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Work-Related Eye Injuries Among Union Carpenters

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Union administrative records were combined with workers' compensation data to identify a cohort of 12,958 active union carpenters, their person-time at risk, and their documented work-related eye injuries between 1989 and 1995 in the state of Washington. The injuries were described using ANSI codes for injury nature, type (mechanism), and source or object associated with the event. Injuries which resulted in paid lost time from work were also described based on the ICD-9 codes attached to claims for their medical treatment. Overall rates of filing compensation claims for eye injuries as well as age, gender, and union local specific rates were calculated. To identify high risk subgroups and explore incident and recurrent events, the person-time and events were stratified by age, gender, time in the union, claim status, and predominant type of work of the union local with which each carpenter was affiliated for multivariate analyses with Poisson regression. Eye injuries were responsible for 12 percent (n = 1730) of workers' compensation claims during this time period, exceeded only by back and finger injuries. Thirty-one claims resulted in paid lost time from work and these cases accounted for one-third of all costs for medical care for eye injuries. *At least* 10 percent of all medical costs for eye injuries and 35.5 percent of medical costs for eye injuries which resulted in paid lost time were associated with injuries sustained while hammering—a very common carpenter exposure. Claims were filed at an estimated rate of 6.1 per 200,000 hours worked. Individuals with previous compensation claims for eye injuries had rates of injury 1.6 times higher than individuals without previous eye injuries. Rates decreased significantly with age and time in the union. Eye injuries among these union carpenters were very common, but the rate of injuries severe enough to require paid time off work was quite low. These findings raise questions about factors which might influence the failure to use appropriate protection including availability and acceptability of eye protection, use by peers, and perception of risk.

Keywords Eye Injuries, Carpenters, Workers' Compensation, Cohort Studies

BACKGROUND

Eye injuries are common work-related injuries among construction workers.[1–3] The Bureau of Labor Statistics (BLS) reported over 77,000 occupational eye injuries or illnesses in all private industries that involved days away from work in the year 1995. Twelve percent of these injuries (9500) occurred in the construction trades (SIC codes 15, 16, 17)[4] which employ less than 6 percent of private sector workers.[5] Among construction workers treated in an urban emergency room, lacerations were the most commonly treated injuries followed by sprains/strains, contusions, and eye injuries.[1] Data from emergency department surveillance[1] may fail to give a representative picture of work-related injuries to the eye because many may not be serious enough to need emergency treatment[2] and may be seen in physicians' offices or urgent care centers. Similarly, data from eye injury registries provide information on the small percentage of injuries that result in serious ocular trauma, but they lack information on the vast majority of claims that are of a less serious nature. Neither of these sources provide information about the population from which the events arose. This lack of information makes it difficult to calculate rates at which these injuries occur, calculations which could be used to monitor trends over time and to evaluate the effect of interventions. The BLS data do not allow the differentiation of recurrent events in the same person, a factor which could be important in understanding risk among workers in jobs with high rates of eye trauma, such as construction workers.

Combined administrative data sources were used to identify a cohort of union carpenters and to describe their work-related eye injuries between the years 1989 and 1995, including the calculation of rates and costs, and the exploration of possible high-risk groups. More serious events are described in detail, including the descriptions of the cause of injury obtained from workers' compensation claims and the ICD-9 (International Classification of Diseases) codes assigned to medical claims for treatment of these injuries.

MATERIALS AND METHODS

Data Sources and Linkage

Health insurance eligibility files from the Carpenters' Trusts of Western Washington (CTWW) were used to identify a cohort of active union carpenters who worked at least three months of union time and had at least one month of insurance eligibility between the years of 1989 and 1995. These files contained the hours worked by each individual for each month from January 1, 1989 through December 31, 1995, providing person-hours at risk as a union carpenter. The CTWW and national union membership files of the United Brotherhood of Carpenters and Joiners of North America (UBC) provided dates of birth, gender, union local affiliation, and initiation date into the union for cohort members. No race information was available from these data sources.

The Washington State Department of Labor and Industries (L&I) provided records of workers' compensation claims filed by these individuals during the period of 1987–1995, including medical-only claims as well as those which resulted in paid lost work time. These data were used to identify the injury events of interest. The compensation claims data included the date of injury, American National Standards Institute (ANSI) codes describing the events in terms of body part injured, the nature of the injury, the type of event causing the injury, and the source of injury as recorded on the first report of injury. In addition, information was available on the amount of lost work time associated with the event and the costs associated with lost time and medical care. The ICD-9 codes assigned to medical claims for treatment of the injury also were available through the Department of Labor and Industries.

Employers who self-insure for workers' compensation in the state of Washington are not required to report events which do not result in lost time from work to the Department of Labor and Industries, and lost time cases do not have to be reported until the case is closed. The data were extracted in December 1996, a year after the last claims were filed in our data set, resulting primarily in under-representation in these data of less serious events.

A unique identifier was assigned to each individual by the Carpenters' Trusts of Western Washington. Data were provided from all sources with this identifier to allow linkage of all data on an individual basis.

Definition of Events of Interest

The analyses presented in this report were based on claims with an ANSI body part code of '130,' identifying an injury to the eye as the primary injury. Only events which occurred in a month that the individual had worked union hours were counted so that events and time at risk were counted on the same basis for rate calculations. Work-related injuries did occur in months when no union hours were worked, but these non-union claims were not included because no information was available regarding the type of work or the number of hours worked in these months. Our data thus reflect an attempt to identify injury rates for work as union carpenters. Initially we included all claims filed by these carpenters, excluding only the claims which were rejected for workers' compensation coverage. Later analyses were limited to events which resulted in paid lost time from work, which occurs in Washington State after the third lost workday.

Incident events were defined by claims filed between the years 1989 and 1995 by individuals who had not filed a previous claim for an eye injury in the state of Washington since 1987. Individuals who filed previous claims in periods of non-union work also were excluded from being considered an incident case.

Definition of Time at Risk and Covariates

Person-hours of work as a union carpenter was used as the measurement of time at risk. For the initial analyses of overall injury rates, individuals were considered to be at risk of filing a work-related claim at any time they were working union hours regardless of prior events. The occurrence of one injury did not remove the worker from the risk set for a new event as long as he or she was still working. When evaluating first and second events, time at risk for the incident event stopped accumulating when the person had an event. Time at risk for a second injury began accumulating in the first month of work following the incident case. Although person-hours are used as the measurement of time at risk, the person-month is effectively the unit of analysis since we do not know when the hours in any given month were accumulated. All the work hours in a month in which an injury occurred were counted as time at risk for that injury.

The covariates considered in these analyses included age, gender, time in the union, and the predominant type of carpentry work. Prior analyses of a smaller cohort (1989–1992) had shown that women and workers under the age of 30 had higher rates of filing all claims.[2] Time in the union was dichotomized at four years in an attempt to separate apprentices from journeymen carpenters. To reach journeyman status an inexperienced carpenter must typically be in the union at least four years and complete the appropriate training. The union local affiliation was the only surrogate available for characterizing the type of work done by cohort members. The locals represented by this cohort were grouped into eight categories by the Carpenters' Health and Safety Fund's District Environmental Coordinator based on the predominant type of carpentry work done by the locals. These work categories included light commercial, heavy commercial, drywall, millwrighting, pile driving, cabinet and fixture work, residential, and a mixed category. Light commercial work involved construction on projects of two to three stories. Heavy commercial involved high-rise buildings, as well as interstate and freeway work. Millwrights are craftworkers in industry and are often involved in installation, repair, and maintenance of

heavy machinery. The mixed category includes those locals for which there was not a predominant type of work.

Analyses

The frequency and proportion of claims filed for eye injuries were calculated from the total number of claims filed. The crude incidence density rate of filing claims for eye injuries was calculated including a correction estimate to account for failure to identify self-insured claims that did not result in paid lost time from work. This correction was based on the assumption that the percentage of all claims (for all injuries and illnesses) from self-insured employers for any local would be the same as the percentage of paid lost time claims that came from self-insured employers among members of the local. The same assumption was made for categories of age, gender, and time in the union.

All claims and those resulting in paid lost time were described using the codes for nature of injury, source of injury and type of event, or mechanism, of injury. Serious claims which resulted in lost time with pay (after three days of missed work in Washington State) were described in more detail, including the ICD-9 codes attached to medical claims for the treatment of these injuries. Medical costs were calculated for claims covered by L&I using the variable for paid medical costs for closed claims and estimated total medical cost for claims which were still open at the time the data were extracted (n = 9).

The percentage of paid lost time claims (not just to the eye) varied considerably by local, ranging from none to 80 percent. Multivariate analyses exploring incident and recurrent claims and high-risk subgroups were restricted to union locals which had less than 10 percent of their paid lost time claims from self-insured employers to decrease potential bias created by the failure to adequately identify cases that did not result in paid lost time. These analyses involved carpenters affiliated with locals doing predominantly light commercial work, residential carpentry, and drywall work. The percentages of self-insured paid lost time claims from self-insured employers were 8 percent, 1.4 percent, and 1.9 percent, respectively, for these categories overall.

The number and rates (events/person-hours at risk) of incident and recurrent claims were calculated. Using a customized program, each of the events of interest and person-time at risk for these individuals was stratified by age, gender, time in the union, and predominant type of carpentry work for analyses with Poisson regression. The program treated age and time in the union as time-varying variables, allowing them to change appropriately throughout the 84-month follow-up period. A popular application of Poisson regression concerns the modeling of failure rates for different subgroups.[6] In this case, it was used to determine whether the rates of eye injuries were significantly different for incident and recurrent events and across strata of age, gender, predominant job task, and time in the union. Recurrent events were differentiated from incident ones using standard dummy variable coding. A priori it was decided that age and gender would be left in the models for descriptive purposes.

The generation of descriptive statistics, initial calculation of crude and stratified rates, and the data stratification were done using SAS (Version 6.12).[7] Poisson regression analyses were done using EGRET.[8]

RESULTS

Description of the Cohort

From the union eligibility file, 12,958 individuals were identified who worked at least three months of union time and had at least one month of insurance eligibility through the CTWW between 1989 and 1995. The cohort was dynamic, with entrances and exits over the seven-year period; months worked ranged from 3 to 84, with a mean of 35 months and a median of 29 months. Over this seven-year period the cohort worked 65,187,647 hours. The total hours worked peaked in the year 1992 (10,248,436 hours) and was lowest in 1995 (8,850,748).

Date of birth and gender were identified for 99 percent of the cohort. The mean age when first observed was 35 years and median age was 33 years. The cohort was predominantly male, with only 323 women (2.5%), who contributed just under 2 percent of the hours worked. The union initiation date, only available from the national union membership files, was missing for 24 percent of the cohort. Using the records from the CTWW, the first year that each individual was observed in the Washington State trust files was identified, i.e., the first year that the CTWW had a record of participation in *any* union pension fund even if outside the state of Washington. Each individual was assigned the earliest of these observed dates (observed in trust data files or union initiation) to estimate time as a union carpenter.

There are 18 union locals included in the Carpenters' Trusts of Western Washington. In addition, the trust maintains records for individuals with a local assignment of '99'; these '99' individuals are members of locals outside of Western Washington but are working in the state of Washington. For 253 individuals, we were unable to identify a union local that is covered through the Carpenters' Trusts of Western Washington. Among the group of 253 people, there were 15 'travelers' assigned a '99,' and 238 individuals for whom a Washington state local was identified in the years of interest but not a local in Western Washington. These individuals made up 2 percent of the cohort and contributed less than 1 percent of the hours worked during this seven-year period. For another 987 individuals, we were unable to identify a union local in Washington State during this time period. These individuals made up 7.6 percent of the cohort but contributed only 1.5 percent of the hours worked.

Claims Filed

Overall Claims

A total of 1730 non-rejected claims for eye injuries were filed by 1428 different individuals between the years 1989 and 1995 in months in which the individual worked union hours. The eye was the third most common body part injured, following back and finger injuries, and accounted for 12 percent of all non-rejected claims.

The ANSI code descriptions of the claims are presented in Table I. The vast majority of these injuries were described as

scratches (82.6%) and were most commonly caused by being abraded by a foreign object (74%) or struck by something (17.2%). The most common source of injury was described as particles (66.3%), followed by metal chips (14.3%). Although there were many objects (source codes) associated with eye injuries, 95 percent were included in the 13 most common which are presented in the table.

TABLE I
ANSI nature of injury descriptions of eye injuries among union carpenters Washington State 1989–1995

Nature of injury	Frequency (%)[A]
Scratches	1421 (82.6)
Conjunctivitis	77 (4.5)
Cut	73 (4.2)
Welders' flash	42 (2.4)
Contusion	33 (1.9)
Ill-defined symptoms	29 (1.7)
Burn/chemical	21 (1.2)
Burn/heat	15 (0.9)
Eye/other	3 (0.2)
Eye diseases	2 (0.1)
Multiple injury	2 (0.1)
Radiation/non-ionizing	2 (0.1)
Injury, NEC	1 (0.1)
(Missing = 9)	
Mechanism of injury	**Frequency (%)[A]**
Abraded	1270 (74.1)
Struck by	298 (17.2)
Skin-absorbed toxin	81 (4.7)
Hot object	13 (0.8)
Skin contact w/toxin	6 (0.4)
Caught	2 (0.1)
Toxin NEC	1 (0.1)
(Missing = 16)	
Source of injury	**Frequency (%)[A]**
Particles	1129 (66.3)
Metal chips	243 (14.3)
Metal fasteners	43 (2.5)
Welding equipment	43 (2.5)
Wood dusts	33 (1.9)
Wood items	26 (1.5)
Metal binders	24 (1.4)
Scrap/waste	17 (1.0)
Cement	16 (0.9)
Chemicals	15 (0.9)
Sliver/splinter	11 (0.6)
Calcium hydroxide	10 (0.6)
Branches/bark	9 (0.5)
(Missing = 27)	
(all others accounted for < 5%; each less than 0.5%)	

[A]Percent of those with code.

Paid Lost Time Claims

There were only 31 claims filed for eye injuries which resulted in paid lost time from work, which occurs on the fourth day away from work in the state of Washington. The nature and source of these more serious injuries are contrasted with those of claims which did not result in paid lost time in Table II. Scratches from particles were the most common injuries overall, but they are responsible for a much greater proportion of the less serious events. Cuts from metal fasteners and cuts from particles were responsible for greater proportions of the lost time injuries.

Twenty-five (80.6%) of the lost time injuries were covered through Labor and Industries, and six were reported from self-insured employers. In Table III, information is provided on days lost, medical costs paid, the ANSI description of the events,

TABLE II
Injury nature and source for non-rejected eye injuries among union carpenters Washington State 1989–1995

Nature and source	Frequency (%)
All claims	
Scratches from particles	1029 (60.7)
Scratches from metal chips	221 (13.0)
Conjunctivitis from particles	51 (3.0)
Welders' flash from welding equipment	42 (2.5)
Scratches from wood dusts	30 (1.8)
Scratches from wood items	23 (1.4)
Scratches from metal fasteners	20 (1.2)
Cut from metal chips	17 (1.0)
Cut from particles	20 (1.2)
Scratches from metal binders	14 (0.8)
Ill-defined symptoms from particles	13 (0.8)
Contusion from metal fasteners	11 (0.6)
Cut from metal fasteners	10 (0.6)
Scratches from sliver/splinter	9 (0.5)
(Missing = 34)	
(all others together account for < 11%)	
Claims resulting in paid lost time from work	
Scratches from particles	8 (28.6)
Cut from metal fasteners	6 (21.4)
Scratches from metal chips	3 (10.7)
Cut from particles	2 (7.1)
Scratches from metal items	1 (3.6)
Scratches from chemicals	1 (3.6)
Scratches from mineral	1 (3.6)
Scratches from non-power tool	1 (3.6)
Scratches from wood items	1 (3.6)
Cut from metal items	1 (3.6)
Contusion from cement	1 (3.6)
Contusion from head coverings	1 (3.6)
Welders' flash	1 (3.6)
(Missing = 3)	

and the ICD-9 codes assigned to the claims for medical care for these more serious eye injuries covered by L&I for which all the information was available. The actual description from the first report of injury was available for seven of the serious injuries and is included to supplement the ANSI description.

When comparing ANSI coded data and ICD-9 codes for treatment of these injuries, some coding imprecision and error is obvious. One event described by ANSI codes as 'ill-defined symptoms' appeared to have involved a contusion to the eye based on the ICD-9 codes associated with the treatment of this injury. One event was described as 'scratches from inhaled toxins,' clearly a coding error. The injury from ICD-9 codes appeared to have been related to toxic effects on the eye of exposure to a metal or fume.

TABLE III

Paid lost time eye injuries: 26 events (81.2%) covered by Labor and Industries with medical data and ANSI codes

Paid lost days	Costs for medical care	ANSI nature, mechanism and source *Description from first report*	ICD-9 diagnoses
198	$27,982	Cut from being struck by metal fastener *Nailing up form; nail stuck in L eye*	Laceration of eye; ill-defined symptoms; retinal detachment; recurrent retinal detachment; cataract; profound impairment both eyes; disorder of refraction; aphakia
94	$14,654	Cut from being struck by flying object; metal fastener *Hammering nails while framing; nail flipped back and struck L eye*	Laceration of eye; ocular penetration; vascular disorder of iris and ciliary body; unspecified disorder of refraction; corneal opacity; corneal degeneration
74	$4654	Cut from being struck by metal fastener *Nail hit eye while hammering*	Penetrating wound of orbit; ocular laceration without prolapse of tissue; laceration of eye; central opacity of cornea; punctate keratitis; unspecified disorder of refraction
65	$13,972	Cut from being struck by flying object; metal fastener *Hit nail with hammer; nail glanced off board into eye*	Open wound of eyeball; ocular penetration
64	$9908	Scratches from being abraded by foreign object; particles *Pulling a nail while installing bridging at truss joint; unidentified object struck eye.*	Penetration of eyeball with magnetic foreign body; corneal foreign body; other foreign body eye; recent retinal detachment, partial with giant tear; vitreous hemorrhage
52	$8826	Ill-defined symptoms *Putting in wires with lag gun*	Unspecified contusion of the eye; hemorrhage of iris and ciliary body; vitreous hemorrhage; penetration of eyeball with magnetic object
36	$9705	Cut from being struck by metal fasteners *Struck in eye with nail after loose nail on floor hit by hammer*	Laceration of eye; ocular penetration; unspecified open wound of the eyeball; foreign body on external eye; retinal hemorrhage; vitreous hemorrhage; corneal opacity; cortical senile cataract; congenital nystagmus; visual field defect
27	$1422	Scratches from being abraded by foreign object; particles	Superficial injury to cornea; corneal ulcer; other corneal deformity
25	$3448	Contusion from being struck by metal items	Ocular laceration without prolapse of ocular tissue; unspecified laceration of eye; other anomalies of iris and ciliary body; corneal opacity
23	$3793	Contusion from being struck against head coverings	Hemorrhage of iris or ciliary body; unspecified disorder of optic nerve; contusion of eye; intracranial injury
18	$3691	Cut from being struck by falling objects; particles	Ocular laceration with prolapse of intra-ocular tissues; penetration of eyeball with foreign body
15	$1806	Cut from being struck by metal fasteners	Contusion of eyeball; unspecified laceration of eye; undiagnosed eye disease; optic neuritis, unspecified
7	$84	Welders' flash; skin-absorbed toxin; welding equipment	Contusion of eyeball

(Continued on next page)

TABLE III
Paid lost time eye injuries: 26 events (81.2%) covered by Labor and Industries with medical data and ANSI codes *(Continued)*

Paid lost days	Costs for medical care	ANSI nature, mechanism and source *Description from first report*	ICD-9 diagnoses
5	$415	Scratches from being abraded by foreign object; particles	Superficial injury to eye; acute conjunctivitis; foreign body on cornea
4	$280	Scratches from being abraded by foreign object; metal chips	Corneal abrasion; corneal foreign body
3	$543	Scratches from being abraded by foreign object; particles	Abrasion infected (joint disorder; selling of limb)
3	$871	Scratches from being struck by non-power tool	Contusion of eyeball; recession of chamber angle; ocular hypertension
3	$270	Scratches from being abraded by particles	Corneal abrasion; pain in/around eye
3	$111	Scratches from being abraded by foreign object; particles	Corneal abrasion; foreign body
2	$299	Scratches from being abraded by foreign object; metal chips	Foreign body; corneal foreign body
1	$135	Scratches from being abraded by foreign object; particles	Conjunctivitis
1	$698	Scratches from inhaled toxin; chemicals	Toxic effect of metals; toxic effects of unspecified gases, fumes, vapors
1	$166	Scratches from being abraded by foreign object	Superficial injury to conjunctiva
1	$287	Cut from being abraded by foreign object; particles	Penetration of eyeball with foreign body
1	$217	Struck by foreign object; wood items	Superficial injury to cornea

Twelve of the paid lost time injuries resulted in over two weeks of lost time from work (i.e., more than seven paid days). These injuries are clearly different from those resulting in a speedier return to work, and the 12 events accounted for over 95 percent of the costs for medical care and paid lost days for paid lost time claims. This group of serious events was most often described as the result of being struck by metal fasteners (6/12 or 50%), resulting in lacerations of the eye, ocular penetrations, and open wounds of the eyeball. The descriptions from the first report of injury identify 'metal fasteners' as nails in five of the six injuries, and we could document that four of the injuries occurred while hammering.

Rates

The overall rate of filing claims for eye injuries, based on reported cases, was 5.3 per 200,000 hours worked. Overall, 13.6

TABLE IV
Estimated rates of eye injuries by year union carpenters 1989–1995 Washington State

	All Claims			Paid lost time claims	
Year	Reported frequency	Estimated frequency	Rate[A] (95%) CI[B]	Frequency	Rate[A] (95%) CI[B]
1989	320	364	8.1 (7.2, 9.1)	6	0.13 (0.05, 0.28)
1990	276	310	6.9 (6.2, 7.7)	4	0.09 (0.02, 0.23)
1991	306	352	7.2 (6.5, 8.0)	4	0.08 (0.02, 0.20)
1992	267	308	6.0 (5.4, 6.7)	6	0.12 (0.04, 0.28)
1993	212	259	5.5 (4.9, 6.2)	4	0.08 (0.02, 0.21)
1994	186	219	4.9 (4.2, 5.7)	4	0.09 (0.02, 0.23)
1995	163	190	4.3 (3.7, 5.0)	3	0.07 (0.01, 0.20)

[A]Rates (cases/200,000 hours worked) based on estimated frequency including non-reported claims without lost time from work from self-insured employers.
[B]Approximate Poisson 95 percent confidence interval.

percent of all claims filed (not just for eye injuries) were from self-insured employers. Estimating additional cases which did not result in lost time among individuals working for self-insured employers would inflate the frequency of claims an additional 273 cases, resulting in an estimated rate of 6.1 per 200,000 hours. Claims resulting in paid lost time from work were filed at a rate of 0.10 per 200,000 hours worked. The rates of filing all non-rejected eye claims and those resulting in paid lost time are presented by year and by age, gender, time in the union, and union local affiliation, in Tables IV and V, respectively. The total number of claims reported in each of these categories is presented, as is an adjusted frequency to include the estimation of self-insured claims not resulting in paid lost time that would not have been reported to L&I.

TABLE V

Estimated rates of filing claims for eye injuries by age, gender, time in the union, and predominant type of carpentry work for union carpenters 1989-1995 Washington State

		Overall claims			Paid lost time claims	
		Frequency				
	Hours worked	Reported	Estimated[A]	Rate (95% CI)[A,B]	Frequency	Rate (95% CI)[B]
Age						
< 20	479,591.7	18	19	7.9 (4.8, 12.3)	0	—
20–24	4,098,550.4	203	223	10.9 (9.5, 12.5)	4	0.19 (0.05, 0.49)
25–29	8,367,937.6	316	355	8.5 (7.6, 9.5)	7	0.17 (0.14, 0.70)
30–34	12,520,719.2	411	478	3.8 (3.5, 4.2)	6	0.10 (0.07, 0.22)
35–39	13,344,818.4	372	433	3.3 (3.0, 3.6)	7	0.10 (0.04, 0.21)
40–44	10,071,049.6	188	221	4.4 (3.8, 5.1)	2	0.04 (0.004, 0.14)
45–49	6,205,783.4	96	116	3.7 (3.1, 4.4)	3	0.10 (0.02, 0.29)
50–54	4,689,650.5	67	82	3.5 (2.8, 4.4)	1	0.41 (0.01, 2.3)
55–59	3,563,723.7	37	45	2.5 (1.5, 3.4)	1	0.60 (0.02, 3.3)
60–64	1,625,954.6	17	22	2.7 (1.7, 4.1)	0	—
65+	145,967.9	5	5	6.7 (2.2, 15.6)	0	—
Unknown age	73,900.0	0	0	—	0	—
Gender						
Male	64,079,314.9	1701	1955	6.1 (5.7, 6.5)	31	0.10 (0.07, 0.14)
Female	1,087,903.6	29	39	5.3 (3.8, 7.2)	0	–
Missing	20,358.3	11	11		0	–
Time in union						
< 2 years	10,295,574.3	395	439	8.5 (7.7, 9.3)	5	0.10 (0.03, 0.23)
2–3 years	7,007,903.6	248	279	8.0 (7.1, 9.0)	6	0.17 (0.06, 0.37)
4–5 years	5,510,456.2	175	203	7.4 (6.4, 8.5)	3	0.11 (0.02, 0.32)
6–7 years	3,995,024.2	121	141	7.1 (6.0, 8.4)	2	0.01 (0.01, 0.36)
8–9 years	3,398,248.5	89	125	7.4 (6.2, 8.9)	1	0.06 (0.002, 0.33)
10+ years	34,980,440.2	697	830	4.7 (4.4, 5.0)	14	0.08 (0.04, 0.13)
Type of work						
Light commercial	17,030,900.5	475	520	6.1 (5.6, 6.7)	7	0.08 (0.03, 0.16)
Heavy commercial	24,653,605.7	514	643	5.2 (4.8, 5.6)	12	0.10 (0.05, 0.18)
Residential	896,358.9	31	31	6.9 (4.7, 9.9)	0	—
Drywall	9,631,821.9	366	373	7.7 (6.9, 9.9)	7	0.15 (0.06, 0.31)
Millwrights	1,251,635.7	41	51	8.2 (6.1, 10.8)	0	—
Piledrivers	4,354,286.4	90	126	5.8 (4.8, 7.0)	0	—
Cabinet/fixtures	415,458.7	1	3	1.4 (0.29, 4.1)	0	—
Mixed	5,383,666.7	114	146	5.4 (4.6, 6.4)	1	0.04 (0.001, 0.22)
Local outside W. Washington	609,510.5	15	17	5.6 (3.3, 9.0)	0	—
No local identified	961,402.0	82	93	19.4 (15.7, 24.1)	4	0.83 (0.23, 2.1)

[A]Rate (per 200,000 hours worked) includes estimate of non-reported claims without lost time from work from self-insured employers.
[B]Approximate Poisson 95 percent confidence interval.

There was a steady decline in the rate of filing claims for all eye injuries over the seven-year period. Although not as steady and not at a level of statistical significance, there was also a decline in the rates of paid lost time claims. The overall rates for men and women were similar. The rates generally declined with increasing age and increasing time in the union. Individuals without a Washington State local identification had significantly higher rates of claims than those for whom the local identification information was available. Individuals affiliated with locals doing predominantly millwrighting, residential carpentry, and drywall work had the highest rates of filing eye injury claims. No women filed claims for lost time eye injuries. There were no significant differences in the rates at which paid lost time claims were filed when comparing age categories or time in the union. Interestingly, the only group that had significantly higher rates of paid lost time eye injuries were those for whom no local could be identified. However, all the rates for paid lost time claims are based on very small numbers.

Costs

The costs associated with medical care for these 1730 claims are summarized in Table VI. The injuries which did not result in paid lost time are presented separately from those which did result in paid lost time. Total medical costs of $309,966 were reported for medical-only claims with a mean cost per claim of $157—this is in marked contrast to the 25 claims covered by L&I which resulted in paid lost time with a mean cost per claim of $4848. Estimating costs for the expected 273 self-insured medical-only claims and the six self-insured claims that resulted in paid lost time, based on average costs for L&I covered claims, results in total costs for all claims of $460,837, for which $150,291 (32.6%) is attributable to the 1.5 percent of claims that resulted in paid lost time from work.

Incident and Second Claims

Among the group (n = 5981) whose locals had less than 10 percent of their paid lost time claims from self-insured employers between 1989 and 1995, 596 incident eye injuries and 88 second eye injuries were identified. Incident events occurred at a rate of 5.1 per 200,000 hours, compared to a rate of 8.3 per 200,000 hours for individuals who had filed a claim previously for an eye injury event (RR = 1.6).

Hours at risk in each strata, number of events, crude rates and rate ratios, and adjusted rate ratios from Poisson regression analyses are presented in Table VII. There was a steady decline in the rate of filing claims with increasing age and increasing time in the union. No statistically significant differences were seen between men and women which is not surprising because there were very few women in the cohort. Individuals affiliated with the local doing predominantly drywall work had significantly higher rates of claims (RR = 1.2) than the light commercial group. The rate ratio for second events (1.6) did not change when adjusted for the other variables in the model. Five (16.1%) of the 31 individuals in our cohort with paid lost time claims had filed a previous eye injury claim.

DISCUSSION

Eye injuries were the third most common work-related injury among this group of union carpenters. The rates of these injuries appear to be decreasing over time, consistent with the overall pattern of compensation injuries among the group. Although very common, these eye injuries rarely resulted in paid lost time from work. One-third of the total costs were attributable to a very small group of serious injuries. Recurrent injuries in this cohort occurred at a rate 1.6 times higher than incident events when controlling for age, gender, time in the union, and the predominant type of work of the union local with which the carpenter was affiliated. High-risk groups included younger carpenters and those with less union experience. The highest rates of injury were among individuals with no known union local affiliation. In addition, millwrights and drywall workers appear to be at higher risk of eye injuries than their counterparts doing other types of carpentry work.

Our findings regarding severity and cost are consistent with those of Waller et al.[3] in their description of injuries to carpenters in Vermont using data from patients seen in a hospital emergency department. Three percent (3%) of the cases of injury to the eye involved an Abbreviated Injury Score (AIS) of 2 (AIS 1 = minor, 2 = moderately severe, 3 = severe, not life threatening),[9] with none higher then 2.[3] The average of the paid lost time for these eye injuries was 1.4, and the median was 0.[10] This reported average time would not have resulted in paid lost time from work in most workers' compensation systems

TABLE VI
Costs for medical care for eye injuries among union carpenters
Washington State 1989–1995

Medical only claims Reported to Labor and Industries	Paid lost time claims Covered by Labor and Industries
Number of claims = 1705	Number of claims = 25
Mean cost per claim = $157	Mean cost per claim = $4848
Total reported costs = $309,966	Total reported costs = $121,203

including Washington State, which pays lost time on the fourth day after injury. The average medical costs were $150 with a median of $50, and the majority resulted in little to no follow-up care. Although the vast majority of these injuries did not reach the threshold for paid lost time in the state of Washington, we do not know how many injuries resulted in loss of time from work of three days or less. The costs associated with this loss would be borne directly by the injured worker.

There is little in the literature about repeat eye injuries among worker populations. In a case-control study of eye injuries among soldiers, prior eye injury in the last year was associated with repeat eye injury (OR 4.8, 95% CI 1.7-13.5).[11] An Australian study of eye injuries among workers seen in an emergency room found that 71 percent had previous eye injuries at work,[12] indicating that repeat injuries are common among other occupational groups as well.

The first report of injury information allowed us to identify that nails were the 'metal fasteners' most commonly associated with serious ocular lacerations and penetrations. These injuries most frequently occurred while hammering (67%)—not while using nail guns as we had originally suspected. Hammering is a documented risk factor for serious penetrating injuries.[13–15] Fong[14] reported 53 percent of penetrating work-related eye injuries were the result of hammering which is consistent with our findings related to the most serious eye injuries among these carpenters. With limited data from first reports, we were able to document that *at least* 10 percent of all medical costs for eye injuries and 35.5 percent of the medical costs for eye injuries which resulted in paid lost time were associated with injuries sustained while hammering. ANSI coded data, which describe the object which caused the eye injury such as the particle or metal fastener, do not allow us to document all of the eye injuries which were the result of hammering.

We observed similar patterns of eye injuries in our study of residential construction workers in North Carolina.[2] Descriptive information was available for 46 medical cost (greater than or equal to $2000) or paid lost time (greater than seven lost days) eye injury cases for the period, 1993–1994. Injuries due to nails accounted for 16 (34.8%) of these more serious eye injuries. The use of a hammer to drive or pull nails accounted for nine (56.3%) of the injuries, and nails from nail guns accounted for two injuries (12.5%). In five of the cases (31.3%), it could not be determined from the descriptive information whether a hammer or a nail gun was involved. The use of a hammer is a very common occupational exposure among carpenters, and the serious nature of injuries sustained from the use of this tool may not be appreciated. This is an important point for preventive efforts among these construction workers.

TABLE VII
Incident and first recurrent eye injuries union carpenters[A] Washington State 1989–1995

	Number of events	Hours at risk	Crude rate[B]	Crude rate ratio	Adjusted rate ratio (95% CI)
Age					
<30 years	242	5,747,744	8.4	1.0	1
30–44 years	368	13,671,429	5.4	0.64	0.80 (0.66, 0.97)[C]
45+ years	74	5,857,395	2.6	0.30	0.46 (0.34, 0.63)[C]
Gender					
Male	674	25,026,950	5.4	1.0	1
Female	10	286,500	7.0	1.3	1.0 (0.51, 2.1)
Time in the union					
<4 years	338	8,701,113	7.8	1.0	1
4–9 years	112	4,018,647	5.6	0.72	0.68 (0.54, 0.85)[C]
10+ years	234	12,611,450	3.8	0.48	0.62 (0.50, 0.76)[C]
Local affiliation					
Light commercial	348	14,508,505	4.8	1.0	1
Residential	29	889,891	6.6	1.4	1.1 (0.76, 1.6)
Drywall	282	8,983,392	6.2	1.3	1.2 (1.0, 1.4)[C]
Claim status					
Incident	596	23,198,833	5.2	1.0	1
Recurrent	88	2,132,377	8.2	1.6	1.6 (1.2, 1.9)[C]
Deviance 175 df = 176.3					

[A]Includes only locals with less than 10 percent of paid lost time claims from self-insured employers 1989–95.
[B]Rate per 200,000 hours worked.
[C]Statistically significant at 0.05 level.

The higher rates of injuries among younger workers and those with less union experience may be related to training and experience or different job exposures. The group of workers for whom we could not identify a union local affiliation had markedly higher rates of eye injuries than other carpenters. These individuals worked proportionately fewer hours and may represent a more transient workforce. Millwrights were not included in our multivariate analyses because greater than 10 percent of their paid lost time claims had come from self-insured employers. Their crude rates were as high as those of drywall workers and residential carpenters and raise concerns. The millwrights exposures in industry may be quite different from those of construction carpenters.

Strengths and Limitations

Anything which influences an individual's decision to file a compensation claim would affect our findings. In addition, the failure to identify claims which did not result in paid lost time from work from self-insured employers resulted in an underestimation of the overall rate. We attempted to estimate the magnitude of this error to allow crude comparisons of patterns by age, gender, time in the union, and the predominant type of work. We did not feel that it was appropriate to look for high-risk subgroups or explore incident and repeat claims using all the locals. For this reason, we limited the latter analyses to union locals which had less than 10 percent of their paid lost time claims from self-insured employers over this seven-year period. We recognize that we still failed to identify all claims and that there was some misclassification of incident and repeat events. However, the bias should be of a lesser extent, and the information gleaned should still be useful in beginning to identify high-risk groups and in understanding eye injuries among this group of construction workers.

These data, based largely on ANSI coding, provided information about the object that entered the eye (usually particles) but did not provide information about what the individual was actually doing at the time of injury. We do not have detailed information concerning the type of work performed by members of this cohort, and the categorization of the predominant type of work of the union locals is crude. For example, we do not know in how many instances the injured party was actually working with the offending substance as opposed to working near someone else who was. This information could be important if workers are at risk from stand-by exposures.

The Georgia Eye Injury Registry reported approximately 20 percent of eye injuries were sustained by bystanders. These were serious events "resulting in permanent and significant structural or functional change . . ." and were not limited to occupational injuries.[16] Hunting[1] and Waller et al.[3] had the advantage of interviewing injured workers, allowing the collection of more detailed information about what the workers were doing at time of injury. In this manner, they were able to identify that welding, drilling, and the use of power tools were often associated with eye injuries[1] and that the majority of eye injuries from circular saws were from flying sawdust.[3] However, the predominantly descriptive data for our carpenter cohort do allow identification of hammering as a significant hazard for the rare but very serious injuries.

We had no information about the use of protective eye equipment by this group of workers. However, among individuals with eye injuries there is a marked variation in the proportion of individuals who report the use of eye protection, ranging from less than 8 percent in a largely non-work-related urban trauma series,[17] to 10 percent among injured agricultural workers,[18] and finally to "many" carpenters.[3] De la Hunty et al.[12] found that 63 percent of Australian workers seen in the emergency department for eye injuries reported wearing protection, but only 14 percent were wearing protection that complied with the current Australian standard. In addition to the quality and condition of the eye protection, the workers reported the history of a previous eye injury as an influential factor in their decision to use eye protection—a particularly interesting fact because these were individuals presenting for treatment of an eye injury. Waller[3] reported that many of the injuries from circular saws among carpenters occurred despite the use of protective goggles, for example, while goggles were being removed. He felt that this fact pointed to the need for mechanical controls such as built-in dust collection systems.

It has been pointed out that relatively little is known about less severe injuries that cause most of the visits to physicians.[19] In this case, understanding more about the nature of eye injuries among construction workers may give more insight into factors which may play important roles in understanding preventive behaviors.

A matrix for understanding injury and identifying multiple points of intervention has been described by William Haddon.[20] This conceptual model uses the classic public health paradigm of agent, host, and environment applied to pre-event, event, and post-event factors associated with the injury. Haddon separates the events leading to the injury and those that occur subsequently that can affect the ultimate outcome. The goal is primary prevention which, within the context of this investigation, involves the prevention of eye injuries. However, Haddon's model looks at prevention at other junctures as well and would involve evaluation of appropriate medical care to maximize visual conservation after injury. Even though these administrative data do not allow us to evaluate prevention at this level, we acknowledge this is an important aspect of prevention of visual impairment after eye injury.

CONCLUSIONS

The literature points to the preventable nature of eye injuries through the use of protective equipment and education of workers.[12,21] Although these steps may seem to be obvious, we question whether this simplistic approach, focused solely

on individual worker's carefulness and compliance with safety measures, is adequate.

Workers' motivation to undertake personal safety initiatives has been reported to be closely related to perceived safety norms of the supervisor. This motivation is higher when the supervisor has some power and influence over decisions that affect the safety of his or her work group and practices joint involvement with his or her work team in injury prevention.[22] In addition, these same researchers reported that the supervisor's involvement in safety was also correlated with other predictors of safety behaviors, including group cohesiveness and cooperative relationships between group members and the supervisor. These findings, from a study of industrial settings, may be even more salient when considered within the context of the culture of construction work.

Construction workers are always working themselves out of a job and, consequently, frequently change employers and work sites. The work assignments change on construction sites as does the cast of workers and contractors. Several trades may work on sites simultaneously, with each trade reporting to different contractors and supervisors. In contrast to many industrial settings, the lack of a permanent job site and the small size of many construction sites make it more difficult to place environmental controls or to easily regulate or encourage the use of safety practices. Construction workers structure their work environment on a daily basis, making decisions that have great potential to affect their health and safety. This is an aspect of construction that can be viewed as an opportunity—if supervisors and workers make appropriate choices and establish work norms that will protect their health.[23,24]

In addition, there is evidence from the consumer product safety literature[25–27] that perceived severity of risk may have more impact on preventive behavior than frequency of events. The worker's involvement in activities aimed at improving health and safety in industry has been shown to be influenced by perceived level of risk as well.[28,29] Minor lacerations or abrasions are likely not to be perceived as serious events by these workers, even though they can become serious without appropriate care. The possible lack of perceived severity of eye injuries may be an impediment to use of eye protection and seems consistent with the high rates of incident and repeat eye injuries we saw among these construction workers. This has practical implications for the messages that carpenters, and their supervisors, should receive regarding their risk for eye injuries and the serious nature of eye injuries associated with the use of a tool common to their work—the hammer.

The prevention of eye injuries among construction workers is likely to require a multifaceted approach. The development of more mechanical controls to decrease exposures to flying particles and chips is clearly reasonable and should have payoffs, as have other public health interventions that do not rely on personal behavior change. Barriers to the use of eye protection, such as visibility, cleanliness, comfort, condition of goggles or glasses, storage near the work site, and group norms[3,12] are all potentially real impediments for construction workers and these issues need to be addressed through organizational factors and eye protection equipment design improvements. Attention should be given to ways of changing the norms on job sites through training of supervisors regarding risk and safety measures, not just focusing on individual workers.

By addressing the problem from multiple perspectives, the Built-Rite program reduced injuries by 77 percent over a two-year period.[30] This program on one large job site involved unions, craftspeople, and contractors in focus groups to evaluate eye injuries and plan preventive strategies for a large petrochemical construction project. An optical company was brought on site during work hours to fit workers for prescription safety glasses. Attention was made to decrease dust exposure by wet-washing some areas before work began, and eyewash stations were located near work areas. This type of intervention warrants further evaluation, particularly because some of these interventions will require more effort to implement on smaller construction sites.

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