR, Flowers CW, Jr, LEE DA, Wheeler NC. Demographic factors in a population based survey of hospitalized, work-related, ocular injury. Am J of Ophthal. 1996;122(2):213–9.
25 Vats S, Murthy GV, Chandra M, Gupta SK, Vashist P, Gogoi M. Epidemiological study of ocular trauma in an urban slum population in Delhi, India. Indian J Ophthalmol. 2008;56:313–6.
26 Kanoff JM, Turalba AV, Andreoli MT, Andreoli CM. Characteristics and outcomes of work-related open globe injuries. Am J Ophthalmol. 2010;150:265–69.
27 Kanoff JM, Turalba AV, Andreoli MT, Andreoli CM. Characteristics and outcomes of work-related open globe injuries. Am J Ophthalmol. 2010;150(2):265–269.
28 World Health Organization. Universal eye health: a global action plan 2014–2019. Geneva, Switzerland; 2012. [cited 2015 Oct 28]. Available from: http://www.who.int/blindness/AP2014_19_English.pdf?ua=1
29 Labor and Employment Agency for Bosnia and Herzegovina. Monthly report. [cited 2016 Jan]. Available from: http://www.arz.gov.ba/statistika/mjesecni/default.aspx?id=1775&langTag=bs-BA