Original Article

Eye Injuries in Singapore – Don't Risk It. Do More. A Prospective Study

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Abstract

Introduction: The purpose of this study was to characterise and describe the epidemiology of all eye injuries presenting to the National University Hospital (NUH). Materials and Methods: A prospective study was conducted over a 7-week period (11/4/2005 to 29/5/2005) on all ophthalmic trauma patients seen by the Department of Ophthalmology in NUH. Data on patient presentation, source of injury and intervention were collected via a standardised interview and examination, and documented using a validated datasheet. Results: A total of 133 patients, and 139 eyes, were included in the study. The average age was 33.5 years, with a range of 5 years to 88 years, and 84.2% (n = 112) were men. Close to half (46.6%, n = 62) of the patients studied were non-Singaporeans. 56.4% (n = 75) of all eye injuries were work-related and only 5% (n = 7) of eyes were open-globe injuries. Common sources of eye trauma included: Use of high-powered tools in activities such as grinding, welding and hammering (38.3%, n = 51), human-inflicted injuries (12.0%, n =16) and road traffic accidents (8.3%, n = 11). Of the work-related eye injuries, 29.3% (n = 22) reported to having used personal protective equipment (PPE) at the time of injury, 38.7% (n = 29) had been issued PPE but had not used them, while 32% (n = 24) reported that PPE had not been issued. An initial visual acuity of 6/12 or better was found in 63.0% (n = 88) of patients and a reading of 6/60 or worse was found in 10.0% (n =14). Superficial foreign bodies (22.4%, n = 55) were the most common clinical finding, followed by periorbital bruise (12.2%, n = 30), lid ecchymoses (6.9%, n = 17), orbital fractures (6.5%, n = 16), lid laceration (6.1%, n = 15) and corneal abrasions (5.7%, n = 14). Conclusion: There is a broad spectrum of causes, mechanisms and severity of ophthalmic injuries seen in the hospital, of which work-related trauma makes up a significant proportion. The patients who suffer occupational injuries are a well-defined group: Young, non-Singaporean males, working with power tools in the construction industry are at particular risk. Although preventive strategies are in place for this high-risk group, the lack of awareness and compliance limit their effectiveness. The adequacy and functionality of PPE should be emphasised. In addition, preventive efforts are equally important in domestic, recreational, sports and transport settings. Eye trauma research and prevention can be further aided by a collaborative registry of eye injuries. A long-term islandwide database of all ophthalmic injuries is recommended.

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Key words: Accident prevention, Blindness, Epidemiology, Eye injuries, Ocular trauma

Introduction

The issue of ophthalmic trauma is a major cause for concern. An estimated 55 million eye injuries occur each year worldwide, leaving 1.6 million patients blind from their injuries.[1] Ocular trauma, a leading cause of visual impairment,[2] impacts not only the individual, but also the healthcare system and the community.[3] The personal costs to the afflicted individual, such as the effects of eye trauma on the quality of life, may be difficult to define but the trauma-associated financial penalty is heavy.[4] In the United States, where almost 2.5 million eye injuries occur annually,[2] hospital charges alone amount to $200 million.[5] This sum exceeds $5 billion with the direct and indirect costs considered.[6,7] The high cost to the state stems from the loss of working capacity,[7] with an estimated loss of 60 work-years as a consequence of eye injuries in an urban eye centre in the US.[6] A study from Australia detailed a similar magnitude of impact.[8] Clearly, the medical, functional and

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socioeconomic aspects of eye trauma pose a huge burden on the patient and the state.

In recent decades, worldwide recognition of the public health importance of eye trauma has sparked a growing interest in the research of eye injuries. Many studies worldwide have provided prevalence and incidence data which are useful in defining the impact of ophthalmic trauma. The epidemiology of eye trauma has been well described in developed countries such as the US,[9-11] Europe[12,13] and Australia.[8,14] In the US, the lifetime prevalence of ocular injuries is estimated to be 14.4%[9] to 19.8%.[15] An incidence rate of hospitalised eye injuries was found to be 13.2 per 100,000.[16,17] This is in comparison to a study from Scotland, in which Desai et al[12] reported the 1-year cumulative incidence of ocular trauma necessitating admission to hospital to be 8.14 per 100,000 population. An Australian study based in Victoria[8] reported the incidence rate of eye injuries requiring hospitalisation to be 15.2 per 100,000 population. Such figures illustrate the scale and severity of eye injuries from an epidemiological perspective.

Despite eye injuries being an important public health concern and a common cause of ocular morbidity, the relative scarcity of local epidemiological data on eye trauma[18,19] is alarming. In a population-based incidence study[18] involving all Singaporean citizens and residents from 1991 to 1996, the overall annual incidence rate of hospitalised ocular injury was reported to be 12.6 per 100,000. In 2001, Voon et al[19] concluded that at the emergency service level in Singapore, ocular trauma involved mainly young, non-resident males who had sustained work-related injuries. Such findings correspond to those found in many other epidemiological studies worldwide, which have delineated a similar high-risk population.[2,14-18,20-28] However, only a few are prospective in design.[12,20,21,28]

This 7-week prospective study investigated the demographics, aetiology, causes, clinical findings and management of all ophthalmic trauma patients seen at the Department of Ophthalmology at the National University Hospital, Singapore. The primary purpose of this study was to characterise and describe the epidemiology of eye injuries seen in all aspects of our ophthalmology practice. Here, we sought to (1) define the population at risk, (2) identify the nature and characteristics of the injuries and treatment rendered, (3) compare these results with other studies in the literature and (4) make recommendations for public health and clinical strategies for the prevention, management and research of eye trauma in the future.

Materials and Methods

This was a prospective study conducted over a 7-week period, from 11 April 2005 to 29 May 2005, at the National University Hospital, Singapore. All patients with eye injuries who presented to the Department of Ophthalmology for the first time during the study period were included. Patients who had previously sustained an eye injury and presented for follow-up review were excluded. Patients were seen by the department under 3 circumstances: (1) accident and emergency department, (2) outpatient clinics and (3) inpatient referrals. A uniform and validated data sheet, modified from the United States Eye Injury Registry questionnaire for Initial Report,[29] was completed for all patients at their initial evaluation, which comprised a standardised interview and examination. The following details were recorded for each patient: demographic data, the type and source of eye injury, patient's activity at the time of eye injury, and clinical findings on examination and intervention.

For the demographic profile of the patient, the age, sex, race and nationality were recorded. The race of the patient was classified under 1 of 5 ethnic groups: Chinese (all persons of Chinese origins), Malays (all persons of Malay or Indonesian origin), Indians (all persons of Indian, Pakistani, Bangladeshi and Sri Lankan origin), Eurasians and Others (all persons other than the first 4 categories). The nationality of the patient was classified as Singaporean (inclusive of Permanent Resident status) or Non-Singaporean.

Details with regard to the injury, such as the date of injury and presentation, the eye affected, presence of bilateral injury, and place, intent and source of trauma, were recorded. The injuries were also broadly classified as work-related or non-work-related. For work-related injuries, information about the use and issue of personal protective equipment (PPE) was recorded. The interval between the time of injury and presentation at the department was also recorded. The intent of the eye injury was classified under the following: unintentional, self-inflicted (intentional), assault or abuse (subdivided into spouse, elderly or child abuse). The source of injury was classified as follows: construction (which includes all activity such as welding, grinding, carpentry and so forth), human-inflicted (refers to both intentional and unintentional trauma caused by another person without the use of any weapon, such as a punch, a kick, etc), road traffic accident (RTA), chemical, burn (thermal), fall, sports and others (all other mechanisms which cannot be classified in the former categories). Those in whom the injury could have taken place under a variety of circumstances and caused by different mechanisms or where the history was unclear were designated as unknown.

Under examination findings, all sites of involvement and clinical features were recorded for each eye, not only the most severe or principal injury found. For example, a patient with a corneal laceration, retinal detachment and orbital fracture would have had all the aforementioned findings recorded. All eye injuries were also classified under open or closed globe injuries as defined by the Birmingham Eye Trauma Terminology.[30-32] All wounds seen were also classified under this system. The initial visual reading was the best corrected Snellen visual acuity (VA) in the affected eye at the time of presentation. A good initial VA was defined as 6/12 or better. Blindness was taken to be a VA of 6/60 or worse.

The need for hospital admission and type of procedures (refers to any intervention, excluding pharmacological, done as part of the management, which can include minor procedures such as irrigation, superficial foreign body removal and surgical operations such as orbital fracture repair and repair of corneoscleral laceration) were recorded. All procedures performed on each patient were recorded.

Due to the relatively short study period, the final visual outcome was not studied for all patients. However, all patients who presented with an initial VA reading of 6/60 or worse were reviewed via hospital and outpatient case records to obtain their VA reading at the time of their latest follow-up during the study period.

Results

This study included 139 eye injuries in 133 patients. The demographic data are summarised in Table 1. Eighty-four per cent (n = 112) of the patients were male, and 15.8% (n = 21) were female. The male-to-female ratio was 5.3:1. Forty-seven per cent (n = 63) were Chinese, 17.3% (n = 23) were Malay, 30.8% (n = 41) were Indian, 0.8% (n = 1) were Eurasian, 3.7% (n = 5) were classified under other racial groups. Fifty-three per cent (n = 71) of the patients were Singaporeans while 46.6% (n = 62) were non-Singaporeans.

Table 1. Gender, Racial and Nationality Distribution

	%	No. of patients
Gender		
Male	84.2	112
Female	15.8	21
Race		
Chinese	47.4	63
Malay	17.3	23
Indian	30.8	41
Eurasian	0.8	1
Others	3.7	5
Nationality		
Singaporean	53.4	71
Non-Singaporean	46.6	62

The age distribution of the patients is shown in Figure 1. The mean age of patients included in this study was 33.5 years with a range of 5 years to 88 years. The age groups were subdivided into 10-year intervals. The majority of the patients (57.9%, n = 77) were in the 20 to 39 years age group, 13.5% (n = 18) were aged 19 years or younger and 28.6% (n = 38) were aged 40 years or older.

Fifty-eight per cent (n = 77) of the patients sustained injuries to the right eye, 37.6% (n = 50) had injuries involving the left eye, and 4.5% (n = 6) of the patients had bilateral injuries. For the time interval from injury to presentation at the department (Fig. 2), 55.6% (n = 74) presented within 24 hours of the injury. A further 27.1% (n = 36) of the patients took less than 3 days to present. Only 3.8% (n = 5) presented 1 week or later after sustaining the eye injury.

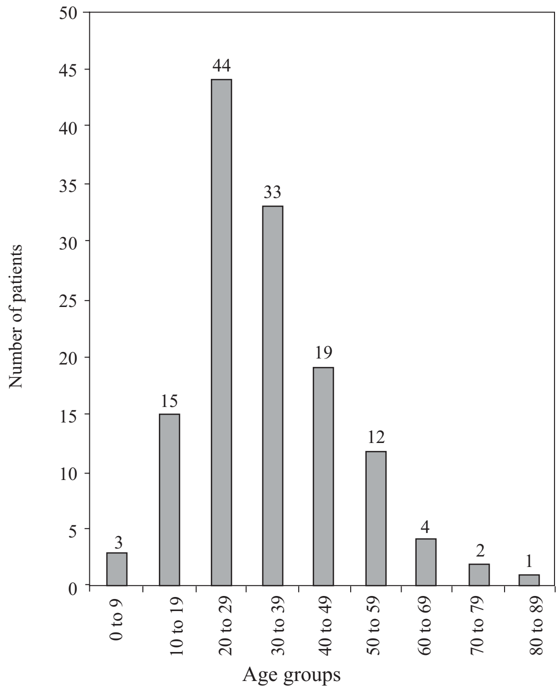

Fig. 1. Distribution of patients by age groups in 10-year intervals.

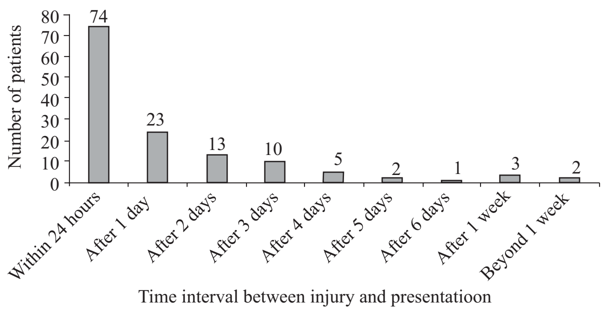

Fig. 2. Time interval between injury and presentation.

The location of injury (Fig. 3) reported was as follows: 54.1% (n = 72) of the patients had been injured on industrial premises, 15.0% (n = 20) of the injuries had occurred at home and 9.8% (n = 13) had occurred on the street and highway. The school and places for recreation and sports each accounted for 6.8% (n = 9) of locations of injury. Seven patients (5.3%) had been injured at a public building, 2 patients (1.5%) at the laboratory (work-related) and 1 patient (0.8%) had been injured at an army camp.

In our study, the majority of the patients (89.5%, n = 119) had sustained their eye injuries accidentally, while 12 patients (9.0%) had been victims of assault. We also saw 2 cases (1.5%) of spousal abuse. The sources of injury were broad and varied (Table 2).

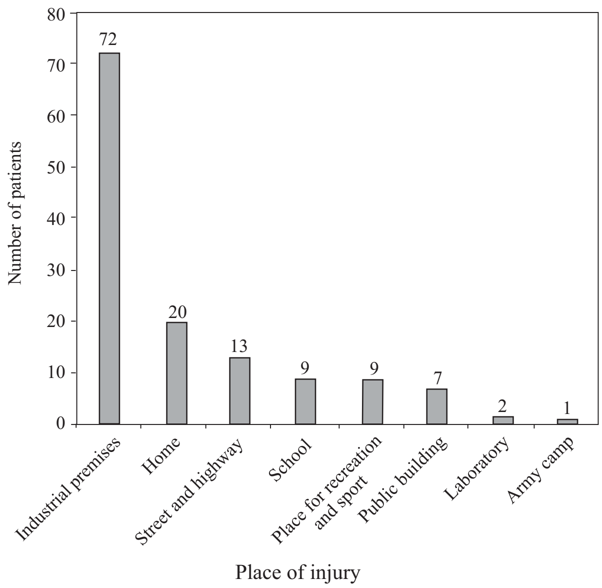

Fig. 3. Distribution of locations at which eye injury took place.

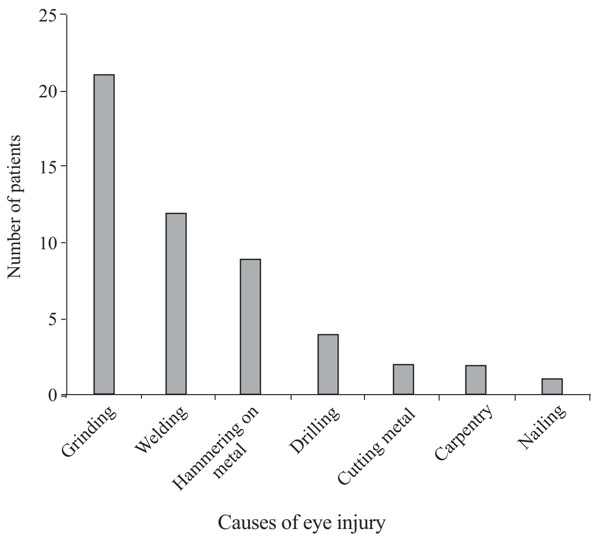

Fig. 4. Distribution of eye injury within the construction industry.

Table 2. Sources of Injury

Source	%	No. of patients
Construction	38.4	51
Grinding	15.8	21
Welding	9.0	12
Hammering on metal	6.8	9
Drilling	3.0	4
Cutting metal	1.5	2
Carpentry	1.5	2
Nailing	0.8	1
Human-inflicted mechanism	12.0	16
Road traffic accident	8.3	11
Chemicals	8.3	11
Fall	6.0	8
Sports	6.0	8
Burn	1.5	2
Others	16.5	22
Unknown	3.0	4

The most common cause was construction activities, accounting for 38.4% (n = 51) of all injuries seen. Of these, grinding and welding (Fig. 4) accounted for the most number of eye injuries, comprising 15.8% (n = 21) and 9.0% (n = 12) of all cases respectively.

Human-inflicted mechanisms were the second most common source of injury, making up 12.0% (n = 16) of all patients. Road traffic accidents (RTA) and chemicals (Table 3) accounted for 8.3% (n = 11) each. Six per cent (n = 8) of the patients had sustained an eye injury from a fall, while only 6.0% (n = 8) had been injured while playing sports. The sports activities implicated included: softball, tennis, rugby, cricket, swimming (1 case each) and basketball (3 cases).

Of all the patients in our study, 56.4% (n = 75) had sustained a work-related eye injury while 43.6% (n = 58) had sustained non-work-related injury.

The majority (70.7%, n = 53) of these work-related injuries occurred in non-Singaporeans. Of all occupational eye injuries, 29.3% (n = 22) reported having used PPE at the time of injury, 38.7% (n = 29) had been issued PPE but had not used them, while 32% (n = 24) reported that PPE had not been issued.

Five per cent (n = 7) of the eyes were diagnosed to have an open-globe injury, while the rest (95.0%, n = 132) were closed-globe injuries.

As shown in Table 4, almost all ocular structures can be affected in trauma. The most common anatomical site of injury was the cornea, involved in 33.1% (n = 81) of all

Table 3. List of Chemical Agents Implicated in our Study

1.	Selenide sulphide antifungal shampoo
2.	Inorganic acids
3.	Hair dye
4.	Silver cyanide
5.	Superglue
6.	Paint
7.	Styrene
8.	Haptane and prochloroethylene 90%
9.	Cyanoacylate adhesive
10.	Dettol

Table 4. Anatomical Sites Involved

	%	No. of eyes involved
Anatomical site		
Cornea	33.1	81
Lid	13.1	32
Conjunctiva	12.2	30
Periorbital region	12.2	30
Orbit	6.5	16
Retina	5.7	14
Iris	3.7	9
Vitreous	3.3	8
Anterior chamber	2.9	7
Sclera	2.0	5
Lens	1.2	3
Limbus	1.2	3
Extraocular muscles	0.8	2
Optic nerve	0.8	2
Lacrimal system	0.8	2
Macula	0.4	1

clinical findings. This is followed by the eyelid (13.1%, n = 32), conjunctiva (12.2%, n = 30) and the periorbital region (12.2%, n = 30). Notably, the orbit was the 5th most commonly involved site, making up 6.5% (n = 16) of all clinical findings. The retina was involved in 5.7% (n = 14) of cases, while vitreous made up 3.3% (n = 8) of findings.

Table 5 summarises all the clinical findings observed at the initial examination. There were 245 findings from 139 eyes. The most common finding was that of a superficial foreign body, at 22.4% (n = 55). Of these, 87.3% (n = 48) were found on the cornea, 9.1% (n = 5) on the conjunctiva and 3.6% (n = 2) on the limbus. The second most common clinical finding was that of contusional injury comprising periorbital bruising (12.2%, n = 30) and lid ecchymoses (6.9%, n = 17). Orbital fractures were involved in 6.5% (n = 16) of findings. Of these, the most common site of fracture was the orbital floor, making up 35.5% (n = 11) of all sites of fracture. Penetrating injury to the eye made up 2.4% (n = 6) of all findings. These were found in 6 different eyes, of which 2 had full thickness laceration of the cornea, 3 had a corneoscleral laceration and 1 had a scleral laceration only. There was also 1 case of globe rupture (0.4%, n = 1).

Table 5. Clinical Findings Observed in Patients at the Initial Examination

	%	No. of eyes
Superficial foreign body	22.4	55
Periorbital bruise	12.2	30
Lid ecchymoses	6.9	17
Orbital fractures	6.5	16
Lid laceration	6.1	15
Corneal abrasion	5.7	14
Chemical injury	5.7	14
Subconjunctival haemorrhage	4.1	10
Commotio retinae	2.9	7
Conjunctival hyperaemia	2.9	7
Penetrating injury of the globe	2.4	6
Traumatic uveitis	2.4	6
Posterior vitreous detachment	2.4	6
Hyphema	1.6	4
Traumatic cataract	1.2	3
Uveal prolapse	1.2	3
Conjunctival laceration	1.2	3
Corneal ulcer	1.2	3
Canalicular laceration	0.8	2
Retinal haemorrhage	0.8	2
Optic neuropathy	0.8	2
Orbital emphysema	0.8	2
Burnt eyelashes	0.8	2
Conjunctivitis	0.8	2
Globe rupture	0.4	1
Thermal injury	0.4	1
Orbital foreign body	0.4	1
Intravitreal foreign body	0.4	1
Vitreous haemorrhage	0.4	1
Vitreous prolapse	0.4	1
Retinal tear	0.4	1
Retinal hole	0.4	1
Retinal dialysis	0.4	1
Retinal detachment	0.4	1
Retinal oedema	0.4	1
Prolapse of lens material	0.4	1
Ciliary body tear	0.4	1
Scleritis	0.4	1

Table 6. Type of Procedures Performed

	%	No. of eyes
Foreign body removal	52.4	55
Irrigation	13.3	14
Repair of eyelid laceration	11.4	12
Orbital fracture repair and reconstruction	8.6	9
Lens surgery	2.9	3
Retinal surgery	2.9	3
Repair of corneal wound	1.9	2
Repair of corneoscleral wound	1.9	2
Globe exploration	1.0	1
Repair of scleral wound	1.0	1
Canthotomy and cantholysis	1.0	1
Craniotomy with optic canal decompression	1.0	1
Vitrectomy (TPPV)	1.0	1

There was 1 eye with multiple orbital foreign bodies (0.4%, n = 1) and another with an intraocular foreign body (IOFB) in the vitreous (0.4%, n = 1).

Only 15% (n = 20) of the patients required hospital admission for their eye injury, while 67.6% (n = 94) of all eyes injured required some form of procedure as part of the management. Table 6 summarises the procedures performed.

The most common procedure was the removal of foreign bodies, making up 52.4% (n = 55) of all procedures done. All except one, which involved a magnet extraction of IOFB retained in the vitreous, were the manual removal of superficial foreign bodies. Thirteen per cent (n = 14) of the procedures done were irrigation of the eye, 11.4% (n = 9) were the repair of eyelid lacerations, while 8.6% (n = 9) of procedures were orbital fracture repair and reconstruction. Of the lens surgeries done for traumatic cataract (2.9%, n = 3), 1 lensectomy and 2 phacoemulsifications were done. Retinal surgery made up 2.9% (n = 3) of all procedures, of which there were 2 retinopexies and 1 cryopexy. Other procedures included the repair of corneal wound (1.9%, n = 2), the repair of corneoscleral wound (1.9%, n = 2), globe exploration (1.0%, n = 1), the repair of scleral wound (1.0%, n = 1), lateral canthotomy and cantholysis (1.0%, n = 1), craniotomy with optic nerve decompression (1.0%, n = 1) and trans pars plana vitrectomy (1.0%, n = 1).

As shown in Table 7, 63.0% (n = 88) of the eyes had an initial VA of 6/12 or better. However, 10.0% (n = 14) of the eyes had a VA of 6/60 or worse.

Of all the 14 patients who presented with an initial VA reading of 6/60 or worse (Table 8), the most common cause was open-globe injury (42.9%, n = 6). Other causes include traumatic optic neuropathy (14.3%, n = 2), superficial

Table 7. Initial Snellen Visual Acuity Reading

	%	No. of eyes
Reading		
>6/9	26.6	37
6/9 to 6/12	36.7	51
6/15 to 6/18	7.9	11
6/24 to 6/30	5.8	8
6/60 to 6/120	3.6	5
Counting fingers	2.2	3
Hand movement	2.2	3
Light perception	0.7	1
No light perception	1.4	2
Not done	12.9	18

foreign body (14.3%, n = 2), chemical injury (7.1%, n = 1), orbital fracture (7.1%, n = 1), lid laceration (7.1%, n = 1) and contusion (7.1%, n = 1). On follow-up of these patients after varying durations, 10 out of 14 (71.4%) patients showed an improvement of VA reading of at least 1 line in their VA. Two (14.3%) patients did not show improvement from their initial VA reading. Two (14.3%) patients were lost to follow-up.

Discussion

The study of ophthalmic injuries is difficult.[33] The wide spectrum of clinical presentation necessitates a large sample size in order to reliably identify populations at risk. Moreover, meaningful analysis can only be achieved from data collected in a uniform and prospective manner. Varying strategies, each with its pros and cons, have been devised in the study of ophthalmic trauma – hospital-based surveys, population-based studies and data from trauma registries and surveillance systems. However, differing project objectives, research methodologies and the lack of a standardised classification of ocular trauma terminology prior to BETT[30-32] have made comparisons of study findings difficult.

The current study was a hospital-based prospective survey of ophthalmic trauma over a 7-week period. The strength of our study is derived from the fact that data were uniformly collected at the patient's initial presentation, when descriptive details regarding the context and circumstances of the traumatic event were still vivid. Clinical findings were made by the ophthalmologist at the first visit. These eliminate the possibility of inadequate documentation and the problems of coding and retrieval commonly seen in studies which are retrospective in nature and based on coded hospital discharge data. In the current study, patients with eye injuries were derived from all aspects of our ophthalmology practice. This is a departure from past

Table 8. Clinical Profile of Patients who had an Initial Visual Acuity Reading of 6/60 or Worse

Patient	Age, Sex	Source of injury	Clinical diagnosis	Initial VA	Follow-up period	VA on latest follow-up	Remarks
A	61M	RTA	Fracture of the left orbital floor, medial, lateral wall and the zygomatic bone.	6/120	1 month	6/12	-
B	31M	RTA	Traumatic optic neuropathy with full thickness laceration of the left upper eyelid involving margin, and fracture of the zygomatic and temporal bone.	Hand movement at ½ foot	1 month	6/12	Visual field defect remained on follow-up.
C	26M	RTA	Traumatic optic neuropathy with full thickness laceration of the right upper eyelid not involving margins, traumatic hyphema and four-wall fracture of the orbit, apex, zygomatic and maxillary bone.	Hand movement	2 months	6/24	Visual field defect remained on follow-up.
D	43M	Work	Right penetrating eye injury with corneoscleral laceration, prolapse of uvea in the visual axis and full-thickness laceration of the upper eyelid.	No light perception	1 month	No light perception	Counselled regarding the option of enucleation, but the patient declined the offer.
E	29M	RTA	Right ruptured globe with corneoscleral wound, disorganised anterior segment, total retinal detachment, orbital roof fracture, multiple orbital foreign bodies and full-thickness laceration of the upper eyelid and upper canaliculus.	No light perception	-	-	While admitted, he refused the option of enucleation and declined other operations. Lost to follow-up upon discharge.
F	26M	Work	Right metallic corneal foreign body while hammering metal removed using forceps. Additional foreign body was removed on follow-up at 3 weeks. Ophthalmic examination was normal except for 1-mm corneal scar in visual axis.	Counting fingers	3 weeks	6/120	Patient has been referred to cornea service regarding option for phototherapeutic keratectomy.
G	41M	Work	Partial thickness laceration of the upper eyelid with involved margins extending posteriorly onto the tarsal surface, and commotio retinae involving the macula.	6/60	-	-	Lost to follow-up.
H	22M	Work	Left corneal foreign body removal done following which he presented with a scleritis picture. He was subsequently treated with atropine and augmentin.	6/120	6 weeks	6/12	-
I	28M	Work	Right open-globe injury with corneal laceration and traumatic cataract.	Light perception	2 months	6/12	-
J	75F	Domestic chemical injury	Corneal epithelial defect as a result of chemical injury from Dettol solution.	Hand movement at 4m	2 weeks	6/36	-
K	13M	Sports	Right open-globe injury with scleral laceration and incarceration of uvea tissue.	6/60	2 weeks	6/6	-
L	53M	Assault	Right contusional injuries consisting of periorbital bruise and subconjunctival haemorrhage.	6/60	2 days	6/9	-
M	39M	Work	Left open-globe injury with corneal laceration and traumatic cataract.	Counting fingers at 1m	2 weeks	Counting fingers at 1½ m.	Functionally blind. Right eye was previously injured (VA:CF)
N	27M	Work	Left open-globe injury with corneoscleral laceration, traumatic cataract, vitreous haemorrhage, intra-vitreal metallic foreign body, retinal oedema at impact site, hyphema, iris prolapse and shaving injury of the left upper lid margin.	Counting fingers	2 weeks	Near vision of N5 on 'N' chart.	-

F: female, M: male, RTA: road traffic accident, VA: visual acuity studies, which focused solely on trauma patients in the emergency setting,[19,21] in which patients suffering eye injuries along with other severe injuries and multiple trauma could be underrepresented. This is unlikely in our study as cross-departmental inpatient referrals allow a good capture of this category of patients. The current study is however limited by its relatively small study size, attributed to the short study period. Moreover, in such a hospital-based study, the size of the population at risk is not accurately known. Its narrower scope predisposes the study to more referral bias, particularly skewing the results towards the more serious causes of eye injury in the community. The fact that patients with minor eye injuries have ready access to primary care in Singapore and can be adequately managed by primary physicians supports this point. It is worth noting that such minor eye injuries are perhaps better studied in large-scale population-based studies. Lastly, there is also a geographical bias inherent in all ophthalmic trauma study designs. Hence, although eye injury rates cannot be derived from the current study and the results may not be generalised to the whole population, the completeness of coverage and detailed data from each patient's history, clinical presentation and examination findings ensure that the spectrum and distribution of ophthalmic trauma in an urban setting are well represented.

It is commonly recognised that young, adult males are more prone to ocular trauma and this has been traditionally attributed to the relatively higher tendency for risk-taking behaviour and the higher proportion of work-related, assault-related and sports-related eye injuries, in which there is a significant male preponderance. In our review of existing literature, most studies showed that male patients formed the overwhelming majority of patients presenting with eye injuries seen,[20,21,23,24,28,34-41] with figures ranging from 70% to 87% of all ocular trauma, and the risk of men sustaining ocular trauma was as many as 3 to 5.5 times that of women.[12,14-17,19] This finding has been echoed by Wong and Tielsch,[18] who reported that men had a rate of injury 4 times higher than that of women. The current study also reported 84.2% of patients being male, with a male to female ratio of 5.3 to 1. The age distribution of patients in this study was such that 57.9% were in the 20 years to 39 years age group, 28.6% were 40 years or older and 13.5% were 19 years or younger. The mean age was 33.5 years, which corresponds to most other studies, which reported a mean age of about 30 years.[21,28,39-41] However, the bimodal distribution, with peaks at 18 years to 25 years and above 70 years in both males and females as reported by Tielsch et al,[16] Klopfer et al[17] and Wong and Tielsch[18] was not seen, probably due to the our small study size. The fact that the majority of our patients were young healthy males, who have a long professional, social and family life ahead of them, carries an added significance when the effects of permanent disability on their quality of life is considered. Although the impact of eye injuries extend beyond the afflicted individual to societal level in terms of loss of productivity and added costs to the healthcare system, these should not be our only concerns. The realisation that the trauma patient bears an immense personal cost is crucial. The quality of life of not only the patient, but also his or her families and friends, is affected. It is perhaps a worthy reminder that the serious consequences of eye injuries, such as visual impairment and physical disfiguration, can also alienate the patient by imposing a barrier to social interaction, both physically and psychologically. These repercussions are especially serious in the young.

Racial variation in eye injuries has also been well reported.[9,16,42] A study from the US[16] estimated that between the ages of 25 years and 65 years, non-whites had a 40% to 60% higher risk of sustaining an eye injury. It has also been reported that in Singapore,[18] persons of Indian ethnicity had almost twice the risk of either the Chinese or Malays. However, in the current study, 47.4% of the patients were Chinese, 30.8% were Indian and 17.3% were Malay. Close to half of our patients were non-Singaporeans (46.6%, n = 62). In those who suffered a work-related injury, 70.7% (n = 53) were non-Singaporeans. This is not surprising as foreign workers from countries such as India, Bangladesh, Malaysia, Thailand and Myanmar constitute a sizeable proportion of our foreign workforce. Hence our findings suggest that for all eye injuries, Chinese Singaporeans are the predominant group, but in work-related injuries, non-Singaporeans predominate.

More than half of all eye injuries (56.4%, n = 75) seen in this study were work-related, with 54.1% (n = 72) of patients having been injured on industrial premises. Past studies[10,26,43] have shown that work is an important cause of eye injury. Baker et al,[38] in a population-based survey of severe work-related ocular injury performed using hospital discharge data, reported that the annual incidence for severe work-related ocular injury was 1.76 per 100,000 employed persons when ocular trauma was the principal diagnosis. In a prospective survey of 5671 cases, Macewen[28] found that 69.9% of eye injuries were work-related. In a population-based study of incidence of eye injuries among New England adults, Glynn et al[22] also reported 16 (59%) out of 27 eye injuries requiring medical attention to be work-related, though the number of injuries identified was small. Schein et al,[21] in a hospital-based study of 3184 patients, reported that 48% of the ocular injuries were work-related, of which 62% could be attributed to construction industries. He also found that 66% of all patients injured at work reported that protective eye wear had been provided, compared to only one-third of patients with severe injury. Only 10% stated that they had been wearing protective eye wear at the time of injury, though none was severe. McCarty et al,[14] in a population-based cross-sectional study of the epidemiology of ocular trauma in Australia, found that the workplace accounted for the majority (60%) of the eye injuries and that less than 20% of workers had been wearing any form of eye protection at the time of injury. In a local prospective study of ocular trauma based in the emergency department done by Voon et al,[19] occupational injuries accounted for 590 (71.4%) cases, where grinding, cutting metal and drilling were the specific activities in more than 90% of the cases. It was reported that only 21.7% of patients with work-related injuries had used PPE, 43.7% had been provided with PPE, but had not used them at the time of injury, while the remaining 34.6% reported that PPE had not been provided. The current study had similar findings when it came to the use and issue of PPE in work-related injuries: 29.3% (n = 22) reported to having used PPE when the injury occurred, 38.7% (n = 29) had been issued PPE but did not use them then and 32.0% (n = 24) reported that PPE had not been issued. These results serve to emphasize an important point in occupational eye injuries: It is only acceptable that workers are issued PPE when carrying out potentially hazardous tasks. We must also acknowledge that protective devices are not foolproof, but they reduce the chance of injury. No PPE is an absolute guarantee against injury.[4] In her study, Macewen[28] reported that 15.4% of occupational eye injury patients had been wearing some form of protection but had been failed by the lack of efficacy of the eye protection. Lastly, it is only common sense that the worker should be obliged to wear the PPE for it to be effective. In terms of the source of injury, activities of construction constitute 38.3% of all injuries seen and 66.7% of all work-related eye injuries. The work tasks implicated include grinding, welding, hammering, drilling, carpentry, cutting metal and nailing. These activities commonly involve high-powered tools which are able to generate projectiles at high velocities, often to devastating effects on the eye. In the course of this study, we encountered patients whose face shields had been shattered or simply had not offered adequate protection during activities such as welding and drilling. Such situations were not uncommon in past reports.[28]

It is noteworthy that despite the predominance of occupational eye injuries locally, there are increasing number of studies, based on western populations, showing that work-related injuries are becoming less common and significant,[26,40,43-46] probably due to better education in the workplace and effective preventive strategies reinforced by legislation. Emerging studies seem to suggest that domestic eye injuries have surpassed work-related injuries in incidence, particularly among children.[21,28,47]

Road traffic accidents constitute 8.3% (n = 11) of all injuries. Although seatbelt laws,[48,49] reduction of speed limits, laminated glass and airbags[50] have dramatically decreased the incidence of motor vehicle crash-related eye injuries,[49-51] they remain important sources of ophthalmic trauma.[5,16,40,52] Kuhn et al,[52] in a study of 150 motor vehicle crash-related eye injuries, reported that 47% of eyes had an initial VA of 20/200 or worse; at a minimum follow-up of 3 months, 63% had an initial VA poorer than 20/200, while 41% remained legally blind. Twelve per cent of eyes needed removal. He attributed the poor prognosis of this group of patients to the large proportion of blunt globe ruptures. In our study, the spectrum of RTA-related eye trauma ranged from minor contusions and lid lacerations to orbital fractures (4 patients), traumatic optic neuropathy (2 patients) and globe rupture (1 patient). Only 1 patient complained of airbag injury along with shattered glasses. The huge mechanical impact present in road traffic accidents probably explained the severity and subsequently poor visual outcome of some of the eye injuries encountered. Although most of the measures as described that have been shown to reduce the incidence of road traffic accident-related eye injuries are currently in place, increased legislative enforcement, enhanced protective applications in vehicles and improved driver's education will further aid prevention.

Eight per cent (n = 11) of the patients in the current study had sustained a chemical injury. Of these, 3 patients had suffered "domestic accidents" involving shampoos, hair-dye and antiseptic solution. Eight patients had been injured at work either on industrial premises or in the laboratory. The agents implicated included: inorganic acids, silver cyanide, superglue, paint, alkaline styrene, haptane, prochloroethylene and cyanoacylate adhesive. Understandably, the nature and extent of exposure determines the prognosis for recovery.[53] Chemical injuries are commonly seen in many different occupational settings, particularly in the chemical industry[54-56] and other industries.[57] Griffith and Jones,[54] in a population-based study of chemical eye injuries in the chemical industry, found that 45.1% of all eye injuries had been caused by chemicals, with an incidence of 11.4 per 1000 employees per year. These findings highlight the importance of preventive measures not only in the chemical industry, but for any person who comes into contact with chemical substances. Domestic accidents involving chemicals are perhaps hard to prevent, though patients can be advised regarding the correct usage of household consumer items and in the event of injury, they should immediately irrigate themselves. In the chemical industry and laboratories, a comprehensive protocol should be in place. Eye goggles and face shields should be worn when dealing with chemical agents, with extensive and continuous eye irrigation being the single most important management step at the time of injury. Chemical injury to the eye is serious and potentially threatening to vision[58] and should be treated without delay to prevent blindness.

There were 14 cases of assault (10.5%), of which 2 cases involved spousal abuse. All of these eye injuries had been caused by blunt trauma inflicted by their bare fist. Only 1 patient reported being assaulted by a screwdriver, but he had sustained only minor injuries. Dannenberg et al,[27] in a report on 648 penetrating eye injuries related to assault derived from the National Eye Trauma System Registry, found that assault-related ocular trauma constituted 22.0% of all eye injuries, with a male predominance of 83% and association with alcohol (48.3%) and illegal drug use (6.2%). The initial VA after the injury was hand movement or worse in 74% of cases. Other studies reported that assault-related ocular trauma constituted 15% to 43% of all cases seen.[21,40,43,44] The severity of assault-related injury underlines its importance.[5] However, the current study found that most assault victims sustained contusional injuries which were low in severity and could be treated on an outpatient basis. The use of alcohol and illicit drugs were not studied. Prevention of civil disturbance and violence (domestic or otherwise) is perhaps beyond the scope of the ophthalmologist,[59] but public efforts to curb the use of alcohol and illegal drug use at a community level may help.[27]

Only 6.0% (n = 8) of all eye trauma patients seen had sustained sports-related injuries. Basketball was the most frequently implicated sport, reported in 3 of our patients. Others include softball, rugby, cricket, tennis and swimming. It has been estimated that sports injuries constituted 3.4% of all eye injuries in the US;[21] 42,000 sports and recreation-related eye injuries were reported in 2000, of which 72% occurred in a person younger than 25 years of age.[60] Although the number of patients was small, our findings were similar to that reported,[21,41,43-44,61,62] that among children older than 5 years and in adults, the sports implicated, in decreasing order of frequency, were: basketball, baseball and softball, swimming and football. Again, the role of protective eyewear in sports should be emphasised as the risk of significant eye injury can be reduced by at least 90% if appropriate, properly fitted eye protection is used.[62-67] For this special group of patients, the development of eye protection which meets adequate standards, with appropriate optical and visual field requirements, is especially important.[28,68]

In the current study, the most common clinical findings on examination were superficial foreign bodies (22.4%, n = 55), contusional injuries such as lid ecchymoses and periorbital bruises (19.1%, n = 47), orbital fractures (6.5%, n = 16), lid lacerations (6.1%, n = 15) and corneal abrasions (5.7%, n = 14). Other findings include corneal epithelial defects due to chemical insult, subconjunctival haemorrhage and commotio retinae. Contusional injuries and subconjunctival haemorrhage were mainly due to blunt trauma. The most common retinal finding in our study was that of commotio retinae (n = 7), also the result of blunt eye trauma[69] and reported to account for 9.4% of all post-traumatic fundus findings.[70] Similar findings were reported by Voon et al[19] in a local emergency department-based study, in which the 3 most common types of injuries were superficial foreign bodies (58.2%), corneal abrasions (24.9%) and blunt trauma (12.6%). Though most of the common eye injuries encountered were minor, it is possible that an apparently "trivial" clinical presentation belies more severe and sinister injuries.[20] Hence, in the best interest of the patient, every patient should have a complete ophthalmologic examination at the time of initial presentation.

Open-globe injuries constitute only 5% (n = 7) of all injured eyes, of which there were 6 penetrating injuries of the globe and 1 globe rupture. This finding is close to that previously reported by Voon et al.[19] Two of the patients had orbital and intravitreal foreign bodies respectively. All the patients seen were male. Five of the patients had sustained the injury at work and 1 in an RTA, while 1 patient had been injured while playing basketball. In Singapore,[18] the annual incidence rate of open-globe injury is 3.7 per 100,000 population and it was also reported that nearly 15% of open globe injuries was associated with an intraocular foreign body. In our study, 14 eyes (10%) had an initial VA of 6/60 or worse. Open-globe injury (n = 6) constitute 42.9% of these. One patient with open-globe injury, whose cornea was penetrated by a piece of wire during work, did not have his VA measured and hence was not included. Of these, only 1 open-globe injury patient showed significant improvement; the rest showed either no improvement or just marginal improvement. Two patients were lost to follow-up. Although marked improvement in the management of open-globe injuries has occurred in the last 50 years,[71] the prognosis remains guarded and is dependent on many factors.[72-75] Other causes of poor initial VA in our study include traumatic optic neuropathy (14.3%, n = 2), superficial foreign bodies (14.3%, n = 2), chemical injuries (7.1%, n = 1), orbital fractures (7.1%, n = 1), lid lacerations (7.1%, n = 1) and contusions (7.1%, n = 1). Of all 14 patients, 64.3% showed improvement of at least 1 line in VA. This indicates that there is still much potential for injured eyes to achieve an improved visual outcome, if they are properly managed.

Prevention is the best policy in ophthalmic trauma. With the knowledge and use of proper eye protection, 90% of eye injuries could be prevented.[2] Fong and Taouk,[76] in a prospective cross-sectional survey of all eye injuries seen at an eye centre in Australia, concluded that the use of safety eyewear is a cost-effective intervention that may result in annual cost savings of $59 million for work-type activities in the occupational and domestic settings. Clearly, most eye trauma research aims to identify risk factors that will facilitate the development of primary, secondary and tertiary prevention programmes.[5] We do not support the claim that eye injuries are a matter of "bad luck", "fate" or "accident",[33,38,77] because there are universal trends, well-defined high-risk populations and settings in eye trauma which permit preventive intervention. Sterling examples of the effectiveness of preventive strategies, particularly the use of PPE, are well-documented in the settings of transport safety,[49,78] sports[79-81] and modern combat.[82] In a study from the UK, Cole et al[49] reported that with the introduction of mandatory seatbelt laws, the rate of motor vehicle crashes as a cause of open-globe injuries plummeted from 17.1% to 6%. Similarly, in the sporting arena, ice hockey has been often quoted as a successful model for the prevention of eye injuries. The use of visors and full facial protection in the game has greatly reduced the number of eye injuries.[79-80,83,84] Even in combat, the use of protective equipment has improved eye safety. In a study of eye injuries and ocular protection in the Lebanon War in 1982, Belkin et al[82] reported a high incidence of ocular trauma (6.8% of all casualties), mainly caused by small high-velocity missiles and ricochets. Yet, not a single eye was injured in soldiers who had ballistic protective goggles properly placed over the eyes at the time of injury. The value of prevention in ensuring ocular safety is undeniable.

A number of preventive strategies are available in the workplace which involves exposure alteration, environment modification and PPE.[85] There is evidence that policy changes are effective in behavioural modification and the reduction of eye injuries in some settings.[86] The finding that 32% of work-related eye injury patients reporting had not been issued any PPE is startling, especially when occupational safety and health laws are already in place. The scope of local legislation is very much focused on and confined to industrial premises as defined by the law. Pertaining to the issue of eye protection, the Factories Act (Chapter 104) has mandated the issue of suitable goggles and effective screens for all work processes that involve a special risk of eye injury.[87] The finding that 38.7% of patients had not used PPE even when the PPE had been issued only highlights a lack of awareness among all ranks in the workplace, which has not changed in recent years.[85] Non-compliance among workers can be partly attributed to inadequate education, ineffective communication (including language barriers), and poorly designed and uncomfortable eyewear. In the course of this study, at least one patient had sustained a work-related eye injury when not wearing PPE because they were deemed "uncomfortable". Hence, more attention should be directed to the ergonomics, resistance and durability[88] of the PPE. However, a lack of organised emphasis on ocular safety seems to be the root of the problem. Here, the role of the ophthalmologist is crucial in (1) promoting the concept that prevention of most eye injuries is within society's grasp,[4] (2) taking concrete steps in assessing the patient's eye injury potential in not just occupational, but also domestic and recreational settings, and (3) prescribing the most appropriate protective device out of the huge selection available.[4]

We also recommend the establishment of a collaborative islandwide registry maintaining a long-term database of all ophthalmic injuries, to aid research on a larger scale and the development of new preventive strategies according to the changing trends in eye trauma epidemiology. Such a registry may also act as a surveillance system for eye injuries, as shown in 2 examples from the US – the United States Eye Injury Registry (USEIR), the only organisation that derives clinical and epidemiological data from hospitals, emergency departments and the physicians' office; and the National Eye Trauma System (NETS), which monitors the circumstances and outcome solely of penetrating injuries through its 52 regional centres. Above all, cooperation between public and private agencies, healthcare facilities, individual ophthalmologists and physicians is required for such a registry to succeed.

From the current study, we can conclude that there is a broad spectrum of causes, mechanisms and severity of ophthalmic injuries seen in the hospital, of which work-related trauma makes up a significant proportion. The patients who suffer occupational injuries are a well-defined group: Young, non-Singaporean males, working with powered tools in the construction industry are at particular risk. Although preventive strategies are in place for this high-risk group, a lack of awareness and compliance limit their effectiveness. The adequacy and functionality of the PPE should also be emphasised. In addition, preventive efforts are equally important in domestic, recreational, sports and transport settings. Eye trauma research and prevention can be further aided by a collaborative registry of eye injuries. A long-term islandwide database of all ophthalmic injuries islandwide is recommended.

Eye injuries are preventable. *Don't risk it. Do more.*

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