CLINICAL STUDY

The epidemiology of ocular injury in a major US automobile corporation

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Abstract

Purpose **Although occupational eye injuries account for a large proportion of ocular injuries, few industry-specific data have been published. To address this problem, we examined the epidemiology of eye injuries in a large automobile corporation.**

Methods **The study population included all hourly-paid persons employed between July 1989 and June 1992 at 33 plants of the UAW-Chrysler Corporation. Incident ocular injury data were obtained from an active surveillance system. Year-end employee censuses were used to estimate the population at risk.**

Results **A total of 1983 work-related eye injuries occurred over the 3 year period, with an incidence rate of 14.9 per 1000 person-years. Workers aged 20–29 years had the highest incidence of eye injuries (28.2 per 1000 person-years). Men had a higher incidence of injury than women across all ages, with an age-adjusted incidence of 15.6 per 1000 person-years and age-adjusted relative risk of 1.5 (95% confidence interval: 1.4, 1.6). Superficial foreign bodies and corneal abrasions made up 86.7% of all injuries while open globe injury occurred in only 3 cases. Only 25% of workers had been using some form of eye protection at the time of injury. Almost one-third (32.3%) of ocular injuries resulted in the inability of workers to resume their normal duties for at least 1 day.**

Conclusion **Workplace eye injuries in the automotive industry account for significant avoidable morbidity and lost productivity.**

Key words Automobile industry, Epidemiology, Eye injury, Incidence, Ocular trauma, Work-related injury

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Although occupational eye injuries are an important cause of morbidity in the adult working population, data on the incidence of eye trauma in the workplace are limited. Various case series and eye registry data in the United States have indicated that they comprise between 22% and 48% of all ocular trauma.[1–4] A recent statewide population-based study using hospital discharge data estimated an annual incidence of severe ocular injury in the workplace of 1.76 and 2.98 per 100 000 employed persons when ocular trauma was the principal discharge diagnosis and principal or secondary discharge diagnosis respectively.[5] However, less severe injuries not requiring hospitalisation were not estimated in this study. A study in Dane County, Wisconsin, estimated an incidence of 55 work-related eye injuries per 100 000 persons treated at emergency departments.[6] Population-based studies yield a much higher rate; one such study in New England estimated the annual incidence of eye injuries occurring at work to be approximately 600 per 100 000 persons.[7]

The burden of less severe eye injuries cannot be dismissed easily because each injury can potentially lead to sight-threatening complications and incur both cost of medical care (direct costs) and time lost from work (indirect costs). Of equal significance is the fact that minor eye injuries are often preventable by using simple protective eyewear and modifying worksite environments. Of the 900 000 occupational eye injuries estimated by the National Institute for Occupational Safety and Health to have occurred in 1982, 84% were classified as minor.[8] In the Dane County study, 97.8% of the 188 cases of work-related trauma were classified as minor or moderate.[6] Studies that include severe injuries exclusively are therefore only partially representative of the size and impact of the problem.

Our objective in this study was to estimate the incidence of eye injuries among workers in a major US automobile corporation and to identify problem areas in eye injury prevention in the workplace.

Methods

Our study population included all hourly-paid persons employed between July 1989 and June 1992 at UAW-Chrysler Corporation plants. The population was derived from a total of 33 plants in the continental United States. Plants were classified into four main categories: assembly (5 plants), stamping (3), power train (8) and parts (17). The age of the employees ranged from 18

Eye (1998) 12, 870–874

to 70 years. Approximately 88% of the workers were male. Data on ethnicity were not available. Year-end census of the UAW-Chrysler employees was used to estimate the population at mid-point for the 12 months from 1 July to 30 June for each of the three study years.

The Chrysler Occupational Medical and Safety Surveillance System (COMSS) was established as an active health and safety surveillance system run by the UAW-Chrysler Corporation. Corporation policy required that within 24 h of the report of an injury to the safety department, the safety department would complete a preliminary investigation of the injury incident and either a nurse or a doctor in the medical department would assess the patient. Both the safety and medical departments recorded this information regarding the injury in the COMSS.

The data of the COMSS contained one record for each injury incident, with 63 fields describing the incident, including information on demographics of the worker (e.g. age, sex, hourly/salaried, job description), workplace location where the injury occurred, description of injury, outcome and additional preventive measures taken by the supervisor after the injury incident. Outcomes from the ocular injury were defined using the following criteria: (1) Occupational Safety Health Administration (OSHA) restricted duty days, defined as the number of days a worker was unable to perform his or her full regular job, (2) OSHA lost days, defined as the number of workdays on which an employee would have worked but could not because of occupationally related illness or injury, (3) temporary transferred days, defined as the number of days a worker was transferred to another job because of occupationally related illness, (4) no work available in plant, defined as the inability of the employee to find another position in the plant as a result of restriction of duties. We defined a worker as being unable to resume his or her normal duty if he or she had any one of the above four outcomes. Statistical comparison with outcomes from all injuries was performed using Student's *t*-test of difference in proportions between all injuries and eye injuries.

When an employee presented with an injury, the initial assessment was recorded by the nurse. If the injury required further medical attention the doctor would perform an independent evaluation and institute additional treatment, if necessary. If the doctor was not present, the patient would be sent to the emergency room of a local hospital. In order to track the recovery from the injury, the employee was required to report periodically to the medical department, where the status of recovery could be assessed and restrictions on work could be implemented to enable the injured employee to resume job tasks or be reassigned to another position.

Narrative-free text fields in the description of the injury and the activity preceding the injury allowed us to go beyond the limitations of coded data to better understand the specific circumstances and nature of the injury as well as the materials associated with the injury. Key word searches and manual review were used to identify these specific injury hazards. Key word searches on 'safety goggles', 'protective eyewear' and 'safety glasses' were also performed to give an indication of use of protective eyewear at the time of injury.

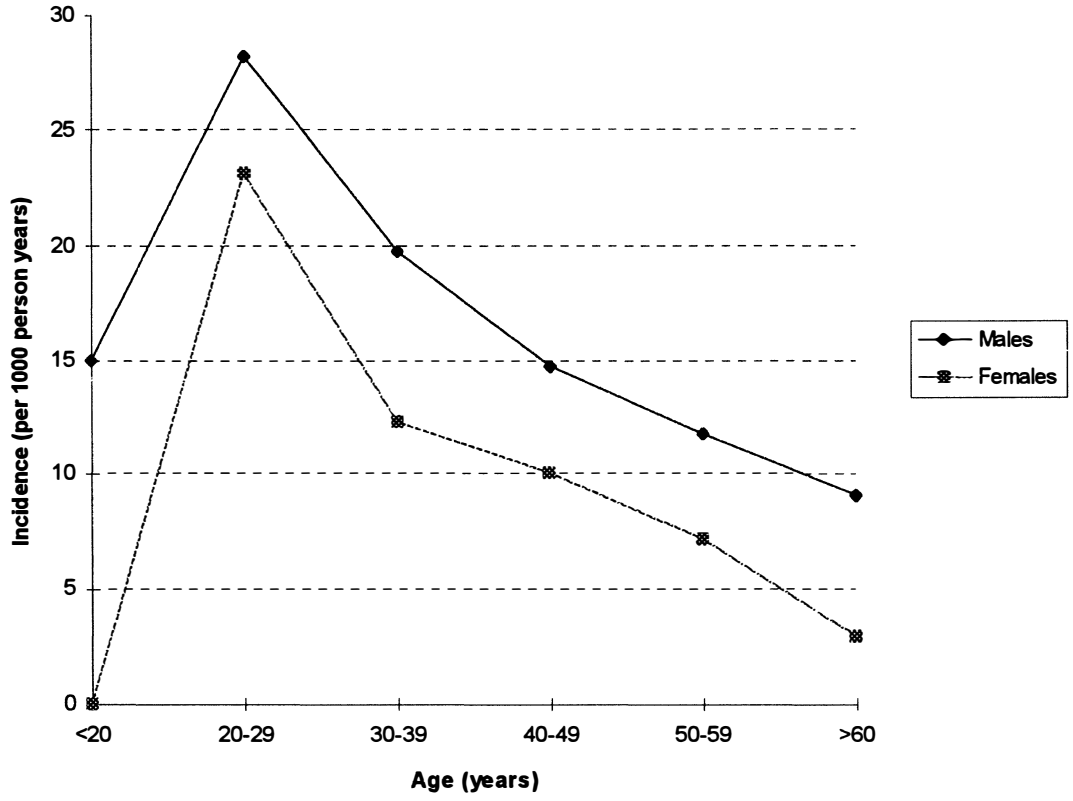

Fig. 1. *Age- and sex-specific incidence of ocular injuries, Chrysler Corporation plants, July 1989 to June 1992.*

Table 1. *Age-specific incidence of ocular injury in males and female workers, Chrysler corporation plants, July 1989 to June 1992*

Age groups (years)	Men			Women		
	No. (%) of ocular injury	Incidence per 1000 employee-years	Relative risks[a] (95% CI)	No. (%) of ocular injury	Incidence per 1000 employee-years	Relative risks[a] (95% CI)
<20	3 (<1)	15.0	1.6 (0.5, 5.1)	0	—	—
20–29	136 (7.5)	28.2	3.0 (2.2, 4.1)	22 (13.4)	23.1	7.8 (1.8, 32.5)
30–39	558 (30.7)	19.7	2.1 (1.6, 2.8)	54 (33.1)	12.3	4.1 (1.0, 16.9)
40–49	751 (41.3)	14.7	1.6 (1.2, 2.1)	61 (37.4)	10.0	3.4 (0.8, 13.8)
50–59	318 (17.5)	11.7	1.3 (1.0, 1.7)	24 (14.7)	7.2	2.4 (0.6, 10.2)
>60	54 (3.0)	9.1	1.0 (referent)	2 (1.2)	3.0	1.0 (referent)
Total	1820 (100)	15.5 (15.6)[b]		163 (100)	10.5 (10.1)[b]	

[a]Relative risks of ocular injury comparing different age groups with workers > 60 years old (referent).
[b]Age-adjusted incidence using total employee population.

Results

Between July 1989 and June 1992 there were 35 483 injury incidents, of which 1983 involved the eyes as the primary body part. This represented 5.6% of the total injuries that occurred in that period. The mean age of the ocular-injured worker was 42 years, with a range of 18–69 years. Eighty per cent were less than 50 years old. One hundred and sixty-three injuries occurred in women (8.2%) and the remainder in men (91.8%). The mean seniority of the workers in their present job was 15.7 years, with a maximum of 44 years. Ninety-two per cent of the injuries occurred on weekdays. Sixty-five per cent of the injuries occurred between 7 a.m. and 7 p.m. Ninety per cent of the injuries occurred during the first and second shifts. As each of the 33 Chrysler manufacturing plants operated on different time schedules and had different definitions of first, second and third shifts, denominator data were not available for calculation of time-specific rates of injury.

The incidence of eye injury among the workers was 14.9 injuries per 1000 person-years. Men had a higher incidence of injury than women across all age groups (Fig. 1), with an age-adjusted incidence of 15.6 injuries per 1000 person-years and an age-adjusted relative risk of 1.5 (95% confidence interval (CI): 1.4, 1.6) (Table 1). The highest incidence occurred in the 20–29 year age group, with an incidence of 28.2 and 23.1 injuries per 1000 person-years in men and women, respectively. This corresponded to a relative risk of 3.0 (95% CI: 2.2, 4.1) in men and 7.8 (95% CI: 1.8, 32.5) in women when compared with the injury rate among those 60 years or older of the respective gender.

Superficial corneal foreign body was the most common type of injury (69.2% of all ocular injuries), with an incidence of 10.3 injuries per 1000 employee-years (Table 2). Corneal abrasion was the next most common injury (17.5% of all ocular injuries), with an incidence of 2.6 injuries per 1000 employee-years. The third most common was chemical injury, with an incidence of 0.68 injuries per 1000 employee-years. Fortunately, penetrating injuries occurred in only 3 cases. One occurred in a 50-year-old man who sustained the injury while drilling under a car. Another 57-year-old man was struck in the eye by a piece of glass during windshield assembly. The third employee, a 43-year-old man, was hit in his eye by an uncoiling brake cable.

Free text searches on the activities and materials related to the ocular injury showed that the bulk of the corneal foreign body injuries and corneal abrasions were related to grinding and welding (Table 3). Nearly 50% of the chemical injuries were related to painting. Free text searches on protective eyewear usage indicated that only 493 (24.9%) workers were using some form of eye protection at the time of injury.

Six hundred and forty injuries (32.3%) resulted in the inability of the worker to resume his or her normal duty for at least 1 day (Table 4). The proportion of injuries that resulted in one or more OSHA lost or restricted workdays were 11.9% and 12.7%, respectively; the total

Table 2. *Incidence of different types of ocular injury and commonly associated jobs, Chrysler Corporation plants, July 1989 to June 1992*

Injury type	No. (%) of all injury	Incidence per 1000 employee-years	Three most common occupations
Superficial corneal foreign body	1372 (69.2)	10.3	Production operator, die maker, assembly mechanic
Corneal abrasion	348 (17.5)	2.6	Production operator, assembly mechanic, technician
Chemical injury	90 (4.5)	0.68	Production operator, technician, machine repairer
Thermal injury	58 (2.9)	0.44	Production operator, millwright, assembly mechanic
Irritative conjunctivitis[a]	41 (2.1)	0.31	Production operator, technician, mechanic
Blunt trauma/orbital injury	30 (1.5)	0.23	—
Lid lacerations	18 (0.9)	0.14	—
Penetrating injuries	3 (0.1)	0.02	—
Others/unspecified	13 (0.7)	0.10	—
Total	1983 (100)	14.9	

[a]Includes non-specific eye irritation.

Table 3. *Related activities and materials for the three most common types of injury, Chrysler Corporation plants, July 1989 to June 1992*

Injury type	Activity	No. (%) of injury	Sample accident description
Foreign body (1372 records)	Grinding	233 (17%)	Grinding a car hood when fragment of steel entered right eye
	Blowing (blew)[a]	179 (13%)	Blowing off a chuck[b] with air hose when a chip went in eye
	Drilling, cutting, screwing or hammering	74 (5%)	Drilling nut plate when shavings blew into eye
	Welding	51 (4%)	Welding when metal slag fell in behind glasses
	Cleaning	49 (4%)	Cleaning flash off part when metal blew into eye
Corneal abrasion (348 records)	Blowing (blew)	50 (14%)	Air gun blew something into eye
	Grinding	46 (13%)	Grinding steel when something flew into eye
	Welding	37 (11%)	Welding when spark flew behind safety glasses
	Drilling, cutting, screwing or hammering	29 (8%)	Grinding, hammering, sanding metal when metal chip flew in left eye
Chemical injury (90 records)	Painting	39 (43%)	Painting when paint got into eye
	Cleaning	11 (12%)	Splashed cleanser into left eye
	Spraying	10 (11%)	Spray painting when fumes from booth affected eye

[a]In many cases the description was 'something entered/flew into my eye'.
[b]Chuck: an attachment for holding a workpiece or tool in a machine (e.g. drill).

number of OSHA lost and restricted workdays were 759 and 448, respectively. Approximately 6.4% of workers had to be temporarily transferred to another job while 8.9% had no work available at their plants as a result of their injury.

Discussion

Occupational eye injury is an important worldwide problem and a major component of the approximately 2.5 million ocular injuries that are estimated to occur each year in the United States.[9] Several studies in the United States reported that between one-quarter and one-half of ocular trauma was work-related.[1–4] In Australia, one study estimated that 42% of ocular injuries were work-related,[10] while in the United Kingdom another study put the proportion of occupationally related eye injury at 70%.[11] The wide variation in estimates results partly from a lack of well-defined populations in all these studies and therefore the inability to calculate rates. Population-based studies with incidence data are not readily available.[12] Two such studies have indicated that the proportion of work-related ocular injury is between 8% and 15%.[5,6]

There is a paucity of data on industry-specific rates of ocular injury. In a study of the chemical industry, an incidence of 23 per 1000 worker-years was observed, with only 22% requiring medical attention.[13] The automotive industry is one of the major components of the economy in the United States. In one Australian study, automotive industry workers had the highest relative incidence of open globe injuries compared with other occupations but these workers were also the least likely to wear safety eyewear.[10]

This study is one of only a few available reports in which incidence rates of workplace ocular trauma could be calculated. We observed an annual incidence rate of 15 eye injuries per 1000 employees in 33 plants of a large automative company. Comparison with other reports on work-related eye injuries could be difficult and inappropriate. While the apparently high incidence in automotive workers might be due to higher risks inherent in this industry, it could also be due to the inclusion of previously underreported minor injuries not requiring medical attention at hospitals and injuries where worker compensation claims were not filed. Our observed incidence rate might even underestimate the true incidence in automotive workers as many did not work for major corporations such as UAW-Chrysler that had explicit occupational health regulations and reporting procedures. While our data have limited generalisability beyond the automotive industry, certain epidemiological features of ocular trauma in the workplace are again highlighted. For example, the high rates of injury in young people in their third decade of life as well as in men had been reported in nearly all ocular trauma studies[1–7] and were reflected in our study

Table 4. *Comparison of severity of ocular injury with all injuries, Chrysler Corporation plants, July 1989 to June 1992*

% of injuries that resulted in:	Ocular injury (n = 1983)	All injuries (n = 35 483)	p value[a]
One or more OSHA restricted workdays (1)	12.7	30.4	<0.01
One or more OSHA lost workdays (2)	11.9	25.1	<0.01
Temporary transfer to another job (3)	6.4	12.1	<0.01
No work available in the plant (4)	8.9	10.6	<0.01
Inability of worker to resume normal duty (defined as either (1), (2), (3) or (4))	32.3	51.5	<0.01

[a]Based on two-tailed Student's t-test of difference in proportions.

as well. This high incidence probably reflects either the placement of younger male workers in more hazardous jobs, or their increased susceptibility from lack of regard for safety practices or simply inexperience. It was also interesting to note that the three penetrating ocular injuries in this series occurred in older men, who were overall less likely to sustain ocular injuries. Although this could be due to sampling variability, the higher risk of severe injury in older people was also noted in hospital discharge data by Tielsch and coworkers.[14]

There were limitations to using occupational job titles as an indicator of risk of injury because of overlap in tasks (Table 2). For example, a production operator might be either hammering nails or connecting wires. Table 3 highlights activities and materials involved in the specific incidents and might be more useful for preventive action. The high proportion of injuries related to either grinding or welding re-emphasises the need for eye protection in these activities. The high proportion of paint-related chemical injuries suggests the need for eye protection in workers exposed to such substances. The recognition of the circumstances associated with injury would help to identify specific hazards and focus preventive efforts.[15]

It had been difficult in the past to estimate the impact of eye injuries in terms of cost, when only severe eye injuries were reported. Less severe injuries, although usually easy to manage medically, accounted for enormous direct and indirect costs. In our series, external foreign bodies and corneal abrasions accounted for 87% of the injuries, but almost one third of the injuries resulted in the inability of the worker to resume his normal duties (Table 4). The actual proportion was probably higher as many workers did not have OSHA-definable work disability outcomes. Different studies indicate that the time lost from work varies. For example, Alexander *et al*.[16] noticed that most patients with corneal foreign bodies did not take more than 1 day off work, while up to 30% sought treatment outside working hours to avoid lost time from work. The discrepancy may be due to the fact that many workers in our study had the benefit of acute medical service within the plant itself.

There were several limitations to this study. The quality of the data in different plants might vary and did not always reflect final clinical diagnoses. Visual outcomes, treatment and complications of these injuries were not assessed to better define the ocular morbidity associated with the injuries. Finally, no information was available about uninjured workers employed in specific occupations to allow quantification of the risks associated with specific job tasks.

However, our study had a number of important strengths. First, the population at risk (denominator) was well defined and incidence rates can be calculated. Second, as in any surveillance study, the details and circumstances of injury were recorded at the time of presentation, minimising recall bias. Third, all reported ocular injuries were captured, both minor and severe. These features served to provide a more complete picture of the incidence and impact of ocular trauma in a high-risk occupational group.

In conclusion, a high incidence of workplace eye injuries was observed in the automotive industry. Although the vast majority of injuries were minor, they could account for significant avoidable morbidity and lost productivity. This series again reinforced the need for better prevention strategies in the workplace.

Supported in part by UAW-Chrysler grant no. 680-888-2068 and by the US Centers for Disease Control grant no. R49 CCR302486. We thank Oliver D. Schein and Andrew L. Dannenberg for their advice. We also thank UAW-Chrysler for the use of their data.

References

1. Dannenberg AL, Parver LM, Brechner RJ, Khoo L. Penetrating eye injuries in the workplace. Arch Ophthalmol 1992;110:843–8.
2. White MF Jr, Morris R, Feist RM, Witherspoon CD, Helms HA Jr, John GR. Eye injury: prevalence and prognosis by setting. South Med J 1989;82:151–8.
3. Schein OD, Hibberd PL, Shingleton BJ, *et al*. The spectrum and burden of ocular injury. Ophthalmology 1988;95:300–5.
4. Morris RE, Witherspoon CD, Helms HA Jr, Feist RM, Byrne JB Jr. Eye Injury Registry of Alabama (preliminary report): demographics and prognosis of severe eye injury. South Med J 1987;80:810–6.
5. Baker RS, Wilson MR, Flowers CW, Lee DA, Wheeler NC. Demographic factors in a population-based survey of hospitalized work-related, ocular injury. Am J Ophthalmol 1996;122:213–9.
6. Karlson TA, Klein BEK. The incidence of acute hospital-treated eye injuries. Arch Ophthalmol 1986;106:785–9.
7. Glynn RJ, Seddon JM, Berlin BM. The incidence of eye injuries in New England adults. Arch Ophthalmol 1988;106:785–9.
8. Centers for Disease Control. Leading work-related diseases and injuries: United States. MMWR CDC Surveill 1984;33:213–5.
9. National Society to Prevent Blindness. Fact sheet. New York: National Society to Prevent Blindness, 1980.
10. Fong LP, Taouk Y. The role of eye protection in work-related eye injuries. Aust NZ J Ophthalmol 1995;23:101–6.
11. Macewen CJ. Eye injuries: a prospective survey of 5671 cases. Br J Ophthalmol 1989;73:888–94.
12. Tielsch JM, Parver L, Shanker B. Time trends in the incidence of hospitalized ocular trauma. Arch Ophthalmol 1989;107:519–23.
13. Jones NP, Griffith GAP. Eye injuries at work: prospective population-based survey within the chemical industry. Eye 1992;6:381–5.
14. Klopfer J, Tielsch JM, Vitale S, See LC, Canner JK. Ocular trauma in the United States: eye injuries resulting in hospitalization, 1984 through 1987. Arch Ophthalmol 1992;110:838–42.
15. Baker SP, O'Neill B, Ginsburg MJ, Li G. Occupational injury. In: The injury fact book. New York: Oxford University Press, 1992:114–33.
16. Alexander MM, MacLeod JDA, Hall NF, Elkington AR. More than meets the eye: a study of the time lost from work by patients who incurred injuries from corneal foreign bodies. Br J Ophthalmol 1991;75:740–2.