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UNINTENTIONAL ADULT EYE INJURIES IN VICTORIA

by

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May, 1998

Report No. 137

MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE
REPORT DOCUMENTATION PAGE

Report No.	Date	ISBN	Pages
137	May, 1998	0 7326 1435 X	36

Title and sub-title:

Unintentional adult eye injuries in Victoria.

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Type of Report & Period Covered:

General, 1986-1995

Sponsoring Organisation(s):

Victorian Health Promotion Foundation.

Abstract:

Eye trauma is the leading cause of blindness worldwide. It is estimated that 116,000 Australians, and nearly 30,000 Victorians, present to hospitals, emergency departments and general practitioners every year with ocular injuries. These figures are probably conservative estimates, as they do not include those managed at work by on-site medical and nursing staff.

The aims of this study were to examine:

- the epidemiology of adult eye injuries occurring in Victoria across three severity levels: inpatients from Victorian public hospitals, and cases presenting to emergency departments and general practitioners;
- two products commonly associated with eye injuries: welders and workshop power grinders;
- the main causes of welding and grinding eye injuries;
- the use of safety eyewear whilst welding and grinding in the home and work environments;
- the type of eyewear worn and the reasons for eyewear failure.

Data was obtained from three databases which provide information on admissions to hospitals, and presentations to emergency departments and the general practitioner. The study involved analysis of coded data fields and the examination of one line "narrative" texts. A critical review of the literature was also undertaken to compare findings and to investigate potential interventions and the issues surrounding their implementation. For the purposes of this study, adults were defined as any person 15 years of age or older.

Nearly one in ten adults presenting to emergency departments with an unintentional injury had sustained an injury to the eye. Welding and grinding were responsible for 29% of all eye injuries. Approximately one half (49%) of those injured through welding-related activities, and one-third (33%) of those injured through grinding-related activities, did not report wearing any form of eye protection at the time of injury. However, the reported use of eye protection was significantly greater among workers than home handy persons. For those that were grinding, objects commonly flicked underneath or through the sides of the safety eyewear (particularly safety glasses). For welders, injuries commonly occurred because the protective equipment was not worn throughout the entire welding process. In many cases (25% of welding and 6% of grinding cases), those not wearing protective equipment, were injured whilst walking past or assisting others who were performing these activities.

Two main issues arising from this study need to be addressed. First, large numbers of individuals are not wearing eye protection whilst performing, or in the vicinity of, activities that present dangers to the eyes. Second, injuries are still occurring despite the use of protective eyewear. Numerous strategies are proposed to increase the use of appropriate protective equipment, particularly for home handy persons. Improved designs that are already available and have the potential to prevent many of the problems observed, are also discussed.

Key Words:
(IRRD except when marked*)

Eye injury, adult, epidemiology

Disclaimer

This report is disseminated in the interest of information exchange. The views expressed here are those of the authors, and not necessarily those of Monash University

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ACKNOWLEDGEMENTS

The authors would like to thank Ms. Karen Ashby for her assistance in providing data for this study from the Victorian Injury Surveillance System database.

EXECUTIVE SUMMARY

INTRODUCTION

Eye trauma is the leading cause of blindness worldwide. It is estimated that 116,000 Australians, and nearly 30,000 Victorians, present to hospitals, emergency departments and general practitioners every year with ocular injuries. A Victorian study estimated that eye injuries cost the state community $39 million each year, with nationwide estimates of $155 million (Fong, 1995). These figures are probably conservative estimates, as they do not include those managed at work by on-site medical and nursing staff.

AIMS

The aims of this study were to examine:

- the epidemiology of adult eye injuries occurring in Victoria across three severity levels: inpatients from Victorian public hospitals, and cases presenting to emergency departments and general practitioners;
- two products commonly associated with eye injuries: welders, and workshop power grinders;
- the main causes of welding and grinding eye injuries;
- the use of safety eyewear whilst welding and grinding in the home and work environments;
- the type of eyewear worn, and the reasons for eyewear failure.

METHODOLOGY

Data was obtained from three databases which provide information on admissions to hospitals, and presentations to emergency departments and the general practitioner. The study involved analysis of coded data fields and the examination of one line "narrative" texts. A critical review of the literature was also undertaken to compare findings and to investigate potential interventions and the issues surrounding their implementation. For the purposes of this study, adults were defined as any person 15 years of age or older.

RESULTS

Nearly one in ten adults presenting to emergency departments with an unintentional injury had sustained an injury to the eye. The majority of patients were men (86 percent of presentations), most of whom were aged between 20 and 44 years (73 percent). While 94 percent of those presenting to emergency departments received some form of treatment for their injury, only 3.7 percent were admitted to hospital. Half the eye injuries recorded by emergency departments were due to foreign bodies (50.5 percent). Superficial abrasions (13.3 percent), inflammation/swelling (11.4 percent), partial thickness burns (9.3 percent) and cuts and lacerations (7.1 percent) were the other major types of eye injuries sustained.

For patients presenting to emergency departments, the most common place for injury to occur was at home (37.8 percent) mainly outside in the garden, yard or garage. This was followed

by areas of production (29.1 percent) such as industrial settings, factories, warehouses and construction sites.

Occupational activities accounted for 38 percent of eye injuries presenting to emergency departments, followed by maintenance activities outside the workplace (31.4 percent), then leisure or recreational activities (15.5 percent). Welding and grinding were responsible for 29 percent of all eye injuries

Grinding-related activities caused about 17 percent of all eye injuries recorded in the databases. Of these, 49 percent occurred in the workplace and 51 percent were the result of "Do-It-Yourself" activities in the home. The main cause of injury was foreign bodies entering the eyes (83 percent of cases). Approximately one-third (33 percent) of those injured through grinding-related activities did not report wearing any form of eye protection at the time of injury. However, the use of eye protection was significantly greater among workers (81 percent) than home handy persons (51 percent). Safety glasses were the most common form of safety eyewear worn (64 percent) either on their own (53 percent of all wearers) or with a visor, shield or mask (10 percent). For those injured whilst wearing some form of eye protection, objects commonly flicked underneath or through the sides of the safety eyewear (particularly safety glasses). In about 10 percent of cases, the protective eyewear was not worn at all times during the grinding process.

Welding activities caused almost 12 percent of all eye injuries recorded in the database. About half (49 percent) occurred in the workplace, with the balance (51 percent) occurring as the result of "Do-It-Yourself" activities around the home. The main causes of eye injury associated with welding were flash burns (54 percent) and foreign bodies entering the eye (32 percent). Only about half of those injured claimed to be wearing some form of protective eyewear. As with grinding injuries protective eyewear was more common in the workplace than at home (60 percent compared to 49 percent). Sixty percent of those using protective eyewear were wearing a welding helmet/mask, shield or visor. However, the main factor, in the case of welding, appeared to be that the injured were not wearing protective eyewear at all times (62 percent of cases) during the welding process. Welders either activated the welder before the protective eyewear was in place, or removed the eyewear due to poor visibility.

In many cases (25 percent of welding and 6 percent of grinding cases), those not wearing protective eyewear, were injured whilst walking past or assisting others who were performing these activities.

DISCUSSION

The main finding from this study is that, despite the availability of appropriate protective eyewear, eye injuries remain common. Nearly one in ten adults presenting to emergency departments, with an unintentional injury in Victoria, have sustained an eye injury. Most eye injuries occur in either the residential setting (particularly the garage and the garden) or in the workplace (particularly industrial areas, factories, warehouses and construction sites). The two activities most frequently associated with eye injuries are welding and grinding. Together these accounted for nearly one third of all eye injury cases presenting to emergency departments and general practitioners.

The findings also highlight the need for bystanders to wear protective eyewear when in the vicinity of welding and grinding activities. This is particularly important if watching or

assisting in welding and/or grinding operations, but also if passing through a workshop area (eg. visitors, management and other workers) in which these activities are taking place. In terms of those engaged in these activities, the literature suggests that the main reasons people do not wear protective eyewear relate to issues such as comfort, style, restricted vision, and safety equipment not provided by employers. Other authors suggest that these reasons are less relevant than the fact that individuals feel that eye protection is unnecessary.

The study also showed that workers are more likely to wear protective eyewear than home handymen. Indeed, other studies have shown that eye injuries at work, while still a large proportion of all eye injuries, have decreased (Jones & Griffith, 1992; Bell, 1994) while domestic injuries have increased (Schrader, 1993). This is not surprising, given that, unlike the workplace, there are major difficulties in targeting the home handy person since there is little control over safety education and no regulation or enforcement in the use of protective equipment.

A recent study (Routley & Ozanne-Smith, 1995) suggested a multi-faceted approach to reduce injuries in the "Do-It-Yourself" area since individual strategies, such as warning labels, are unlikely to succeed alone (Petré, 1996). They suggested a coordinated approach with four main locations for intervention : the workplace; retail outlets; manufacturers; and the media.

The results of this present study suggest that, when protective eyewear is worn, it is often the wrong type. In the case of grinding-related eye injuries, in particular, over half the cases injured whilst wearing protective eyewear were wearing safety glasses as opposed to wide-vision goggles, face-shields or visors. It has been shown that the relative risk of injury whilst wearing safety glasses is 4.3 times greater than when wearing goggles (Henderson, 1991). Since safety glasses provide only frontal protection many injuries are caused by objects impacting from the side or from below.

For welding-related eye injuries, this and other studies suggest that flash burns often occur when welders strike the arc before lowering the eye shield. Auto-darkening filters are becoming increasingly available and, while more costly than fixed filters, allow the welder to perform the entire welding process without raising the protective shield. This improves the quality, quantity and consistency of welding, as well as reducing the risk of injury.

CONCLUSION

Two main issues arising from this study need to be addressed. First, large numbers of individuals are not wearing eye protection whilst performing, or in the vicinity of, activities that present dangers to the eyes. Second, injuries are still occurring despite the use of protective eyewear. In general, it seems that those injured often wear inappropriate safety or ill-fitting eyewear for the task being undertaken, or do not wear protective eyewear at all times while undertaking the task. The finding that safety glasses may not provide adequate protection against small, off-centre particles, needs to be addressed, and the use of goggles promoted.

While this study highlights several important issues, further research investigating the details of these issues is necessary. In particular, research is required to determine why home handy persons, in particular, do not wear eye protection, and what factors influence the likelihood of their wearing protection. Until these issues are addressed, and prevention strategies implemented, eye injuries will remain a common cause of emergency department and general practitioner presentations.

1. INTRODUCTION

Eye trauma is the leading cause of blindness worldwide (Fong, 1995; Bell, 1994). It affects approximately 2.4 million individuals each year, in America alone (Parver, 1988; Summerer and Johnson, 1996). It is estimated that 116,000 Australians, and nearly 30,000 Victorians, present to hospitals, emergency departments and general practitioners every year with ocular injuries (Fong, 1995). These figures are probably conservative estimates, as they do not include those managed at work by on-site medical and nursing staff.

Although less severe eye injuries do not cause blindness, they still result in considerable pain and suffering, and may require lengthy hospitalisation or repeated treatments over a long period (Bell, 1994). They also account for enormous direct medical costs and indirect costs to the families and the community, particularly through lost productivity (Schein et al, 1988, Summerer et al, 1996). A Victorian study estimated that eye injuries cost the state community $39 million each year, with nationwide estimates of $155 million (Fong, 1995). Again, due to on-site management of occupational injury, this figure is probably an underestimate of the real costs (Jones and Griffith, 1992; Griffith and Jones, 1994).

Ironically, eye injuries are possibly one of the most easily preventable injuries, with simple, cost-effective solutions/protective eyewear readily available. The National Society for the Prevention of Blindness (U.S.) estimates that 90% of all eye injuries can be prevented with protective equipment (Burlew, 1991), as most injuries occur in predictable situations (Byhr, 1994).

Whilst there are some discrepancies in the literature regarding whether most eye injuries occur in and around the home (Bell, 1994, Summerer et al, 1996; Arrotti, 1995), or at work (Schein et al, 1988, Henderson, 1991), it is evident that eye injuries are common in both occupational settings and the home environment (Fong, 1995, Byhr, 1994; Hassett et al, 1994; Schrader, 1993; Parver et al, 1993). The majority of the literature to date, however, has concentrated on either occupational-related (Banerjee, 1990; Dannenberg et al, 1992; Davey, 1987; Foster, 1988; Griffith et al, 1994; Hassett and Kelleher, 1994; Head, 1995; De la Hunty and Sprivulis, 1994; Jones and Griffith, 1992; Lexau and Bishop, 1995; Liu et al, 1990; Mencia-Gutiérrez et al, 1988; Nakagawara, 1989; Shaikh and Bhojani, 1991; Steinle, 1992; Streff et al, 1993; Turiff, 1991;) or sports-related eye injuries (Aburn, 1990; Coroneo, 1985; David et al., 1995; Della-Giustina, 1992; Fong, 1994; Genovese et al, 1990; Jones, 1988; Miller & Miller, 1993;), with little or no emphasis on home injuries. Although brochures, magazines and books providing safety information on "Do-It-Yourself" activities are available, few studies have looked at the home handyperson (Routley and Ozanne-Smith, 1995; Backham, 1990). A recent German study revealed a significant increase in domestic eye injuries, indicating the need for further research to prevent such injuries to home handypersons (Schrader, 1993).

In order to develop preventive strategies, it is essential to understand the nature and causes of eye injuries occurring in Victoria. Two studies have previously investigated eye injuries in Victorian patients, however, both utilised data from only one specialist eye (and ear) hospital, and therefore may not represent the entire spectrum of less severe eye injuries (Fong 1995; Fong and Taouk, 1995).

2. AIMS

The aims of this study were to examine:

- the epidemiology of adult eye injuries occurring in Victoria across three severity levels: inpatients from Victorian public hospitals, and cases presenting to emergency departments and general practitioners;
- two products commonly associated with eye injuries: welders, and workshop power grinders;
- the main causes of welding and grinding eye injuries;
- the use of safety eyewear whilst welding and grinding in the home and work environments;
- the type of eyewear worn, and the reasons for eyewear failure.

3. METHOD

Data was obtained from three databases which provide information on admissions to hospitals, and presentations to emergency departments and the general practitioner. For the purposes of this study, adults were defined as any person 15 years of age or older.

3.1 HOSPITAL ADMISSIONS

Eye injury cases admitted to Victorian hospitals were extracted from the Victorian Inpatient Minimum Dataset (VIMD). The VIMD contains injury data collected from all public hospitals in Victoria, from July 1986 to June 1995. Due to the lack of information in the first financial year of data collection, only the last 8 years were utilised in this study. Patients who were readmitted within 30 days were excluded, as were cases admitted to private hospitals, since private hospital data was not available consistently throughout this period.

Up to 12 injuries are coded for each patient, using ICD-9-CM (1986) injury codes. Cases with an eye injury listed in one or more of the 12 injury codes, were selected [1]. These patients may also have sustained other non-eye injuries. Of the 8379 patients admitted to public hospitals in Victoria with eye injuries, 1649 cases of intentional injuries (self-inflicted and inflicted by others) or undetermined intent injuries were excluded. A further 353 cases, due to adverse reactions of surgery or drugs, medical misadventures, and late effects of accidents, were also excluded from the analysis.

Accidental foreign body eye/adnexa injuries, (a subset of the total unintentional eye injuries), were then examined separately, using the Ecode 914.

Rates for all unintentional eye injuries, and the subset of foreign bodies in the eye, were calculated using Victorian population figures down-loaded from the Australian Bureau of Statistics website.

Activities undertaken at the time of the injury were unable to be studied further due to the limitation of ICD-9 coding employed in the VIMD. Analysis of hospitalised cases provided an epidemiological picture of moderate to severe eye injuries.

3.2 EMERGENCY DEPARTMENT PRESENTATIONS

Eye injury cases presenting to emergency departments (EDs) were extracted from the Victorian Injury Surveillance System (VISS) database. This data was collected for 5 years (July 1991-June 1996) at the Latrobe Regional hospitals (Moe and Traralgon), for 2 years at the Western Hospital (Dec 1991-Dec 1992) and the Royal Melbourne Hospital (Mar 1992-Feb 1994), and for 1 year at the Preston and Northcote Community Hospital (Mar 1992-Feb 1993). Cases include those who presented to the ED and were subsequently discharged, as well as those who were then admitted to hospital. Admitted cases were included here since more detailed information, on circumstances of the injury, is available from this source, compared with the VIMD.

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[1] Codes: 870.0 to 870.9, 871.0 to 871.9, 918.0 to 918.9, 921.0 to 921.9, 930.0 to 930.9, 940.0 to 940.9, 941.02, 941.12, 941.22, 941.32, 941.42, 941.52.

Eye injuries were selected on the basis of a "body part" injured variable, relating to eye and ocular adnexae. From the 6071 adults presenting to this selection of hospitals with eye injuries, 638 intentional injuries were excluded. VISS recorded up to four products, or factors, involved in each injury: two for "what went wrong", and another two for "what actually caused the injury". Grinding and welding related eye injuries were selected using appropriate codes listed in either of these two variables. Grinders included portable, stationary and unspecified workshop power grinders, whilst welders included electric, fuel-burning and unspecified welding equipment.

Place of occurrence and use of protective equipment by those involved in welding and grinding, were also examined.

3.3 GENERAL PRACTITIONER PRESENTATIONS

Eye injury cases presenting to the general practitioner (GP) were extracted from the Extended Latrobe Valley Injury Surveillance (ELVIS) database. This database consists of one year of injury cases presenting to GP's in the Latrobe Valley, a Victorian regional centre, from November 1994 to November 1995. Eye injuries were selected on the "body part" injured variable. Eleven cases of intentional or undetermined intent eye injuries were excluded. Grinding and welding related eye injuries were selected using the same method as described for ED presentations.

Comparison of proportions was calculated using a Chi-square test, in Epi-Info (Dean et al, 1996). Statistical significance was taken at the 0.05 level.

4. RESULTS

In Victoria, over the past eight years, 6377 patients were admitted to hospital with unintentional eye injuries. This represents 2.3% of all adults admitted to hospitals with unintentional injuries. Many of these adults had other injuries, which may have been the primary cause for admission.

A total of 5433 adults presented to the selected emergency departments during the data collection period with unintentional eye injuries. This represents 8.9% of the total number of adults presenting to these hospitals with unintentional injuries.

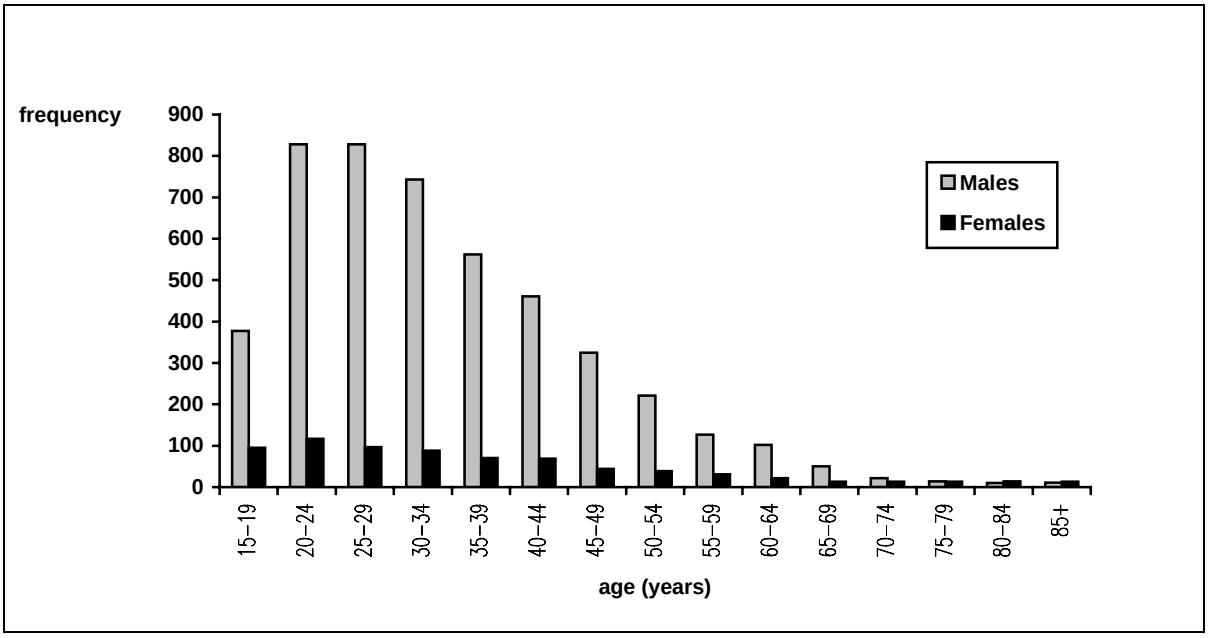
In the one year that data was collected from La trobe Valley general practitioners, 355 adults presented with ocular injury, representing 6.2% of the total number of adults presenting to GP's in this area with an unintentional injury.

4.1 AGE & GENDER

The majority of patients with eye injuries were males (76.2% of admissions, 86.2% of ED presentations, and 86.5% of GP presentations) (Table 1), most of whom were aged between 20 and 44, (73.1% of emergency department presentations, and 72.3% of GP presentations.) For hospital admissions, almost half (48.4%) of the males were aged between 15 and 29 years of age. The peak age group of adults presenting to emergency departments or admitted to hospitals with eye injuries was the 20-24 year olds (Figure 1), whilst the age group presenting to GP's with the greatest proportion of total eye injuries, was the 35-39 year old age group, (though high numbers prevailed from 20 through to 40 years).

Those hospital admissions with foreign body eye injuries, were also mostly males (88.1%), with almost half (44.7%) aged between 20 and 34 years.

Figure 1: Eye injury emergency department presentations by age and gender



Source: VISS (1991-96, non-population based sample of Victorian hospitals)

Table 1: Number of hospital admissions, and emergency department and general practitioner presentations with eye injuries in databases, by gender.

	HOSPITAL ADMISSIONS[a]		ED PRESENTATIONS[b]		GP PRESENTATIONS[c]	
	n	**(%)**	***N***	**(%)**	***n***	**(%)**
Males	4,858	(76.2)	4,681	(86.2)	307	(86.5)
Females	1,519	(23.8)	738	(13.6)	48	(13.5)
Unknown	-	-	14	(0.2)	-	-
TOTAL	**6,377**	**(100.0)**	**5,433**	**(100.0)**	**355**	**(100.0)**

[a] VIMD : All Victorian hospitals (1987-95)

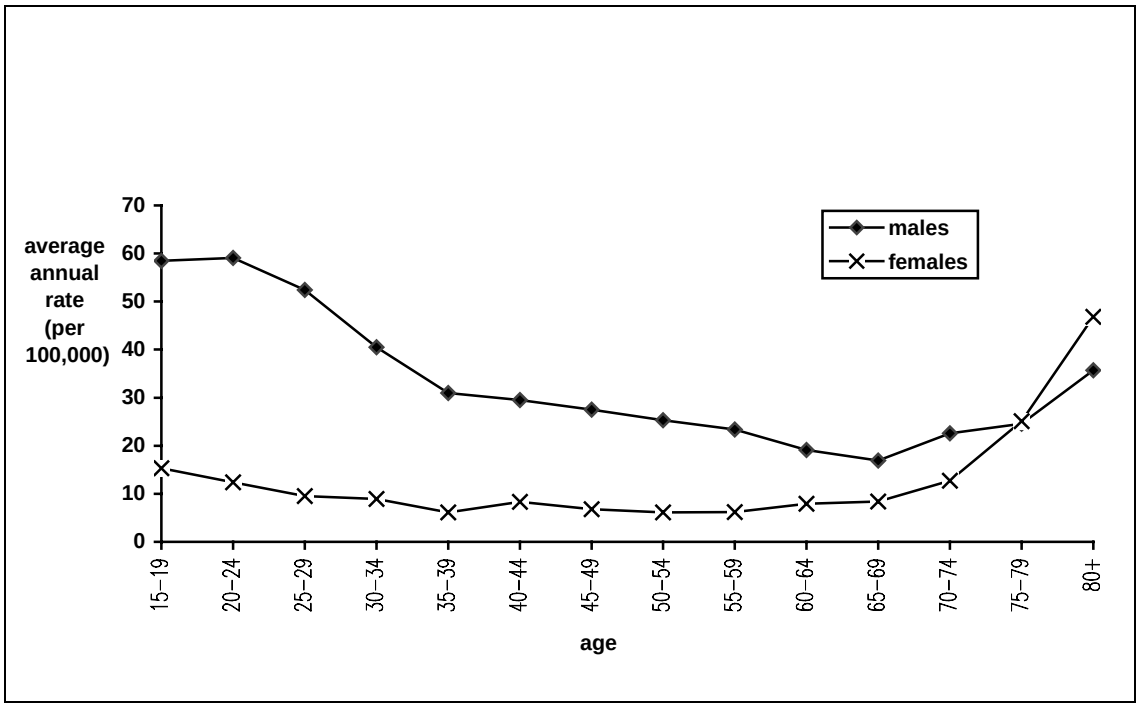
[b] VISS : sample of several hospitals (not population-based) (1991-96)

[c] ELVIS : Latrobe Valley only (1995)

4.2 HOSPITAL ADMISSION RATES

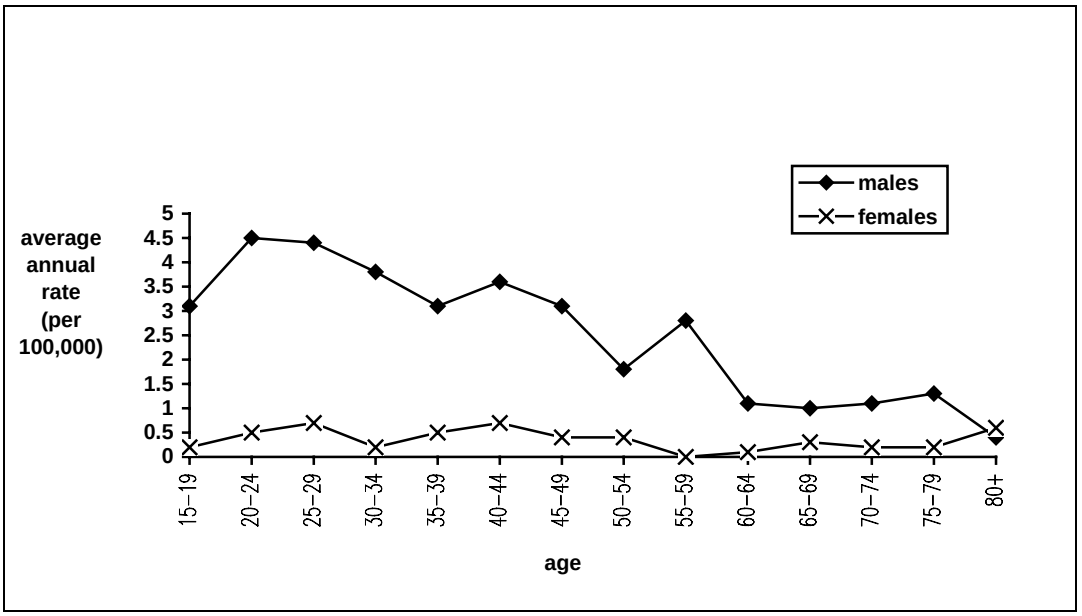
The average annual public hospital admission rate for eye injuries (1987-1995), was 18.9 per 100,000 adults, rising to 29.0 per 100,000 for males. Admission rates were consistently higher for men, except in the over 75 age group. Men aged 20-24 years were at the highest risk, with admission rates of 59.1 per 100,000 for any eye injury, and 4.5 per 100,000 for foreign bodies in the eye. Eye injury rates decreased with increasing age, until rising again in those over 70 years (Figures 2 & 3).

Figure 2: Average annual admission rates for males and females with eye injuries (Victoria)



Source : Victorian Inpatient Minimum Dataset (1987-1995)

Figure 3: Average annual rates for males and females admitted to Victorian hospitals with foreign body eye injuries



Source: Victorian Inpatient Minimum Dataset (1987-1995)

4.3 TREATMENT

Admission to hospital was not common for adults with eye injuries. While 94.2% of those presenting to emergency departments had some type of treatment, only 3.7% were admitted to hospital or transferred for further treatment (Table 2).

Most adults presenting to general practitioners with eye injuries were treated by the GP (89.6%). Only 4.5% were referred to other sources (including specialists).

Table 2: Disposal from emergency departments, adults with unintentional eye injury

Type of treatment	***N***	**(%)**
No treatment	115	(2.1)
Treated (no referral)	1,224	(22.5)
Significant treatments	3,893	(71.7)
Treated - referral to out-patient department	*212*	*(3.9)*
Treated - referral to GP	*795*	*(14.6)*
Treated - other referral	*132*	*(2.4)*
Casualty review	*2,754*	*(50.7)*
Admissions	146	(2.7)
Short stay ward observation	*23*	*(0.4)*
Admitted (short stay ward or inpatient ward)	*123*	*(2.3)*
Transferrals	55	(1.0)
TOTAL	**5,433**	**(100.0)**

Source: VISS (1991-1995)

For patients admitted to Victorian public hospitals, most (84.6%) stayed one week or less. Forty-three percent were only admitted for two days or less, and 12.1% were admitted for less than 24 hours. There were some cases which stayed over a month (1.5%). It is likely that these cases had sustained other serious injuries, apart from eye injuries, that required lengthy hospitalisation.

4.4 TYPE OF EYE INJURIES

4.4.1 Emergency department and general practitioner patients

As emergency department data allows for up to three injuries to be coded per patient, a total of 6139 injuries were sustained by the 5433 patients, 92.9% of which were eye injuries. Of these eye injuries, half were due to foreign bodies (50.5%). Superficial abrasions (13.3%), inflammation/swelling (11.4%), partial thickness burns (9.3%), and cuts and lacerations (7.1%) were the other major types of eye injuries sustained.

A similar pattern of eye injuries was observed in the general practitioner presentation patients. In particular, foreign bodies were again the most common type of eye injury sustained (62.8%), followed by superficial abrasions (13.8%) (Table 3).

Table 3: Proportions of types of eye injuries sustained by emergency department and general practitioner patients (VISS, ELVIS)

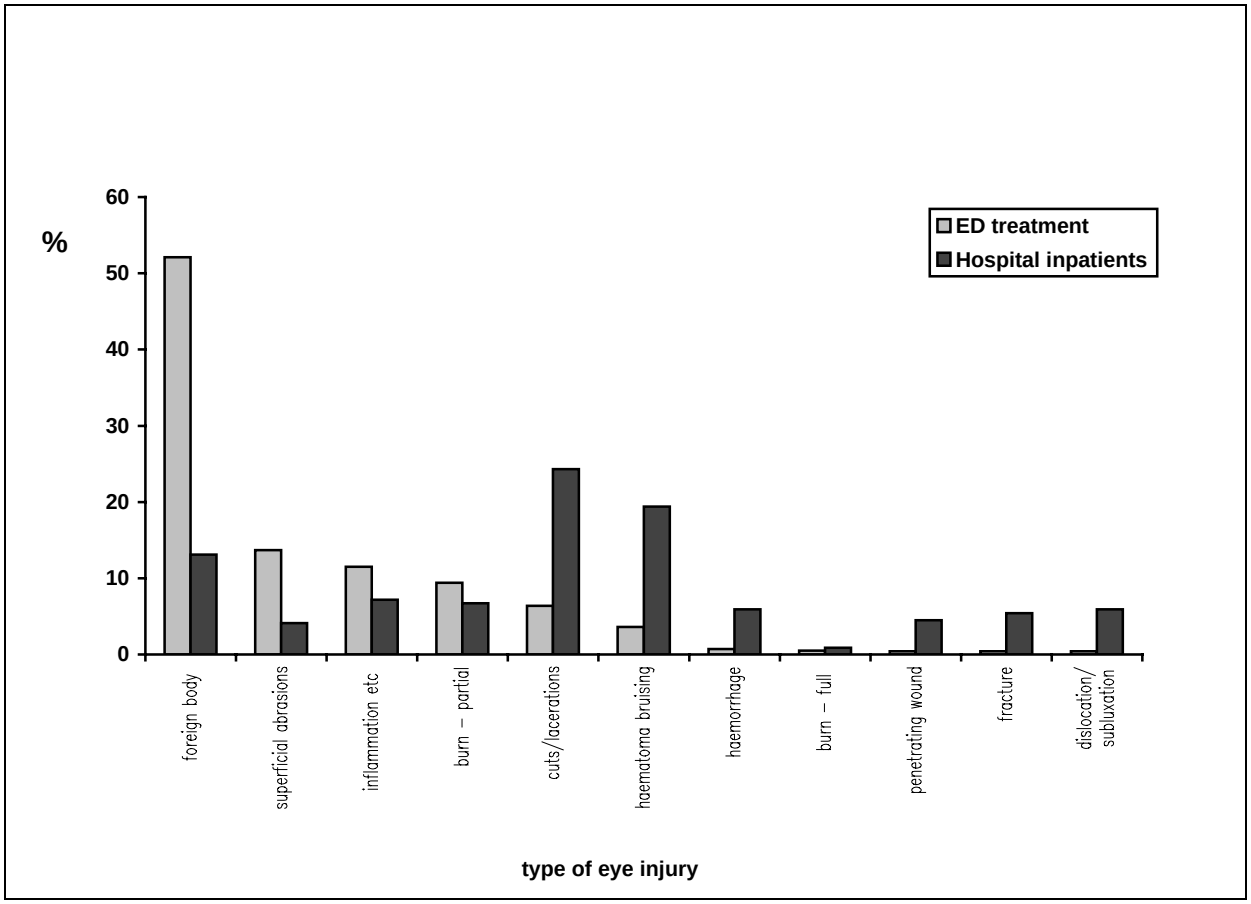
Eye/ocular adnexa injuries	ED %*	GP %**
foreign body	50.5	62.8
superficial abrasions	13.3	13.8
inflammation/swelling/oedema/pain	11.4	6.2
burn - partial thickness	9.3	5.1
cuts and lacerations	7.1	3.7
haematoma bruising	4.2	4.8
Haemorrhage	0.9	1.7
penetrating wound	0.6	0.6
Fracture	0.6	-
burn - full thickness	0.5	0.3
other wound inc. traumatic amputation of eye	0.4	0.3
Bites	0.3	0.3
Punctures	0.2	0.3
dislocation/subluxation	0.2	-
sprain/strain	0.1	-
crushing injury	0.0	0.3

* More than one eye injury may be reported per case (n=6139).

** Only one eye injury reported per case (n=355).

Major differences in the type of injuries sustained were found between those who were treated in the emergency department, and those who required admission to hospital (after presenting to the emergency department). For patients not admitted to hospital, eye injuries accounted for 95.4% of all injuries sustained. However, for those who were admitted, eye injuries accounted for 57.2% of all injuries sustained, and there was a higher proportion of other head injuries (19.3% compared to 2.5% for the ED treatment group). Differences were also apparent when comparing the nature of the eye injuries sustained. Whilst foreign body in the eye accounted for half of the eye injuries in the ED treated patients, they only constituted 13.1% of the eye injuries in the admissions group. Cuts and lacerations (24.3%), and haematoma/bruising (19.4%) were more prevalent in the admissions group, as were haemorrhages, penetrating eye injuries, dislocations/subluxations of eye/ocular adnexa, and ocular adnexa fractures (Figure 4).

Figure 4: Types of eye injuries sustained by those admitted to hospital and those presenting to the emergency department (VISS data)



4.4.2 Hospital admissions patients (VIMD)

As the VIMD records up to twelve injuries per patient, of the 6,377 patients with eye injuries, only 56.3% of the total number of injuries (12,578) were to the eye. Contusions (44.2%) and open wounds (39.4%) were the most common types of eye injuries sustained. Of the open wounds, penetrating wounds (n=1,035) and lacerations (n=1,134) were common, accounting for 14.6% and 16.0% of the total eye injuries, respectively. Foreign body eye injuries, including foreign body on external eye (n=246) and penetrating wounds with foreign bodies (n=608), accounted for 12.1% of all eye injuries. Other eye injuries sustained include superficial injuries (6.3%), burns confined to the eye/adnexa (5.4%: one-third of which were chemical burns), and burns to the eye and face, head and neck (1.2%) (Table 4).

In total, there were 447 cases admitted to hospitals with foreign body eye injuries as the *primary* cause of injury, accounting for 7.0% of all patients with eye injuries.

Table 4: Types of eye injuries sustained by patients admitted to hospital, VIMD (1987-1995)

Eye injuries	*n**	%
Contusion of eye and adnexa	3,130	44.2
Open wound of eyeball/ocular adnexa (inc. penetrating wounds with foreign body)	2,788	39.4
Superficial injury of eye and adnexa	448	6.3
Burn confined to eye and adnexa	384	5.4
Foreign body on external eye	246	3.5
Burn of eye and face, head and neck	84	1.2
TOTAL	**7,080**	**100.0**

* Number of eye injuries sustained (n=6,377 patients).

4.5 PLACE OF OCCURRENCE

For emergency department presentations patients, the most common place for eye injuries to occur, was in a residential location (37.8%), followed by production areas (29.1%). For eye injuries sustained in residential areas, the garden/garage/yard vicinity was the most common place of occurrence (69.5%), followed by living or sleeping areas (17.3%). Of those who sustained injuries in areas of production, "other industrial" regions (51.2%), factories/warehouses (25.4%), and construction sites (14.6%) were the most common places for these injuries to occur. For GP presentations, more eye injuries occurred in areas of production (39.2%). Often this was at a mine or quarry (18.7%) reflecting the nature of work in the Latrobe Valley region (Table 5).

Table 5: Place of occurrence of injury (VISS, ELVIS)

Place of occurrence of injury	ED		GP	
	n	**(%)**	***n***	**(%)**
Residential	2,052	(37.8)	102	(28.7)
Areas of production	1,580	(29.1)	139	(39.2)
Transport and areas used by transportation	362	(6.7)	13	(3.7)
Areas of commerce	213	(3.9)	33	(9.3)
Areas for organised sport	179	(3.3)	9	(2.5)
Areas of outdoor land-based recreation	105	(1.9)	3	(0.8)
Educational	94	(1.7)	11	(3.1)
Areas of outdoor water-based recreation	31	(0.6)	-	-
Public playground and amusement areas	24	(0.4)	-	-
Institutions (non-residential/non-commercial)	6	(0.1)	-	-
Unknown or not elsewhere classified	787	(14.5)	45	(12.7)
TOTAL	**5,433**	**(100.0)**	**355**	**(100.0)**

For hospital admissions (VIMD), the place of injury variable was mostly unspecified (68.6%). However, where it was specified, the street and highway (25.0%), recreational areas (23.5%), the home (23.3%), and industrial areas (13.1%) were the most common places for eye injuries to occur. The majority of foreign body eye injuries, occurred in an industrial setting (44.6%) and at home (32.4%).

4.6 ACTIVITY AT TIME OF INJURY

A different pattern of activities undertaken at the time of injury was observed for patients who required admission to hospital (after presenting to the ED), compared to those who solely received treatment in the emergency department. For patients treated in the emergency department (or by their GP), approximately three-quarters sustained their eye injury during occupational or maintenance related activities. For patients admitted to hospital, however, transport and leisure/recreational activities were most commonly undertaken at the time of injury (Figure 5, Table 6). It is likely that these patients sustained injuries apart from eye injuries that required hospitalisation, or possibly transport and leisure/recreational activities produced more serious eye injuries.

Figure 5: Type of activity undertaken at time of injury by level of treatment: general practitioner (ELVIS) and emergency department presentations and hospital inpatients (VISS)

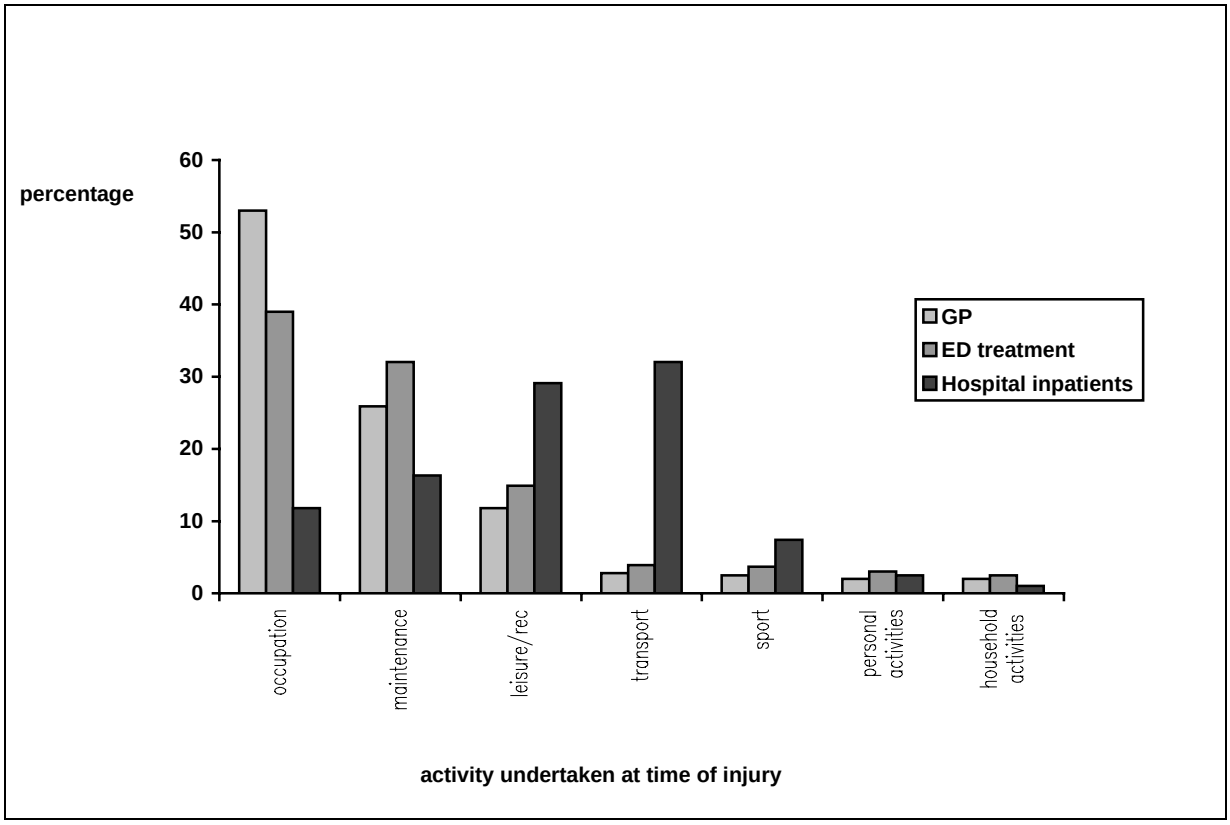


Table 6: Activity undertaken at time of injury by ED and GP presentation patients (VISS, ELVIS)

Activity	ED presentations*		GP presentations	
	n	(%)	*n*	(%)
Occupational	2,062	(38.0)	188	(53.0)
Maintenance	1,708	(31.4)	92	(25.9)
Leisure/Recreation	840	(15.5)	42	(11.8)
Transport	268	(4.9)	10	(2.8)
Sport	208	(3.8)	9	(2.5)
Personal activities	162	(3.0)	7	(2.0)
Household activities	134	(2.5)	7	(2.0)
Other/no details	51	(0.9)	-	-
Total unintentional eye injuries	**5,433**	**(100.0)**	**355**	**(100.0)**

* All ED presentations, including those subsequently admitted.

4.7 OCCUPATIONAL EYE INJURY

For the patients presenting to emergency departments (n=2,062), and to the GPs (n=188) with occupational related eye injuries, over half were aged 20-34 years, and the majority were male, (95.8% of GP and 93.3% of ED presentations). Of these, tradespersons (55.8%), labourers (18.2%), and plant/machine operators and drivers (13.5%) were the most commonly injured occupational groups. The three specific occupations presenting with the highest number of eye injuries were (in descending order):
1) structural steel/boilermaking/welding tradespersons,
2) metal fitters and machinists, and
3) trades assistants.

Other occupations presenting to emergency departments with high numbers of eye injuries were: vehicle mechanics, power generation plant operators, carpenters and joiners, paper/paper products machine operators and farmers. Since exposure data are unknown, it was not possible to determine relative risks by occupation.

The majority of occupational eye injuries, were due to foreign bodies (73.4% of GP and 60.2% of ED presentations). Inflammation/swelling/pain, superficial abrasions and partial thickness burns were also common. These injuries were mostly caused by objects hitting or entering the eye (80.6%), welding flashes (9.5%), and chemical splashes (7.8%).

Overwhelmingly, the major factors involved in these eye injuries were workshop tools and appliances (43.5%). Smaller numbers of injuries involved industrial or retail plant equipment (8.9%) and wind blowing objects into eyes (6.2%).

The tools/appliances most frequently involved in occupational eye injuries were workshop power grinders, buffers and polishers, (21.0%), and welding equipment (15.4%). Smaller numbers of occupational eye injuries were associated with drills (1.7%), hammers/sledges/mallets (0.9%), and power saws (0.8%).

4.8 MAINTENANCE EYE INJURY

Equally frequent to occupational related injuries, were the high numbers of eye injuries occurring during maintenance related activities outside the workplace. These include home handyperson activities. Almost half (47.0%) of the emergency department patients were within the 20-34 year old age group, whilst the majority (52.0%) of the GP patients were in a slightly older 30-44 year age group.

Foreign body in the eye was the most common eye injury (56.2% of ED, and 60.9% of GP presentations), followed by superficial abrasions (13.0% of ED and 16.3% of GP presentations). Partial thickness burns, and inflammation/swelling/oedema/pain, were also relatively common. As with occupational related injuries, these were mostly caused by objects hitting or entering the eye (83.0%), welding flashes (12.6%), and chemical splashes (2.8%).

The majority of these injuries occurred during “Do-It-Yourself” activities (49.9%), followed by gardening (12.8%) and vehicle maintenance (10.3%). “Other maintenance” accounted for 26.7% of the total. Most occurred in the garden/garage/yard areas (69.8%) of their own, or another’s, home.

Again, by far the two most common product groups involved in these eye injuries, were grinders, buffers and polishers (26.8%), and welding equipment (17.2%). There were also smaller numbers of injuries involving cars (4.7%), lawn mowers (3.0%), drills (3.0%), power saws (1.7%), chain saws (1.0%), and hammers/sledges/mallets (0.8%).

4.9 OTHER ACTIVITIES UNDERTAKEN AT TIME OF INJURY

Fifteen percent of ED patients, and 11.8% of GP presentations with eye injuries, were undertaking leisure and recreational activities at the time of injury. These were caused by mechanisms such as falls, walking into objects (eg. branches), people accidentally poking eyes whilst playing, and objects blowing/dropping into eyes during recreational activities.

Transport related injuries accounted for less than five percent of emergency department and GP presentations with eye injuries. These were mostly a result of car accidents, or objects blowing into eyes whilst walking, riding bikes, or in cars.

Sport-related eye injuries accounted for less than four percent of all eye injuries. They were caused by objects such as balls and rackets hitting the eye, or peoples' body parts colliding with the eye. The sports most commonly involved in these eye injuries were: football (27.9%); cricket (16.8%); basketball (10.1%); and squash (8.2%).

Less than 3 percent of patients were involved in personal activities at the time of injury. These activities were varied, ranging from spraying deodorant accidentally into eyes, to waking up with objects in the eye, and to falling in the shower/bath or out of bed, hitting eyes. Injuries caused during household activities (2.5%), included chemical splashes, dust, and objects in the eyes whilst cleaning and doing housework.

5. GRINDING AND WELDING INJURIES.

Grinding and welding related activities were the most common causes of eye injuries, accounting for 27.9% of eye injuries from the emergency department, and 33.0% from GP databases. Due to these high numbers, the remainder of the article will focus on these injuries in more detail.

5.1 GRINDING

Grinding related activities caused over a quarter of all eye injuries in adults presenting to a GP, and nearly 17% of those presenting to emergency departments. Almost all patients with grinding related injuries were males (99.2% of ED and 100% of GP patients). Of the ED patients, more than half (52.9%) sustained their injuries outside of work. One third of the ED patients and 21.1% of GP patients were not wearing any form of eye protection at the time of injury. Stated use of eye protection was significantly greater amongst workers than home handypersons (Table 7).

Table 7: Occupational and non-occupational grinding eye injuries for ED and GP presentation patients*. (VISS, ELVIS)

	Occupational		Non-Occupational		OR (95% CI)/ p value
	n	**%**	***n***	**%**	
Emergency department presentations (n=918)	**432**	**(100.0)**	**486**	**(100.0)**	
wearing eye protection	346	(80.1)	248	(51.0)	4.2 (3.0-5.7)
not wearing eye protection	78	(18.1)	233	(47.9)	p<0.001
[not specified	8	(1.8)	5	(1.0)]	
General practitioner presentations (n=90)	**61**	**(100.0)**	**29**	**(100.0)**	
wearing eye protection	55	(90.2)	16	(55.2)	7.5 (2.2-26.6)
not wearing eye protection	6	(9.8)	13	(44.8)	p<0.001

*A small number of people (n=50 ED, n= 4 GP) were completing grinding AND welding activities around the time of injury, and therefore were counted in welding and grinding.

The majority of eye injuries sustained whilst grinding, were caused by foreign bodies, (82.9% of ED, and 88.9% of GP). There were smaller numbers of superficial abrasions to the eyes and ocular adnexa (9.3% of ED and 6.7% of GP patients). The one line "narrative" text field of all patients with grinding related eye injuries (ED and GP combined) were studied. Eye injury causes were not provided in 7.2% of cases. A further 23.9% stated that a foreign body caused the injury, but did not specify the type of foreign body. Of the remaining cases, (n=691), 54.4% were caused by pieces, flakes or filings of metal and steel. Sparks (23.7%), hot metal and steel (5.4%) and dust or grit (6.7%) were also common causes of eye injury. There were 11 cases (1.6%) of grinding discs shattering, or fragments of the disc breaking off, entering the eyes.

5.1.1 Adults wearing eye protection

Two thirds of the patients who were injured whilst grinding claimed to be wearing eye protection (n=665: ED and GP combined). Of these cases, around two thirds (n=373 ED and n=71 GP) specified the general type of eye protection that they were wearing. Safety glasses were the eye protection most commonly used, either on their own (53.9% ED, 50.7% GP) or with another type of protective equipment (8.6% ED, 19.7% GP). The protective equipment most often paired with safety glasses, were shields (n=16 ED, n=6 GP), and helmets (n=9 ED, n=3 GP). Whilst one fifth of the ED sample wore safety goggles, this percentage was slightly lower for the GP sample (12.7%). Welding shields and helmets or masks were also relatively common, constituting 12.6% of ED and 9.6% of GP presentations (Table 8).

Table 8: Type of eye protection worn by adults injured whilst grinding*.

Type of eye protection worn	ED		GP	
	n	**(%)**	***n***	**(%)**
safety glasses	201	(53.9)	36	(50.7)
safety goggles	76	(20.4)	9	(12.7)
safety *glasses* plus one of the following: Shield/helmet/mask/hood/safety visor	32	(8.6)	14	(19.7)
Shield/welding face shield/safety visor	32	(8.6)	3	(4.2)
welding helmet/mask	15	(4.0)	4	(5.6)
safety *goggles* plus one of the following: shield/helmet/mask/hood/safety visor	8	(2.1)	1	(1.4)
incorrect shield and/or glasses	1	(0.3)	1	(1.4)
other**	8	(2.1)	3	(4.2)
TOTAL	**373**	**(100.0)**	**71**	**(99.9)#**

* Includes only those specifying eye protection worn

** Includes "all safety apparel", metal face protectors, and shields plus welding hoods, masks or safety guards.

Rounding error

In most cases (74.7%: ED and GP combined) there was insufficient detail in the one line "narrative" text field to explain why injuries were still occurring, despite the reported use of protective equipment. The remaining cases (n=168: ED and GP combined) however, provided some indication of the mechanism of injury (Table 9). A similar pattern was observed for both ED and GP patients.

The most prevalent problem with safety eyewear, was that objects, such as grinding sparks and pieces of metal, were flicking underneath safety glasses and to a lesser extent, shields/masks/visors, and contacting the eye. One person stated that the particle entered from the gap between the glasses and the nose. Objects were also reported to have entered the eye area through the side of the safety glasses.

In 10% of cases, the protective eyewear was not worn at all times. Occasionally injuries occurred after the patient had finished grinding, (when they were rubbing their eyes or wiping their faces after grinding, or when grinding filings washed from their hair and into their eyes whilst showering). Fewer patients stated that they were not wearing the correct type of eye protection (eg. wrong safety glasses for type of job, or not wearing proper shield). Two cases of eyewear not being worn correctly were also observed: in one case, the face shield was "up a little", in the other, the "dust mask prevented the glasses from fitting properly".

Table 9: Reasons why eye injuries occurred in patients who claimed to be wearing eye protection whilst grinding (VISS and ELVIS)*.

REASON	*n*	(%)
Problems with protective eyewear	143	(85.1)
objects under safety glasses	*48*	
objects behind glasses/goggles/shield/mask/eye protection (not specified)	*24*	
objects under safety shield/masks/visor/eye protection ns	*16*	
objects through side of safety glasses/goggles	*10*	
objects bypassed glasses/goggles/shield	*10*	
objects under goggles	*7*	
objects penetrated safety equipment (eg. "glasses did not hold spark")	*6*	
objects over top of glasses/shield	*4*	
spark bounced around safety glasses, or between glasses and screen	*3*	
spark ricocheted off glasses into eye	*2*	
Other	*13*	
Protective eyewear not worn at all times	17	(10.1)
glasses/eye protector fell off/slipped	*6*	
removed glasses and did not replace (eg. forgot)	*4*	
lifted eyewear- either too soon or while someone else still grinding	*4*	
took goggles off because visibility reduced (eg. fogged up)	*3*	
Occurred after grinding when eyewear not in use	4	(2.4)
Incorrect eyewear	2	(1.2)
Eyewear not worn correctly	2	(1.2)
TOTAL	**168**	**(100.0)**

* A combination of n=141 ED and n=27 GP presentations.

5.1.2 Adults not wearing eye protection

For those who did not wear any eye protection little information could be deduced from the narratives regarding reasons why it was not worn. One reason specified for a few cases, (n=20: ED and GP combined), was that the injured patients were not actually grinding themselves. They were either walking past (n=8), watching (n=5), assisting (n=4), or standing near (n=3) someone who was grinding .

5.2 WELDING

Welding resulted in 11.9% of all eye injuries in adults presenting to emergency departments, and 8.7% of those presenting to the general practitioner. These injuries occurred nearly exclusively in men (99.1% of ED and 100% of GP patients). Around half occurred in the work environment (48.8% of ED, 71.0% of GP patients). Use of protective eyewear was not universal, and was reported in only 47.8% of ED and 80.6% of GP cases. As with grinding injuries, eye protection was more commonly worn at work than at home (Table 10).

Table 10: Occupational and non-occupational welding eye injuries for ED and GP presentation patients*.

	Occupational		Non-Occupational		OR (95% CI)/ p value
	n	%	*n*	%	
Emergency department presentations (n=649)	**310**	**(100.1)**	**339**	**(100.0)**	
Wearing eye protection	180	(58.1)	130	(38.3)	2.3 (1.6-3.1)
not wearing eye protection	125	(40.3)	203	(59.9)	p<0.001
[not specified	5	(1.6)	6	(1.8)]	
General practitioner presentations (n=31)	**22**	**(100.0)**	**9**	**(100.0)**	
Wearing eye protection	19	(86.4)	6	(66.7)	3.2 (0.3-29.4)
not wearing eye protection	3	(13.6)	3	(33.3)	p=0.3

*A small number of people (n=50 ED, n=4 GP) were completing welding AND grinding activities around the time of injury, and therefore were counted in welding and grinding.

The welding injuries were caused either by flash burns/arc flashes (55.9% of ED, and 22.6% of GP presentations) or foreign bodies (30.2% of ED and 61.3% of GP presentations). For the remainder, the cause was either unknown or unspecified. The types of objects causing foreign body injuries, were pieces of metal/steel, hot metal, sparks, and dirt/dust/grit. Slag from the weld was also relatively common, (n=43), often caused while chipping it from the weld, or from slag and spatter flicking up and flying into eyes.

5.2.1 Adults wearing eye protection

Almost half (49.3%) of those injured by welding related activities (ED and GP combined) claimed to be wearing eye protection. Of these, 96.0% of GP and 65.8% of ED patients specified the type of eyewear worn. Welding helmets or masks, safety glasses and shields were commonly used. In total, 30.9% of the ED and 54.1% of the GP patients injured whilst welding were wearing safety glasses, or safety glasses plus another piece of equipment. The protective equipment most often paired with safety glasses, were shields (n=11 ED, n=2 GP), and helmets (n=5 ED, n=4 GP). Only two of the cases specified that the glasses worn were welding glasses, (Table 11). As can be seen in Table 11, the pattern of eye protection worn differed slightly for ED and GP patients. Whether this is a reflection of the severity of the injuries sustained with differing eye protection, or an artefact of the small sample of GP patients, remains a question for further investigation.

Table 11: Types of eye protection worn by those injured whilst welding*

TYPE OF EYE PROTECTION WORN	ED		GP	
	n	**(%)**	***n***	(%)
welding helmet/mask	58	(28.4)	2	(8.3)
safety glasses	45	(22.1)	8	(33.3)
shield/welding face shield/safety visor	38	(18.6)	4	(16.7)
safety goggles	32	(15.7)	2	(8.3)
safety ***glasses*** plus one of the following: shield/helmet/mask/hood/safety visor	18	(8.8)	5	(20.8)
safety ***goggles*** plus one of the following: shield/helmet/mask/hood/safety visor	8	(3.9)	1	(4.2)
clear plastic goggles	1	(0.5)	-	-
other**	4	(2.0)	2	(8.3)
TOTAL	**204**	**(100.0)**	**24**	**(99.9)#**

* Includes only those specifying eye protection worn.
** Includes face screen, hood, and "all safety gear"
# Rounding error

As with grinding injuries, most cases (78.8%: ED and GP combined) had no explanation in the "narrative" text field of why the injury occurred, despite the reported use of protective equipment. The remaining cases (n=71: ED and GP combined), however, provided some indication of the mechanism of injury. The main factor was that people were not wearing the protective equipment at all times (62.0%) (Table 12). This was mostly due to activating the welder before the shield was in place, eg "mask up while lining things up", "didn't put safety mask down quick enough". Occasionally eye protection was removed due to reduced visibility. Other injuries were caused by lifting the shield too early, or removing it while someone nearby was still welding.

A smaller number of people had problems with their protective eyewear (33.8%). These were mostly due to foreign bodies flicking under safety glasses or welding shields. One person specified that the point of entry of the foreign object was through the vent hole in the side of the safety glasses. Another group of people stated that their welding glasses or shields were cracked, or had small pieces of glass missing.

5.2.2 Adults not wearing eye protection.

Patients not wearing eye protection whilst welding rarely indicated reasons for not doing so. As with grinding injuries, however, there were several cases (25.4%) where the injured person was not actually welding themselves. For work-related injuries, 33.6% of those without protective equipment were not welding themselves (n=43), whilst 20.4% of those injured outside of work were not welding themselves (n=42). These patients were either assisting (n=37) or watching (n=28) someone who was welding, with fewer working/standing near (n=14), or walking past welders (eg through the welding area of workshop, n=6). Of those assisting welders, (eg by holding the metal to be welded), many were trades assistants or family and friends.

Table 12: Reasons why eye injuries occurred in patients who claimed to be wearing eye protection whilst welding, (VISS and ELVIS)*.

REASON	***n***	**(%)**
Protective eyewear not worn at all times	44	(62.0)
welder activated before shield in place (1 by mistake)	*10*	
took away to see clearly, inspect work	*5*	
lifted/removed shield- too early, or while someone else welding nearby	*4*	
screen on helmet not down/ forgot to put visor down	*2*	
mask slipped off/helmet jammed in up position	*2*	
no details (wearing safety eyewear, but not all the time)	*21*	
Problems with protective eyewear	24	(33.8)
objects under glasses/goggles	*7*	
piece of glass missing/cracked welding glasses/screen	*5*	
objects behind glasses	*3*	
objects under shield	*3*	
through goggle vent hole	*1*	
over mask (hand-held)	*1*	
spatter went down shield into eyes	*1*	
helmet came apart	*1*	
faulty shield	*1*	
mask didn't fit properly	*1*	
Incorrect eyewear (clear plastic goggles)	1	(1.4)
Eyewear not worn correctly	1	(1.4)
Occurred after welding, ie cleaning up	1	(1.4)
TOTAL	**71**	**(100.0)**

* A combination of n= 63 ED and n=8 GP presentations.

6. DISCUSSION

6.1 LIMITATIONS

There were some limitations with the data utilised in this study. Firstly, there was a lack of detail in the "narrative" text field, restricting the information that could be extracted. Secondly, the emergency department and general practitioner data is not statewide, and therefore may not be representative of all Victoria. Thirdly, for patients that were welding and grinding around the time of injury, due to the structure of the database, it was not possible to determine which of these activities they were undertaking at the time of injury. The welding and grinding groups therefore, are not mutually exclusive. Despite these limitations, however, the data sets provide a good overall picture of the types of situations leading to eye injuries.

6.2 MAIN FINDINGS

The overwhelming finding from this study is that, despite the availability of appropriate protective eyewear, eye injuries remain a common cause of hospital admissions, emergency department presentations, and visits to the general practitioner in Victoria. Nearly one in ten adults presenting to emergency departments with an unintentional injury, have sustained an eye injury, indicating the extent of this problem. Adolescents to middle aged males, particularly 20-24 year olds, have the greatest risk of sustaining eye injuries. The high risk to males in their twenties has been repeatedly shown in other studies (Byhr, 1994; Dannenberg et al, 1992; Fong, 1995; Fong and Taouk, 1995; Hassett and Kelleher, 1994; Mencía-Gutiérrez et al, 1988; Parver et al, 1993; Saini and Sharma, 1993; Schein et al, 1988; Schrader, 1993; Summerer and Johnson, 1996). This is possibly due to the exposure of young men to high risk tasks.

Adults with eye injuries rarely require hospital admission, (Fong 1995; Fong and Taouk, 1995). Only 3.7% of the patients presenting to emergency departments in this study, were subsequently admitted to hospital. On the basis of this, extrapolating from statewide admission figures, it has been estimated that 21,500 adults present to Victorian emergency departments with eye injuries each year. The most common injuries for non admitted patients were foreign bodies in the eye. Admitted cases more commonly had sustained contusions, open wounds, and other non-eye injuries. Although eye injuries sustained by patients not admitted to hospital were less severe, they may still have resulted in time off work, lost income, and extensive medical costs.

Most of the eye injuries occurred either in residential areas (particularly the garage and garden), or in areas of production, (particularly industrial regions, factories, warehouses, and construction sites). Patients injured at work were commonly trades persons and labourers, in particular, structural steel, boiler-making, or welding trades persons, metal fitters or machinists, and trades assistants. Other studies have also shown metal workers, builders, construction workers and automotive workers to have a high risk of sustaining eye injuries (Byhr, 1994; Dannenberg et al; 1992; Fong & Taouk, 1995, Hassett & Kelleher, 1994; Shein et al, 1988;). Home handymen were the other major group who sustained eye injuries, mostly during "Do-It-Yourself" activities, gardening, or vehicle maintenance. Previous research has also found that most eye injuries occur at work or at home, (Bell, 1994; Byhr, 1994; Fong, 1995; Hassett et al, 1994; Henderson, 1991; Parver et al, 1993; Schein et al, 1988; Schrader,

1993; Summerer et al, 1996;), emphasising the importance of considering both these environments when developing preventive strategies.

6.3 GRINDING AND WELDING RELATED EYE INJURIES

The two specific activities frequently associated with eye injuries, were grinding and welding. These accounted for nearly one third of all eye injury cases presenting to the ED or GP. The dangers of welders and grinders to the eyes have been well documented (Henderson, 1991; Fong & Taouk, 1995; Lexau et al, 1995; Moller, 1997; Routley and Ozanne-Smith, 1995). A recent US study of visits to emergency departments, ranked welders as the second, and grinders/buffers/polishers as the fourth leading cause of consumer product related ocular trauma (excluding work and transport related accidents) (Sastry et al, 1995).

6.4 EYE PROTECTION USE DURING WELDING AND GRINDING

Despite the high incidence of injuries associated with welding and grinding, the use of correct protective eyewear during these activities has been shown to be low (Routley and Ozanne-Smith, 1995; Fong and Taouk, 1995; Henderson, 1991). For ED and GP presentations combined, half of those injured through welding related activities, and around one third of those injured through grinding related activities did not report wearing any form of eye protection. It is disturbing to find that, for activities like welding, where flash burn injuries are almost guaranteed when eye protection is not worn, such high numbers of individuals still fail to wear eye protection. It is important to note that this study, and others, have sampled the injured population only. The usage rates for correct safety eyewear in this population would be expected to be low, as those wearing appropriate eyewear tend to be protected from eye injuries (Dannenberg et al, 1992). Research investigating the true incidence of wearing safety eyewear, particularly in the home environment, is necessary.

6.5 ISSUES SURROUNDING INJURIES THAT OCCUR WHILST NOT WEARING EYE PROTECTION

6.5.1 Reasons for not wearing eye protection

Although injured samples may not be representative of the entire population, they offer useful findings. In particular, many of those not wearing eye protection were not actually welding (25.4%) or grinding (6.1%) themselves. They were often walking past, standing near, watching or assisting others who were performing these activities. Other studies have also shown that bystanders account for up to 24% of those with eye injuries (Summerer & Johnson, 1996; Bell, 1994; Owen et al, 1987). This raises a number of prevention strategies. Firstly, it reiterates the importance of wearing eye protection if watching or assisting someone weld or grind. Closing the eyes or looking away at appropriate moments is certainly insufficient protection. The high numbers of trades assistants injured in the workplace, and family and friends injured at home, whilst helping or watching those welding and grinding, suggests the need to target these groups. Secondly, where there is the possibility of others walking by, or working near, someone welding or grinding, care must be taken to prevent stray flashes and foreign bodies from reaching these bystanders. This can be achieved by placing suitable curtains and screens around the person welding or grinding. In the workplace, these activities may be confined to certain areas. Lastly, all persons, including management, visitors and contractors, must wear eye protection throughout any operational areas (Turiff, 1991; Hall, 1987). This rule must be adhered to even when walking through workshop areas.

Due to the limitations of the data sets used, aside from not actually welding themselves, no further information was provided on reasons why eyewear was not worn. A review of the literature, however, indicates several common reasons eye protection is not worn. The main factors include: comfort; potential view restriction or vision impairment (by dirty, misted or scratched lenses); provision of equipment by employers; and style (Arrotti, 1995; Banerjee, 1990; Davey, 1987; de la Hunty & Sprivulis, 1994; Doremus, 1992; Henderson, 1991; Liu et al, 1990; Mencía-Gutiérrez et al, 1988; Owen et al, 1987; Shaikh & Bhojani, 1991; SAA HB9-1994; Turriff, 1991; Yelland, 1989). Others suggest that these reasons are less relevant than the fact that individuals feel eye protection is not necessary (Owen et al, 1987). Reasons for this include: the feeling that eye protection is not normally used or practical (Anon, 1990); that the job isn't dangerous (Turriff, 1991); or that they are "only going to be at risk for just a moment" (Mencía-Gutiérrez et al, 1988). Some workers even accept these injuries and hazards as part of the job (Liu et al, 1990; Shaikh & Bhojani, 1991). These findings all stress the importance of further education to workers and home handy persons. Most studies researching attitudes to eye protection have been occupationally based (Banerjee, 1990; de la Hunty & Sprivulis, 1994; Liu et al, 1990; Shaikh & Bhojani, 1991). Therefore, further research investigating barriers to the use of protective equipment, particularly in home handy persons, is necessary.

6.5.2 Eye protection use in the home and work environments

The results of this study suggest that different factors may be involved in the use of eyewear in the home and work environments. In particular, for welding and grinding injuries, it was found that workers were more likely to wear eye protection than home handymen, a result also noted by other Australian studies Fong and Taouk (1995) and Fong (1995). These findings may be biased by increased reporting of eyewear use by workers, due to legal or attitudinal implications of stating a failure to wear protection. The high numbers of work injured patients who state they were *not* wearing eye protection, however, suggests that this bias may be small.

Under the Occupational Health and Safety Act (1985), employers are required to 'provide and maintain so far as is practicable for employees a working environment that is safe and without risks to health'. It is beneficial for them to promote safety in the workplace, in order to prevent the costly medical treatments, time off work, and legal situations that may result from a work-related injury. In this environment, there is greater opportunity for controlled education of the employees regarding safety equipment (Venema, 1996) and enforcement of usage. In the home environment, however, there is less control over safety education, and the use of protective equipment is not regulated.

Some studies have shown that eye injuries at work, although still a large proportion of eye injuries, have decreased (Jones and Griffith, 1992; Bell, 1994), and domestic injuries have significantly increased (Schrader, 1993). Companies are recognising that it isn't only work-based injuries that keep employees out of action. Research shows that domestic injuries also keep workers away from the job (Vic Health, 1997). It has been estimated that more than half of the injuries sustained by workers occur off the job (Streff et al, 1993). Thus, by preventing injuries occurring in the home environment, the potential benefit to industry, due to reduced health care cost, absenteeism and productivity, is enormous (Nakagawara, 1989).

6.5.3 Strategies to increase eye protection use in the home environment

Due to the difficulty of targeting home handy persons, other means of safety education need to be employed in order to reduce the occurrence of injuries in this environment. Although there is much literature regarding the implementation of protective eyewear programs in the workplace (Doremus, 1992; Nakagawara, 1989; Turriff, 1991; Hall, 1987; Steinle, 1992; Streff et al, 1993), interventions are needed that promote safe behaviour beyond the confines of the worksite. WorkCover Victoria is currently encouraging companies to implement 24 hour safety programs. A Victorian aluminium company, Alcoa, is also conducting a program which actively promotes off the job safety. In addition to family days to promote skills, they send regular information sheets covering a range of health and safety materials, to employees' households (Vic Health, 1997). As a critical first step, organisations need to recognise that it is beneficial for them to play an active role in preventing all injuries, whether they occur at work or in the home.

A recent report has suggested a number of possible strategies to reduce injuries during "Do-It-Yourself" activities (Routley & Ozanne-Smith, 1995). The authors suggest four major locations for intervention: the workplace; retail outlets; manufacturers; and the media. Workplaces may promote DIY safety by developing a tool library/workshop for workers to borrow protective equipment or tools. "This would encourage the "Do-It-Yourselfer" to use the equipment most appropriate to the purpose, would save the workers money and give access to equipment which is more likely to be of better quality and have up-to-date safety features" (p.30). Employers may also provide training in the use of borrowed equipment, and offer home appliance safety checks in the workplace. Retailers and hirers may promote eye protection with special sale prices, or inclusion of eyewear in special deals on DIY tools. Manufacturers can assist in education, by using warning labels on the equipment, alerting users of the possible hazards to the eyes. Pictorial tags on equipment may also remind users of the appropriate eyewear for that particular tool. Brochures or information cards regarding eye protection should also be provided by retailers or hirers, situated near the corresponding tools, or attached to the tools as swing tags. They should be simple, easy to read, and readily depict the most suitable eyewear for certain tasks. The discrepancies in the literature regarding appropriate eyewear need to be addressed, in order to develop an accurate, concise and comprehensible source of information for the home handy person.

It is important to recognise that individual strategies, such as warning labels, are unlikely to succeed alone (Petrè, 1996). A combined approach is preferred, which, particularly for the home handy person, may include the use of mass media. The media may co-operate by disseminating important findings and recommendations, and by assisting in the development of industry or occupational safety authority sponsored commercials (Routley & Ozanne-Smith, 1995).

6.6 ISSUES SURROUNDING INJURIES THAT OCCUR WHILST WEARING EYE PROTECTION

The other major finding from this study, is that despite the reported use of protective eyewear, eye injuries still occurred. Reasons for this differed depending on whether the patient was welding or grinding at the time of the injury.

6.6.1 Grinding

Portable grinders appear to be more often associated with injury while wearing eye protection than are other tools (Moller, 1997). In this study, two-thirds of those injured whilst grinding claimed to be wearing eye protection.

For those that were grinding, the majority of injuries were caused by objects entering the gap between the safety eyewear and the eyes. This was commonly under safety glasses or shields/masks, but there were also cases where objects passed through the side or over the top. This suggests that either the eye protection was poorly fitting or the wrong type of protection was worn. The U.S. Bureau of Labor Statistics (1980) found that in 94.1% of cases in which eye injury occurred while the individual was wearing eye protection, it was a result of selecting the wrong device.

In the present study, more than half of those injured while grinding, and who claimed to be wearing eye protection, were using safety glasses. There appears to be a common misconception that safety glasses are multi-functional, as they are frequently used for tasks which require a higher level of protection (De la Hunty & Sprivulis, 1994; Fong & Taouk, 1995). In fact, safety glasses only provide *frontal* protection to the eyes from low energy flying fragments (SAA HB9-1994). Many eye injuries, however, are caused by side impact, (Arotti, 1995; Henderson, 1991; Dannenberg et al, 1992). In the workplace especially, sparks and foreign matter from other workers may pass laterally around the glasses. Another common point of entry for foreign matter, particularly for those with thin faces, is the gap between the cheek and the lower edge of the frame (Watts, 1988). The Bureau of Labor Statistics (1980) study concluded that most eye injuries occurred because the protector did not provide sufficient angular coverage. Safety glasses cannot protect against airborne dusts or small particles, and as the majority of eye foreign bodies are very small (Bureau of Labor Statistics, 1980) properly fitting goggles with indirect ventilation offer increased safety (Watts, 1988; Henderson, 1991) and are essential (Yelland, 1989). In fact, the relative risk of sustaining injury whilst using glasses rather than goggles, has been found to be 4.3 times greater (Henderson, 1991).

In line with the original standard (*AS 1336:1982 Recommended practices for eye protection in the industrial environment*), the Australian Standards Handbook on *Occupational Personal Protection* (SAA HB9-1994) recommends the use of wide vision goggles, faceshields, hoods or helmets for protection against medium impact flying particles such as those generated by activities such as grinding. However, the recently revised Standard, *AS/NZS 1336 : 1997 Recommended practices for occupational eye protection,* also includes wide-vision spectacles as providing frontal and side protection to the eyes from medium energy flying particles.

A recent study by Moller and Bordeaux (1997) suggests that the AS1336 recommendations for medium impact operations are inadequate. They argue that, under the influence of the Standard, workers and employers are choosing wide-vision spectacles, which provide the greatest comfort, under the false impression that they provide will adequate protection. However, the Standard does not adequately define fit, and the use of wide-vision spectacles, without ensuring adequate fit, does not provide sufficient protection from injury during metal-working tasks. To provide effective protection, protective eyewear used during these activities should fit so that the gap between the face and the eyewear at any point where particles can enter is no greater than 1 mm (Moller & Bordeaux, 1998).

The high numbers of sparks and hot metal causing injuries during grinding (and welding), indicates the need for eyewear that can withstand thermal shock. Glass lenses are inadvisable

in situations where sparks or molten metal are a hazard, (Liautaud, 1985). In general, polycarbonate lenses are stronger, more scratch-resistant, lighter, safer, more comfortable, and reduce the rise in temperature better, than glass lenses, (Liautaud, 1985; Arrotti, 1995; Doremus, 1992; Pabley & Keeney, 1984; Foster, 1988).

Although the data did not provide details on the exact type of eyewear worn, the mechanism of injury suggests that many injured persons wore incorrect eye protection or eyewear that was poorly fitting. Problems with eyewear slipping or falling off, could have been prevented by the use of adjustable or elastic headbands. There were also some cases where goggles were taken off because visibility was reduced. New improved designs of goggles should prevent these complaints. There are now designs available that have indirect ventilation, anti-fog coatings, frosted tops to reduce glare, optically correct lenses to prevent distortion and headaches, and panoramic lens shapes to allow 180 degrees of uninterrupted lateral vision. Shields used in conjunction with these goggles would also provide full facial protection in cases where severe exposure to flying particles is a possible hazard (Foster, 1988).

6.6.2 Welding

For those that were welding, the majority of injuries were caused by injured persons not wearing the protective eyewear at all times. Rather than being due to discomfort, this was generally to see more clearly whilst lining the welding rod up or inspecting the work. The results of this study and others (Proctor, 1989) suggest that flash burns are often caused because welders strike the arc before lowering the shield. "There is a temptation to do this, because once the filter covers the eyes the welder cannot see the position of the welding rod until the arc strikes", (Proctor, 1989). In the past decade, welding filters that automatically darken when the welding arc is struck, have become increasingly available (Sliney, 1992; Palmer, 1996; Proctor, 1989). With these helmets/shields in place, welders can now see adequately whilst aligning and fitting the parts to be welded. This means the welder can perform the entire welding process without raising the protective eyewear, eliminating flash burns caused by lifting eyewear, or activating the welder too early then forgetting to put eyewear back in place.

As well as meeting the standards for fixed filters, one of the most important factors that needs to be considered when purchasing these autodarkening filters, is the speed of filter switching. The faster the switching speed, the less light will enter the eye when the arc is struck. With advancing technology, these welding filters can now darken in faster than 0.1 milliseconds (Sliney, 1992). It is also important that these filters offer protection in the event of malfunction, or battery failure (Palmer, 1996). Manufacturers may use a dark or intermediate shade as the "off" or resting state, to warn welders in advance that the filter is not on, or is not operating properly. Although these autodarkening filters are more costly than the fixed filters, they improve the quality, quantity and consistency of welding, (Sliney, 1992) as well as the risk of eye injuries. The welder is able to work continuously and to begin the weld at precisely the desired position. There is also a reduced training time for new welders who no longer have to cope with blind periods during the weld cycle (Sliney, 1992).

Five welding injuries were caused by patients wearing glasses that were cracked or had a piece missing, reinforcing the importance of regular inspections and maintenance (Nakagawara, 1989; Turriff, 1991; SAA HB9-1994). There were also large numbers who had sustained foreign body injuries whilst welding. Some of these cases may also have been grinding around the time of the injury, making it difficult to determine whether the foreign body was a result of welding or grinding. However, there were also cases who were welding

only, and still sustained foreign body injuries. It should be noted that there are many different types of welding (Pabley & Keeney, 1984), and different eye protection is recommended for each (Anon, 1990; SAA HB9-1994). Although the data does not indicate the type of welding variety undertaken, it suggests that for some types, spectacles with filter lenses may not adequately protect the welder against foreign body injuries. As with grinding eyewear, there is often a gap between the spectacles and the face, where foreign matter may enter. An interesting finding was that many of the foreign body injuries occurred either when patients were chipping slag from the weld, or from slag and spatter flicking up and flying into their eyes. The removal of slag takes place either after welding or at various stages throughout welding. It is therefore possible that welders remove or lift their safety eyewear before completing this process. This would particularly be the case if *fixed* darkened lenses were worn, preventing the welder from seeing clearly. It may also be the case that safety glasses fail to provide adequate protection. To prevent the likelihood of eye injury from flying particles, welders need to be educated that goggles should be worn whilst removing slag from the weld.

Few details were available in the databases on the type of protection worn by welders. Further investigation into the exact type and brand of eyewear worn by welders and grinders is necessary. It would also be valuable to determine whether people wear the same eyewear for numerous different tasks, instead of choosing equipment appropriate for that task.

6.7 OTHER PRODUCT-RELATED ISSUES

Grinding discs shattered, or fragments of the discs broke off in eleven cases in this study. Although there was no information regarding the presence or absence of guards on these grinders, machine guards may help to prevent these pieces from flicking up. The circumstances around these incidents, and the stability of grinding discs, requires further investigation.

7. CONCLUSION

The results of this study highlight two important issues. First, large numbers of individuals are still not wearing eye protection whilst performing, or in the vicinity of, activities that present dangers to the eyes. With such a large variety of stylish, light and comfortable eye protection available for all people, (whether they have broad noses or wear contact lenses or glasses), many excuses for not wearing eye protection, are unfounded. Second, injuries are still occurring despite the use of protective eyewear. In general, it seems that people do not wear the protective equipment at all times or they wear inappropriate or ill-fitting eyewear. The finding that safety glasses may not provide adequate protection against small, off-centre particles, needs to be addressed, and the use of wide-vision goggles promoted, particularly where wide-vision spectacles cannot be fitted with a gap of less than 1 mm.

Although this report highlights several important issues, further research investigating the details of these issues is necessary. In particular, research to determine reasons why home handy persons, in particular, do not wear eye protection, and what factors would influence their likelihood of wearing protection is essential. Until these problems are addressed and prevention strategies implemented, eye injuries will remain a common cause of emergency department and general practitioner presentations.

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