

ORIGINAL ARTICLE

Welding related occupational eye injuries: a narrative analysis

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Table 5 and an appendix can be viewed on our website.

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Objective: To determine the activities and circumstances proximal to a welding related occupational eye injury, a hybrid narrative coding approach derived from two well developed classification systems was developed to categorize and describe the activity, initiating process, mechanism of injury, object and/or substance, and the use of protective eyewear from the narrative text data reported for each injury.

Methods: Routinely collected workers' compensation claims over a one year period (2000) were analyzed from a large US insurance provider. An index term search algorithm of occupation, incident, and injury description fields identified 2209 potential welding related eye injury claims. After detailed review of these claims, 1353 welders and 822 non-welders were analyzed.

Results: During 2000, eye(s) as the primary injured body part accounted for 5% (n=26 413) of all compensation claims. Eye injuries accounted for 25% of all claims for welders. Subjects were mainly male (97.1%) and from manufacturing (70.4%), service (11.8%), or construction (8.4%) related industries. Most injuries were foreign body (71.7%) or burn (22.2%) and 17.6% were bilateral. Common activities include welding (31.9%) and/or grinding (22.5%). Being struck by an airborne object occurred in 56.3% of cases. Non-welders showed similar patterns except that burns (43.8%) were more frequent and more often initiated by another worker (13.9%).

Conclusions: Narrative injury text provides valuable data to supplement traditional epidemiologic analyses. Workers performing welding tasks or working nearby welders should be trained to recognize potential hazards and the effective use of proper safety equipment to prevent ocular injury.

Eye injuries account for a substantial proportion of all work related injuries,^{1–3} including 12% of all workers' compensation claims among carpenters² and 11% of all injuries to construction workers requiring an emergency room visit.³ Welders are at particularly high risk for eye injuries. A Canadian study reported that welders represented 21% of all eye injury claims.⁴ According to the US Bureau of Labor Statistics (BLS), welders, cutters, and welding machine operators held about 521 000 jobs in 2000.⁵ The welding process exposes workers to a number of sources of mechanical, radiant, thermal, or chemical energy.⁶ A two year study of eye injury among workers in automobile manufacturing reported that 15% of the most common types of injuries (foreign body, corneal abrasion, and chemical injury) were welding related.⁷ Welding is also the second leading cause of consumer product related ocular trauma.⁸

Welding can also be performed by workers other than welders—for example, pipe fitters or construction workers. A recent study of work related eye injuries reported that workers who are “sometimes” or “often” exposed to welding had a fourfold increased risk of an eye injury compared with non-exposed workers.⁹ However, little is known regarding the specific activities or circumstances involved in eye injuries among welders.

Narrative text analysis has become a useful adjunct to traditional epidemiologic analyses in identifying workplace hazards and possible injury prevention strategies.^{10–13} This method allows for the analysis of qualitative data, routinely collected in administrative data systems, that are typically not coded for detailed analyses of injury circumstances. For example, this method was used to identify pre-crash manoeuvres and crash types from insurance claims narratives of vehicle crashes in roadway construction zones,¹⁰ in

comparing international causes of fatal work related injuries,¹¹ and in improving the information quality collected by emergency department surveillance systems.¹²

To identify and describe the circumstances and events leading to eye injury among welders, we investigated all welding related eye injuries reported to a large US based workers' compensation provider during 2000. Routinely collected narrative data describing the injury and related events were assessed using an original narrative coding approach to categorize the activity, initiating process, mechanism, object, or substance causing the injury and the use of protective eyewear.

METHODS

Design and data sources

Workers' compensation claims from period 1 January through 31 December 2000 were extracted from all claims filed with a US based workers' compensation insurance provider (n = 531 214). These claims represented medical only, lost work time (indemnity), or zero cost claims (those with no medical or indemnity costs). Five percent of all claims (n = 26 413) had eye(s) as the primary injured body part(s).

Welders were identified using a substring text search for the term “weld” in the occupation field (n = 1368). Non-welders (those not selected based upon occupational title) sustaining a welding related eye injury (n = 841) were identified using a narrative substring text search using for the terms “weld”, “braz”, or “solder” (to identify welding, brazing, or soldering) in the injury and incident (“accident”)

Abbreviations: PPE, personal protective equipment.

description fields (for example, pipe fitters with an eye injury while welding).

Injuries involving multiple body parts, including the eye, were excluded from the study as the etiology of these injuries (for example, motor vehicle crashes) are likely different from welding related eye injuries. An index term search for "eye" as a secondary body part injured was performed using the injury and accident description fields (including multiple injuries, head injury, injury to facial bones or facial soft tissue, multiple systems, artificial appliance, and unknown). This yielded approximately 1500 eye injury claims (about 5% more) from the 531 214 claims. If the relative proportion of claims attributed to welding were the same as for single eye injuries, this would yield 75 additional welding related claims.

The combined selection criteria yielded 2209 potential welding related eye injury claims. These claims were then manually reviewed for accuracy and completeness. Thirty four (1.5% of the total) claims were excluded; 14 were duplicates and 20 had either miscoded body part(s) or were incomplete. The final sample for analysis included 2175 workers with welding related eye injury claims, accounting for 8.2% of all eye injuries in 2000.

The Liberty Mutual Research Institute for Safety's Institutional Review Committee for the Protection of Human Subjects approved the study.

Narrative coding

Our narrative coding approach (see <http://www.injuryprevention.com/supplemental> for Appendix 1) is adapted from an approach originally proposed by Lincoln *et al* for coding safety report narratives.¹³ This hybrid approach was derived from two well developed classification systems, the Occupational Injury and Illness Classification Manual,¹⁴ developed by the Bureau of Labor Statistics and the International Classification of External Causes of Injury from the World Health Organization.¹⁵ Our approach permitted the analysis of two routinely collected narrative text fields: "accident description" which describes the activity at the time of the incident and injury description which contains the nature of the injury. Each field was up to 120 characters of text. Our objective was to develop a customized coding approach that would provide a clear understanding of the circumstances proximal to a welding related eye injury.

Coding categories included activity (the activity or task that the worker was performing when the injury occurred), initiating agent (the initiating process resulting in a specific mechanism of injury), intent (for example, intentional or unintentional), mechanism of injury (the operation or action that caused the object or substance to contact the eye), source (object or substance impacting the eye), any mention of the use or non-use of personal protective equipment (PPE) (yes/no), and eye involved (right, left, or both). Intent was initially coded; however as 99% of claims were unintentional, this data field was dropped. A trained reviewer (RP), who co-developed the coding approach, initially coded all 2175 claims. Ambiguous descriptions of incidents (n = 43) were reviewed and coded by consensus agreement among four researchers.

A typical incident description for narrative coding might be, "the employee grinding a weld when piece of metal flew under safety glass into right eye" with the injury description "metal sliver in right eye". The resulting codes would be "grinding" as the activity, "normal mechanical work process initiated" (not involving a malfunction) as the initiating agent, "propelled or airborne" as the mechanism of injury, "particulate or small solid" as the object or substance causing the injury, "yes" for PPE use, and "right" for eye involved.

Industry coding

Workers' compensation claims were precoded using the four digit 1987 OSHA Standard Industrial Classification (SIC) system to identify the primary business of the establishment.

Data analysis

Descriptive statistics (that is, frequencies, column percentages, means, and SEM) were calculated for demographic, occupational, and injury related variables (for example, sex, age, nature of injury) for welders and non-welders separately. Narrative analysis variables were cross-classified (for example, injury source by mechanism) and frequencies and column percentages were calculated. As different criteria were used to select welders and non-welders, statistical comparisons of these two groups were not conducted and descriptive comparisons cannot be made. All data analyses were conducted using SAS (Version 8, SAS Institute Inc, Cary, NC, USA).

The underlying population at risk of reporting an eye injury claim was unknown in this study (denominators), precluding the calculation and comparison of incidence rates. Proportionate injury ratios were estimated to compare nature of injury between welders and all other workers reporting eye injuries during the same year (2000). Proportionate injury ratios and associated 95% confidence intervals were calculated using methods for calculating proportionate mortality ratios.¹⁶ The PIR is interpreted as whether the observed proportion of cases in each stratum is greater or less than what would have been expected based on the distribution of a selected reference population (for example, non-welders). As proportions must equal 100%, an increase in one nature of injury category will be offset by a decrease in another.

RESULTS

Worker characteristics

Eye injuries accounted for 5.0% (n = 26 413) of all workers' compensation claims. Welders comprised 1353 cases or 5.1% of all eye injury claims. Eye injuries accounted for 25% of all claims filed by welders; 97% were male, mean (standard error of the mean) age 34.9 (SEM 0.3) years (table 1). Primary SIC category was available for 64.4% of workers; manufacturing (70.4%), services (11.8%), and construction (8.4%). The most frequent two digit subgroups under manufacturing were industrial, commercial machinery, computer equipment, and fabricated metal products.

The second narrative index search criteria identified 822 non-welders with an eye injury from a welding related task (3.1% of all eye injury claims). These workers were similar to welders with respect to sex and age, mostly employed in manufacturing (47.3%), construction (21.2%), and services (12.5%). The most common non-welder occupations were mechanics, laborers, maintenance workers, assemblers, pipe fitters, boilermakers, ironworkers, millrights, and riggers.

Injury characteristics

Of the combined 2175 welding related eye injury claims, 24.2% were bilateral; 17.6% of welders and 35.1% of non-welders had bilateral injuries. Single eye injuries were distributed evenly among the left and right eye (table 2). The most frequent nature of injury was foreign body (63.4%) and then burns (30.3%). Among welders, foreign bodies (71.7%) and burns (22.2%) were most common, followed by inflammation, laceration, and contusions (each comprised less than 3% of the total). In comparing the nature of injury for welders (n = 1353) to all other worker eye injury claims reported for the year (n = 25 060) (see fig 1), welders had proportionally more burns than workers in other occupations reporting eye injuries (PIR = 4.7; 95% CI 4.2 to 5.2) demonstrating greater exposure

Table 1 Demographic characteristics of welders and non-welders

Characteristic	Welders (n = 1353)		Non-welders (n = 822)		Total (n = 2175)	
	n	(%)	n	(%)	n	(%)
Sex						
Male	1314	(97.1)	798	(97.1)	2112	(97.1)
Female	39	(2.9)	24	(2.9)	63	(2.9)
Age* (years)						
15–20	30	(2.2)	32	(4.0)	62	(2.9)
20–24	199	(14.9)	103	(12.8)	302	(14.1)
25–34	480	(35.9)	236	(29.3)	716	(33.4)
35–44	371	(27.8)	261	(32.4)	632	(29.5)
45–54	201	(15.0)	129	(16.0)	330	(15.4)
55–64	54	(4.0)	40	(5.0)	94	(4.4)
65+	3	(0.2)	4	(0.5)	7	(0.3)
Mean (SEM)	39	(0.28)	36.0	(0.38)	35.3	(0.23)
SIC category†						
Manufacturing	573	(70.4)	277	(47.3)	850	(60.7)
Construction	68	(8.4)	124	(21.2)	192	(13.7)
Services	96	(11.8)	73	(12.5)	169	(12.1)
Wholesale and retail trade	40	(4.9)	43	(7.3)	83	(5.9)
Transportation, communications, electric, gas, sanitation services	19	(2.3)	40	(6.8)	59	(4.2)
Finance, insurance, real estate, public administration	13	(1.6)	14	(2.4)	27	(1.9)
Agriculture, forestry, fishing, mining	5	(0.6)	7	(1.2)	12	(0.9)
Non-classifiable estimate	0	(0.0)	8	(1.4)	8	(0.6)

*Age was missing for 32 workers.

†775 (35.6%) of the claims were not assigned Standard Industrial Classification (SIC) codes.

to UV radiation (note: 87.3% of burns to welders was UV ray induced) and proportionally fewer lacerations, contusions, inflammation, and other natures of injury. The proportion of foreign bodies was generally similar.

Narrative analysis Welders

Welding (31.9%) and grinding (22.5%) were the most common activities at the time of injury (table 3). Activities also included cleaning or brushing (3.7%), or observing or being a bystander (3.0%) among others. Almost 22% of activities were non-classifiable due to a lack of information. Injury sources (table 4) were frequently particulates or small solids (63.4%) and ultraviolet rays (19.7%). The primary mechanism of particulates, hot substances, and solid objects was propelled or airborne (ranging from 50–77.6%), whereas chemicals, liquids, and caustics were primarily from splashes or sprays (77.3%). Injuries (table 5; see <http://www.injuryprevention.com/supplemental>) were most often

initiated by the work process (74.9%) during a normal mechanical operation (that is, not a malfunction) (86.8%). Processes initiated by another worker (or co-worker) accounted for 4.7% of all eye injuries and most often during a normal mechanical process (93.6%). The use of PPE (for example, safety goggles, masks, helmets) was mentioned only in 14.7% of all welders' claims (data not presented), of which 20.6% reported donning or removing their PPE and 7.0% reported not wearing PPE at all.

Non-welders

Among non-welders, welding (49.4%), grinding (9.3%), and multiple tasks (6.1%) were the most frequent activities at the time of their injury (table 3). Observing, standing, walking, or assisting a welder accounted for another 6.1% of injuries. Injury sources (table 4) commonly were ultraviolet rays (41.1%), particulates or small solids (40.4%), and hot substances (5.7%). As in welders, the mechanism of particulates, hot substances, and solid objects was primarily propelled or airborne (ranging from 58.8–77.1%). Chemicals, liquids, and caustics were most often due to splashes or sprays (80.0%). The injury process (see <http://www.injuryprevention.com/supplemental> for table 5) was typically initiated by the work process (74.6%) not involving a mechanical malfunction (91.4%). Processes initiated by another worker accounted for 13.9% of all eye injuries and most often during a normal mechanical process (96.5%). Personal protective equipment (PPE) use or non-use was mentioned in 17.8% of all non-welders' claims (data not shown). Of these 146 cases, 24.0% reported donning or removing their PPE and 11.6% reported not wearing any PPE at the time of their injury.

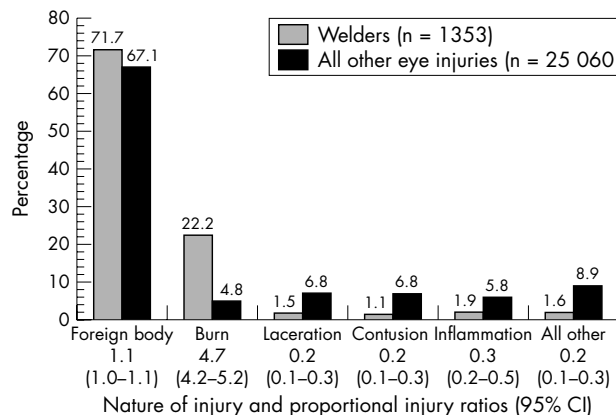


Figure 1 Comparison of nature of injury and proportional injury ratios for welders with other workers with work related eye injury claims in 2000.

DISCUSSION

Traumatic eye injury continues to be an important occupational health and safety issue for workers who are engaged in the welding processes. In our study, welders comprised 5.1% and workers engaged in welding related activities comprised 8.2% of all reported eye injuries. The proportion of eye injuries to welders is similar to most other studies: 9.1% of

Table 2 Eye injury characteristics for welders and non-welders

Characteristic	Welders (n = 1353)		Non-welders (n = 822)		Total (n = 2175)	
	n	(%)	n	(%)	n	(%)
Injured eye*						
Single	1113	(82.4)	528	(64.9)	1641	(75.8)
Right	443	(39.8)	203	(38.4)	646	(39.4)
Left	433	(38.9)	169	(32.0)	602	(36.7)
Unspecified	237	(21.3)	156	(29.5)	393	(24.0)
Bilateral	238	(17.6)	285	(35.1)	523	(24.2)
Nature of injury						
Foreign body	970	(71.7)	409	(49.8)	1379	(63.4)
Burn	300	(22.2)	360	(43.8)	660	(30.3)
Inflammation	26	(1.9)	21	(2.6)	47	(2.2)
Laceration	20	(1.5)	5	(0.6)	25	(1.2)
Contusion	15	(1.1)	8	(1.0)	23	(1.1)
All other†	22	(1.6)	19	(2.3)	41	(1.9)

*Location of injured eye could not be determined for 11 workers.

†Includes infection or contagious, poisoning/chemical, strain, puncture, radiation, vision loss, and unspecified. Percentages may not sum to 100% due to rounding.

worker compensation eye injury claims in West Virginia¹ and 6.0% of more serious eye injuries resulting in days away from work,¹⁷ but is in marked contrast to another study,⁴ where welders comprised 21% of all worker compensation eye injury claims. Possible reasons for this discrepancy are unknown; however, the latter study was conducted 20 years ago and circumstances such as welding practices or industry make-up may have changed. For example, the rate of non-fatal eye injuries and illness with days away from work decreased 47% during the period 1993–2000 (11.2 per 10 000 full time workers to 5.9 per 10 000).¹⁸ Welders also may have experienced similar decreases in overall injury rates as other workers. However, in our database, eye injury claims continued to account for a significant proportion (25%) of all workers' compensation claims filed by welders in 2000.

An important contribution of our study is the availability of data that describe the nature and circumstances of a large case series of welding related injuries. We found no comparable studies that provide similar data on workers doing welding related activities, including Reesal's study which analyzed only 395 welders.⁴ One important finding is

that non-welders doing welding related activities experienced a high proportion of burns from ultraviolet rays in spite of the well known hazards of UV light (see tables 2 and 4). These differences may be in part due to the selection criteria used to abstract claims; however, it is clear that training in the proper use of personal protective equipment (for example, protective eyewear) is critical for all workers performing welding related tasks.

In our study, foreign body injuries accounted for 71.7% and burns accounted for 22.2% of all injuries. Reesal *et al* reported similar findings (72% and 25%, respectively)⁴ and similar data on the location and pattern of eye injuries.

The injuries in our study were mostly minor; only 1.2% of those injured were disabled long enough to qualify for wage replacement (indemnity) benefits. The average cost of a welding related eye injury was only slightly higher than the cost (\$157) for medical only eye injury claims among construction workers.²

Injuries resulting from processes initiated by another worker (or co-worker) accounted for 8.1% of our eye injuries (4.7% for welders and 13.9% for non-welders); 177 injuries

Table 3 Activity at the time of a welding related eye injury among welders and non-welders

	Welders (n = 1353)		Non-welders (n = 822)		Total (n = 2175)	
	n	(%)	n	(%)	n	(%)
Welding related activity						
Welding	432	(31.9)	406	(49.4)	838	(38.5)
Grinding	304	(22.5)	76	(9.3)	380	(17.5)
Multiple tasks	32	(2.4)	50	(6.1)	82	(3.8)
Standing/walking/observing	40	(3.0)	33	(4.0)	73	(3.4)
Cleaning/brushing	50	(3.7)	22	(2.7)	72	(3.3)
Manual material handling	37	(2.7)	19	(2.3)	56	(2.6)
Chipping	35	(2.6)	15	(1.8)	50	(2.3)
Other*	27	(2.0)	12	(1.5)	39	(1.8)
Cutting	34	(2.5)	3	(0.4)	37	(1.7)
Work with machinery/drilling	26	(1.9)	7	(0.9)	33	(1.5)
Sanding/sand blasting	21	(1.6)	9	(1.1)	30	(1.4)
Soldering/brazing	1	(0.1)	25	(3.0)	26	(1.2)
Assisting welder	6	(0.4)	18	(2.2)	24	(1.1)
Putting on/removing PPE	14	(1.0)	7	(0.9)	21	(1.0)
Non-classifiable or missing	294	(21.7)	120	(14.6)	414	(19.0)
Total	1353	(100.0)	822	(100.0)	2175	(100.0)

*Other includes hammering, burning, fitting, painting, polishing, using air impact gun and wrench, banding, belting, lining, confrontation, deburring, driving, lubricating, repairing, pressing, sharpening, showering, spraying, testing, tipping, and wiring. Percentages may not sum to 100% due to rounding.

Table 4 Injury source by mechanism for welding related eye injuries among welders and non-welders

Source/mechanism	Welders (n = 1353)		Non-welders (n = 822)		Total (n = 2175)	
	n	(%)	n	(%)	n	(%)
Particulate/small solid	858	(63.4)	332	(40.4)	1190	(54.7)
Propelled/airborne	666	(77.6)	256	(77.1)	922	(77.5)
Falling object	38	(4.4)	26	(7.8)	64	(5.4)
Other*	18	(2.1)	3	(0.9)	21	(1.8)
Smoke/irritation	5	(0.6)	5	(1.5)	10	(0.8)
Splash/spray	0	(0.0)	2	(0.6)	2	(0.2)
Non-classifiable or missing	131	(15.3)	40	(12.1)	171	(14.4)
Ultraviolet rays†	266	(19.7)	338	(41.1)	604	(27.8)
Hot substance	41	(3.0)	47	(5.7)	88	(4.0)
Propelled/airborne	35	(85.4)	33	(70.2)	68	(77.3)
Other*	2	(4.9)	6	(12.9)	8	(9.1)
Splash/spray	1	(2.4)	5	(10.6)	6	(6.8)
Falling object	1	(2.4)	3	(6.4)	4	(4.6)
Smoke/irritation	1	(2.4)	0	(0.0)	1	(1.1)
Non-classifiable or missing	1	(2.4)	0	(0.0)	1	(1.1)
Solid object	28	(2.1)	17	(2.1)	45	(2.1)
Propelled/airborne	14	(50.0)	10	(58.8)	24	(53.3)
Other*	9	(32.2)	3	(17.6)	12	(26.7)
Falling object	3	(10.7)	3	(17.7)	6	(13.3)
Non-classifiable or missing	2	(7.1)	1	(5.9)	3	(6.7)
Chemicals, liquid, or caustics	22	(1.6)	5	(0.6)	27	(1.2)
Splash/spray	17	(77.3)	4	(80.0)	21	(77.8)
Other*	2	(9.1)	0	(0.0)	2	(7.4)
Propelled/airborne	0	(0.0)	1	(20.0)	1	(3.7)
Non-classifiable or missing	3	(13.6)	0	(0.0)	3	(11.1)
Other sources‡	2	(0.2)	7	(0.9)	9	(0.4)
Non-classifiable or missing	136	(10.1)	76	(9.3)	212	(9.8)
Propelled/airborne	45	(33.1)	19	(25.0)	64	(30.2)
Smoke/irritation	17	(12.5)	16	(21.1)	33	(15.6)
Other*	6	(4.4)	3	(4.0)	9	(4.3)
Falling object	2	(1.5)	1	(1.3)	3	(1.4)
Splash/spray	1	(0.7)	0	(0.0)	1	(0.5)
Non-classifiable or missing	65	(47.8)	37	(48.7)	102	(48.1)
Total	1353	(100.0)	822	(100.0)	2175	(100.0)

*Other mechanisms include stationary or swinging object, heat/pressure, other contact, or multiple.

†All mechanisms were ultraviolet radiation.

‡Other sources include multiple substances, vapor/gas, or electricity and the mechanisms included propelled airborne, ultraviolet radiation, splash/spray, and other.

(68.4%) were from UV rays (49.1% for welders and 79.0% for non-welders), and 22.6% were from particulates or small solids. Non-welders, such as pipe-fitters, laborers, and helpers were often walking past or around a welder leading to flash burns to the eye. The use or non-use of personal protective equipment (PPE) (for example, safety goggles, masks, helmets) was only mentioned in 14.7% of welders' and 17.8% of non-welders' claims, suggesting a very important area for intervention. Welding activity has considerable potential to affect other workers and the perimeter around this work should be considered hazardous. For example, that area could be 100 square feet (10 by 10) or greater; however this distance could be influenced by the confined nature of some welding work. It is apparent that workers near welding activity would benefit from training in the proper use of PPE, as most work related ocular injuries are potentially preventable.¹⁹

There are several limitations related in this study. Workers' compensation claims may underestimate the occurrence of injuries, including eye injuries. Additionally, the majority of eye injuries in our study were minor in severity and these data may not be representative of welding related eye injuries of greater severity treated in hospital emergency rooms. The narrative analysis method is also limited by the completeness and consistency of the available text data.¹³ Additionally, sensitivity is likely to be better than specificity—that is, when keywords are found in the narrative they probably indicate real contributions to the incident/injury. It is unknown

whether there are words that were truncated, forgotten, lost in conversation, or abbreviated by those reporting or recording the claim. Thus, narrative analysis likely underestimates the magnitude of these contributing factors/circumstances to eye injuries.

Another limitation of this study is in the method of injury type classification. The current study used the broad nature of injury categories rather than ICD-9 or other similar diagnostic codes to classify injuries. For example, in our coding system, keratitis ("welder's flash") and burns from hot slag are confounded and would be coded as burn. However, compared with the findings reported by Islam *et al* which used ICD-9 coding,¹ both data sources rank foreign body (ICD-9; 930–930.9) as the leading type of compensable injury and a similar proportion of burns (ICD-9; 940–940.9) are reported (approximately 5%).

Strengths of this study include the relatively large number of cases for analysis, including 1353 welders and 822 non-welders (a much larger sample size than other published studies), and a diverse study population from multiple industries. These results should be fairly representative of the insured working population.

Eye injuries are considered to be largely preventable especially if adequate eye protection is used and appropriate machine guards are positioned over obvious hazards.^{19, 20} A detailed review of prevention strategies is beyond the scope of this paper; however, common and effective approaches to the prevention of injury from the welding process have been

Key points

- Injuries to the eye as the primary body part accounted for 5% of all workers' compensation claims for a large US insurance provider.
- The most common welding related eye injuries are foreign body or burns. Frequent work activities at the time of injury include welding, grinding, cleaning, brushing, or observing a welder.
- Injury narratives provided valuable data for describing the circumstances of welding related and other injuries.
- Workers performing welding tasks or working near welders should be trained to recognize potential hazards and the effective use of proper safety equipment to prevent ocular injury.

published.²¹ They suggest a well communicated eye safety policy for employees, protective eyewear available at no cost to workers (meeting ANSI Z87.1-1989), periodic vision screening, and spot checks for the use of PPE when hazards are present. As many welding related eye injuries are due to foreign bodies, we emphasize focusing on the prevention of hazards associated with propelled particulates during welding and grinding activities through engineering controls and improved tool design.

Developing preventive strategies for reducing welding related eye injuries requires a detailed understanding of injury circumstances such as is provided in our study. For example, the fact that UV light exposure burns continue to occur to welders suggests a need to better implement known strategies such as UV light shields. More studies are needed to determine the important barriers to the use of known prevention strategies (for example, PPE use) and to identify potentially modifiable worker related, work environment, and work equipment related transient risk factors for eye injuries. These studies will reduce the burden of eye injuries and the potential risk of long term serious sequelae.

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Appendix Welding related eye injury narrative coding categories and codes

Activity (activity when injury occurred)		Initiating agent (what initiated the process leading to injury)		Intent	Mechanism of injury	Source (object/substance causing the injury)	
110	Manual material handling (MMH)	210	Work activity initiated	310	Unintentional	410 Splash/Spray	510 Chemicals/caustics
	110.01 Hook/unhook		210.01 mechanical process - normal				
	110.02 Open/Close		210.02 mechanical process -malfunction	311	Intentional	411 Falling object	511 Liquid (non-chemical & normal temperature)
	110.03 Install/Remove		210.03 non-mechanical				
	110.04 Lift/Lower			388	Non-classifiable	412 Propelled/airborne	512 Solid
	110.05 Load/Unload	211	Co-worker initiated process				
111	Operating handtool		211.01 mechanical process-normal	399	Missing	413 Release of pressure/pressurised contents	512.01 Particulate/ Small solid (eg dust)
	111.01 Powered (drill, welder)		211.02 mechanical process-malfunction			414 UV ray-induced injury	512.02 Solid object (medium-large) (eg rocks, packages)
	111.02 Non-powered (hammer)						
112	Work with machinery		211.03 non-mechanical process				513 Hot substances (eg hot metal)
	112.01 Operating machinery	212	Object-initiated		415 Heat-induced injury (incl electric burns)		
	112.02 Machinery maintenance						
			212.01 mechanical process-normal				514 Vapor/Gases (other than chemicals)
113	Operating (or passenger in) vehicle		212.02 mechanical process-malfunction		416 Slip/Trip/ Fall		515 Infectious substance
			212.03 non-mechanical process				
114	Automotive work	213	Environment		417 Swinging object		516 UV rays
115	Painting*		213.01 wind		418 Stationary object		517 Electricity
			213.02 precipitation				
116	Plastering*		213.03 sunlight		419 Smoke/irritation		518 Heat source (other than hot substance)
117	Cooking*	214	Gravity		420 Contact (other than above)		519 Multiple objects/substances
118	Cleaning*	215	Animal		488 Non-classifiable		
119	Polishing*	216	Explosion		499 Missing		588 Non-classifiable
120	Cutting*	288	Non-classifiable				599 Missing
121	Grinding*	299	Missing				
122	Standing/Walking/Running (without a load in the hands, incl exiting/entering a vehicle)						
123	Supervising people						
	123.01 Confrontational activities						
	123.02 Non-confrontational activities						
124	Work involving chemicals/caustics						
188	Non-classifiable (no specific activity was mentioned)						
199	Missing						

*With no tool/machinery involved or mentioned.

Table 5 Initiating agent for welding related eye injuries among welders and non-welders

	Welders (n=1353)		Non-welders (n=822)		Total (n=2175)	
	n	(%)	n	(%)	n	(%)
Initiating process						
Work process initiated	1014	(74.9)	613	(74.6)	1627	(74.8)
Mechanical-normal	880	(86.8)	560	(91.4)	1440	(88.6)
Non-mechanical	70	(6.9)	23	(3.7)	93	(5.7)
Mechanical-malfunction	18	(1.8)	18	(2.9)	36	(2.2)
Unknown	46	(4.5)	12	(1.9)	58	(3.6)
Initiated by another person	63	(4.7)	114	(13.9)	177	(8.1)
Mechanical-normal	59	(93.6)	110	(96.5)	169	(95.5)
Non-mechanical	3	(4.8)	3	(2.6)	6	(3.4)
Mechanical-malfunction	1	(1.6)	1	(0.9)	2	(1.1)
Object initiated	29	(2.1)	11	(1.3)	40	(1.8)
Mechanical-normal	17	(58.6)	5	(45.5)	22	(55.0)
Mechanical-malfunction	6	(20.7)	3	(27.3)	9	(22.5)
Non-mechanical	4	(13.8)	2	(18.2)	6	(15.0)
Unknown	2	(6.9)	1	(9.1)	3	(7.5)
Other initiating processes	21	(1.6)	11	(1.3)	32	(1.5)
Environment	20	(95.2)	8	(72.7)	28	(87.5)
Explosion	1	(4.8)	3	(27.3)	4	(12.5)
Non-classifiable or missing	226	(16.7)	73	(8.9)	299	(13.7)
Total	1353	(100.0)	822	(100.0)	2175	(100.0)

Percentages may not sum to 100% due to rounding.