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Eye trauma epidemiology in regional Australia

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Manuscript Title

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Abstract

Purpose: To describe the epidemiology of eye trauma presenting to a regional referral health service in New South Wales, Australia.

Methods: A two-stage retrospective and prospective case series study was conducted. Patients who presented with eye trauma to Wagga Wagga Base Hospital (WWBH) emergency department (ED) during a one year review period formed the retrospective case series (RCS). Patient inclusion was determined using SNOMED CT and ICD-10 codes applied to medical records. Patients presenting with eye trauma to the WWBH ED or its ophthalmology service over a prospective 80 day study period formed the prospective case series (PCS). The main outcome measures were patient demographics, eye trauma incidence for Wagga Wagga and the Murrumbidgee region and injury details.

Results: Four hundred and eleven and 117 eye injuries were identified for the RCS and PCS, respectively. Mean age was 35.5 years ± 18.6 (RCS) and 34.1 years ± 17.1 (PCS), with male predominance, 77.9% (RCS) and 89.7% (PCS). The incidence of eye trauma in Wagga Wagga and Murrumbidgee was estimated from the PCS at 537.1 and 334.4 per 100,000 person-years, respectively. A large proportion of injuries were work-related, 40.2% (RCS) and 45.8% (PCS). Protective eyewear use in work-related injuries was low, 27.6% (RCS) and 39.0% (PCS).

Conclusions: Eye trauma remains a significant public health concern with a high incidence in Wagga Wagga and the Murrumbidgee region. Protective eyewear compliance is low in work-related eye injuries. Patient demographic and occupational factors may be targeted to reduce the burden of disease.

Keywords: Epidemiology, eye trauma, protective eyewear, regional, rural

Running Title: Eye trauma epidemiology in regional Australia

Introduction

Eye trauma is a significant cause of preventable blindness and morbidity worldwide with an estimated 55 million eye injuries occurring annually.[1] The Australian Bureau of Statistics' National Health Survey estimates approximately 45,400 eye injuries occur monthly, nationwide.[2] Morbidity and service provision associated with eye trauma in Australia carries a considerable cost.[3]

There have been several previous epidemiological reports on eye trauma in Australia.[3-11] Young males have been noted to be at particular risk of injury. Work-related eye trauma has been identified as a significant public health concern, with protective eyewear compliance at suboptimal levels.[12]

The emergency department (ED) and ophthalmology clinic are important referral sources for eye injuries.[13] Eye trauma has been reported to be the most common cause of ophthalmology-related ED presentation.[14]

Characterisation of eye trauma epidemiology in regional Australia is important given the challenges of providing access to health services in rural areas. Males from rural areas have been found to be at higher risk of eye injury than their metropolitan counterparts.[5] In addition, patients sustaining open-globe injuries in regional Australia have been identified to have worse visual outcome when compared to those located in metropolitan areas.[15]

Adequate understanding of eye trauma epidemiology may enable development of effective prevention strategies. The epidemiology of eye trauma has been described in parts of Australia; however, regional New South Wales remains largely unexamined. Previous work has relied mainly on the retrospective use of emergency department records. We conducted an epidemiological study of eye trauma presenting to a regional hospital ED and its ophthalmology service. This is the first report on eye trauma epidemiology within Wagga Wagga and the surrounding Murrumbidgee region.

Method

A two-stage retrospective and prospective case series study was conducted. Case series were developed from consecutive eye trauma presentations to Wagga Wagga Base Hospital (WWBH) ED and its ophthalmology service. WWBH is a 256-bed regional referral hospital located within the Murrumbidgee local health district (LHD) in south-western New South Wales, Australia **(Figure 1a, 1b)**. The WWBH ophthalmology service provides public outpatient clinics and receives referrals from within the Murrumbidgee LHD.

WWBH is the only public healthcare facility within the Murrumbidgee region to have full-time comprehensive ophthalmology services. Eye trauma cases requiring specialist ophthalmology management within the region are referred to WWBH ED or its ophthalmology service. As a result, the study series are considered to represent the entire spectrum of significant eye trauma within the region.

Retrospective case series (RCS)

WWBH and ED medical records were reviewed for eye trauma presentations over a one year period, 1st May 2011 – 30th April 2012. Cases were identified using relevant Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT) and International Classification of Diseases 10th revision (ICD-10) codes. A keyword search was conducted of the SNOMED CT codes database using the following terms: “eye”, “cornea”, “iris”, “orbit”, “globe”, “sclera”, “pupil”, “retina”, and “vision”. The initial search revealed 7,454 clinical terms of which 788, pertaining to injuries, were retained for use in retrospective case identification and retrieval. After initial search of the electronic medical records, charts were reviewed. Data were extracted on patient demographics, injury details, clinical examination findings, and clinical management. Cases in which the primary diagnosis was not related to eye trauma were excluded.

Prospective case series (PCS)

Patients who presented with eye trauma to the WWBH ED or ophthalmology service were recruited over an 80 day period, 2nd May 2012 – 20th July 2012. A prospectively established database recorded

patient demographics, injury details, clinical examination findings, and clinical management details from electronic medical records. Upon presentation, patient consent was requested for follow-up telephone interview. Additional prospective information was subsequently collected relating to patient details, injury details, and morbidity via follow-up telephone interview within seven days of presentation. Participants were excluded if their primary diagnosis was not trauma-related. Only participants over the age of 18 were considered eligible for telephone follow-up. Those less than 18 years of age were included within the PCS, with information collected from medical records.

Data analysis and classification

The Birmingham Eye Trauma Terminology (BETT) system provides standardized definitions for use in eye trauma epidemiology.[16] As per the BETT system, open-globe injuries have been defined as those resulting in a full thickness wound of the eyewall.[16] Patient occupation was classified according the Australian Standard Classification of Occupation.[17] Injury mechanism and location were classified by a single investigator (LN) into identifiable groups. Patient education level was categorized according to the Australian Standard Classification of Education.[18] Patients less than 15 years of age were excluded from education level analysis.

Morbidity was estimated by patient-reported work or school days lost due to eye trauma. Estimates were taken to the nearest day. Due to the limited follow-up period, estimates were provided up to and including seven days. The following exclusion criteria were applied when developing morbidity estimates: children less than or equal to five years of age, unemployed, pensioners, and retirees.

Statistical analysis and incidence estimates

Descriptive statistics were calculated for RCS and PCS data using Microsoft Excel 2008 (Microsoft, Redmond, USA), SPSS version 20 (SPSS, Chicago, USA), and OpenEpi version 2.3.1.[19] Categorical variables were compared using the chi square test for goodness-of-fit. Where expected counts were less than or equal to five, Fisher's exact test was used.[20] Statistical significance was set at a *p*-value of <0.05.

Crude yearly incidences were calculated for both the Murrumbidgee region and Wagga Wagga. The number of observed eye trauma cases was used as the numerator for incidence estimates. As the entire population was considered at risk, the denominator was derived from 2010 census data. The population of the Murrumbidgee region and Wagga Wagga was 159,624 and 58,610, respectively.[21,22] Observed eye trauma cases for Wagga Wagga were conservatively estimated using relevant postal codes (2650 and 2651) from patient data. Confidence intervals for proportions were calculated using the Wilson score method, approximating a normal distribution.[23] The Wilson score method provides sufficiently conservative confidence limits for our proportion estimates.[24]

Eye trauma requiring hospital admission was used in the calculation of hospital-admitted eye trauma incidence estimates. The number of eye trauma cases requiring admission to WWBH was used as the numerator for incidence estimates. The denominator was taken as the Wagga Wagga population, 58,610.[22]

This study received ethics approval from the Institutional review board, Western New South Wales Local Health District, and followed the tenets of the Declaration of Helsinki.

Results

Four hundred and eleven and 117 eye injuries were identified for the RCS and PCS, respectively. Fifty seven of 103 adults (55.3%) in the PCS participated in telephone follow-up. Mean age was 35.5 years ± 18.6 (RCS) and 34.1 years ± 17.1 (PCS). A significant male predominance was evident in both the RCS (77.9% male, $p<0.001$) and the PCS (89.7% male, $p<0.001$). Eye injuries were most common within the 20-24 year old age group **(Figure 2)**. Technicians and trades workers were the most frequently affected occupational group in the PCS (38.3%) (n=81) (Table 1). Almost 59% (n=63) of patients within the PCS reported junior secondary education as their highest level achieved (Table 2).

Incidence estimates

Preliminary analysis was performed on the RCS to assess the distribution of eye trauma throughout the year. As no significant seasonal variation was identified ($p=0.365$), it was considered appropriate

to use the PCS yearly incidence estimates for comparison with the RCS. Crude incidence estimates for eye trauma within the Murrumbidgee region and Wagga Wagga are displayed in Table 3. The PCS produced significantly higher regional (p<0.001) and regional city (p=0.03) incidence estimates.

The incidence of patients requiring admission to hospital with eye trauma (hospital-admitted eye trauma incidence) was estimated at 20.5 per 100,000 person-years [95% confidence intervals (CI), 11.7 – 35.8] and 62.3 per 100,000 person-years (95% CI, 45.1 – 86.0) for the RCS and PCS, respectively. The PCS produced significantly higher hospital-admitted eye trauma incidence estimates (p<0.001). The RCS identified three cases of open-globe injuries. Each of these cases was referred from outside of Wagga Wagga. The incidence of open-globe injury in the Murrumbidgee region is estimated at 1.9 per 100,000 person-years (95% CI, 0.6 – 5.5).

Injury details

Injuries were evenly distributed between eyes, with left eye involvement in 52.4% and 49.1% of monocular injuries for the RCS and PCS, respectively. There was bilateral involvement in 3.9% (RCS) and 4.4% (PCS) of all injuries.

The majority of patients in both the RCS and PCS first presented for management of their eye injury to WWBH ED, **75.2% and 65.8%, respectively**. The most common source of referral to the WWBH ED was from local medical officers **(11.7%, RCS; 17.1%, PCS)**, followed by peripheral hospitals within the Murrumbidgee region **(10.7%, RCS; 10.3%, PCS)**. Significantly more patients first presented to WWBH ED in the RCS than the PCS (p=0.04).

Ophthalmology review by the registrar or consultant was required in 24.1% and 26.9% of ED presentations for the RCS and PCS, respectively. Within the PCS, 41.9% of all cases required ophthalmology review. Twenty-one percent of these consultations occurred within the ED and 20.5% in ophthalmology clinics. Sixteen patients (13.7%) within the PCS presented directly to the ophthalmology clinic, after referral from local medical officers, optometrists, or other hospitals within the region.

The most frequently encountered injury mechanism was grinding (Table 4). This included angle grinding with power tools and other grinding-related mechanisms. There were significantly more cases of foreign bodies falling into the eye in the RCS when compared to the PCS (p=0.02). There were significantly more sport-related injuries in the PCS (p=0.04). Within the PCS, alcohol use at the time of injury was reported in 9.3% (n=75) of cases. Four out of the seven cases reporting alcohol use at the time of injury involved assault.

Eye trauma cases were similarly spread across the days of the week and throughout the months of the year. There was no significant difference in the frequency of presentations throughout each month of the year. Mean delay in presentation after injury occurrence was 1.3 (± 4.8) days and 1.4 (± 4.2) days for the RCS and PCS, respectively.

Eye injuries most frequently occurred within the workplace, followed by the home, for both the RCS and PCS (Figure 3). A greater proportion of injuries occurred in the garden in the RCS compared to the PCS (p=0.02). There were significantly more injuries in sport-related locations in the PCS compared to the RCS (p=0.001).

The majority of injuries were superficial, with the most common diagnosis being corneal foreign body followed by corneal abrasion (Figure 4). Despite this similarity, there was a significantly greater proportion of corneal abrasion in the RCS (p=0.01). The PCS displayed a greater proportion of hyphaema *(p=0.03),* orbital fracture (p=0.01), and periorbital tissue injury (p=0.03) as primary diagnoses. There were no open-globe injuries recorded during the prospective study period.

Work-related eye trauma made up a large component of both case series, 40.2% (n=266) and 45.8% (n=96) for the RCS and PCS, respectively. Sub-analysis of protective eyewear use was performed on cases reporting work-related and grinding-related injury. The majority of patients in both case series reported not using protective eyewear when they sustained work-related eye trauma (Table 5). Protective eyewear compliance rates were also low for grinding-relate eye trauma (54.6%, RCS; 55.2% PCS). Safety glasses were the most frequently used protective eyewear device in work-related

(43.8%, RCS; 75.0%, PCS) and grinding-related injuries (60.0%, RCS; 69.2%, PCS). There was no significant difference in proportion of protective eyewear use between these two subgroups.

Injury management and morbidity

Twelve patients (2.9%) required admission in the RCS for an average of 5.3 days (± 8.2). Of those admitted, seven required surgical management including repair of three open-globe injuries, removal of three foreign bodies from children, and repair of an eyelid laceration. Two of the patients with open-globe injuries were referred for further management to a tertiary ophthalmology service.

Eight patients (6.8%) required admission in the PCS for an average of 5 days (± 4.2). Of those admitted, two required surgical repair of eyelid lacerations. Seven of the eight admissions were for orbital fractures. One patient, who did not require admission, was referred to a tertiary ophthalmology service for management of a complicated eyelid laceration. There was no significant difference in the proportion of admissions between case series. Work and school days lost due to eye trauma were recorded for the PCS. A total of 121 (n=68) work and school days were lost at an average of 2.0 days (± 2.3) per patient.

An overview of management in both case series is presented in Table 6. There were significantly more patients who required referral to maxillo-facial surgery in the PCS when compared to the RCS ($p=0.04$).

Discussion

This study presents the first epidemiological data on eye trauma within the Murrumbidgee region of south-western New South Wales, Australia through retrospective and prospective case series. Eye trauma presentations to the WWBH ED were reviewed. The additional prospective recruitment period enabled collection of data not available from medical records and allowed the inclusion of cases presenting to the ophthalmology clinic.

Eye trauma incidence estimates in regional Victoria, Australia have been reported at 945 per 100,000 person-years.[7] Incidence estimates in metropolitan Victoria have been reported to reach approximately 500 per 100,000 person-years within the 25-29 year old male subgroup.[3] ED eye trauma presentation rates in the United States of America have been reported at 322.0 and 581.4 per 100,000 population for women and men, respectively.[14] Our PCS incidence estimates are comparable to previous national and international reports. In addition, hospital-admitted eye trauma incidence estimates derived from the PCS were found to be similar to previously reported eye trauma hospital admission rates in Australia.[5,8]

There were clear differences between incidence estimates derived from each case series. These differences may be accounted for in the unique recruitment strategies. The PCS incidence estimates are likely to have greater accuracy as they take into account a higher number of community and regional eye trauma referrals, many of which never present to the ED. The lower incidence for the Murrumbidgee area compared to Wagga Wagga may reflect the fact that some eye injuries from outside of Wagga Wagga are treated exclusively in smaller rural hospitals within the surrounding region.

Patients experiencing eye trauma demonstrated clear demographic features. The significant young male predominance observed in this case series is consistent with previous international reports.[25,26] Technicians and trades workers have been highlighted previously as an at risk group for work-related eye injury.[5,12] In this study, the proportion of technicians and trades workers (38.3%) sustaining eye injuries was well over the expected 14.6% representation of this occupational group within the Murrumbidgee region of Australia.[21]

A low level of education is associated with an increased lifetime risk of eye trauma.[27] Prospective data on the education level of eye trauma patients demonstrated secondary education to be the highest level achieved by over three-quarters of recorded patients. Bachelor degree level was achieved by only 8% of cases. Previous analysis of lifetime eye trauma prevalence reports work-related eye injuries to be twice as likely in patients with less than or only secondary education when compared to those who have achieved a higher level of education, such as university studies.[28]

Referral patterns and site of first presentation for eye trauma management were unique between case series. Significantly more patients were noted to first present to WWBH ED for medical review of eye trauma in the RCS. This difference would be expected because ophthalmology clinics were included in the PCS. Indeed, almost 14% of patients within the PCS were reviewed solely within ophthalmology clinics, having been referred for management from the local community or region. Ophthalmology clinics have previously been reported to be an important source of eye trauma referral.[13] Eye trauma is unique in its potential to be managed outside of the ED and resource allocation and future studies should reflect this.

The workplace and home are two important locations where eye trauma frequently occurs.[25,29, 30]Work-related eye trauma has been identified as a significant public health issue in Australia and worldwide.[28,31] Whilst work-related eye trauma accounts for only 2.2% of all work-related injuries, it represents 19.1% of work-related presentations to the ED.[32] Importantly, there is also a high rate of open-globe injuries sustained at work with subsequent poor visual outcome and significant morbidity.[12,15, 33]

Angle-grinding and other forms of grinding are a common mechanism for eye trauma.[3,5,7,13] In this study, grinding-related injuries featured heavily across both case series. Injuries sustained as a result of this mechanism are often preventable with protective eyewear use. The rate of use of eye protection in grinding-related injuries is known to be low.[34] Safety glasses were the most frequently used form of eye protection in grinding-related injuries for both case series. Fewer patients reported using safety goggles or a welding helmet. These devices provide greater protection from foreign bodies projected at various angles towards the eye and may be a more appropriate alternative to safety glasses.

Appropriate employment of health and safety procedures and protective eyewear in the workplace has been demonstrated to be central to reducing the risk of work-related eye injuries.[35,36] Workplace protective eyewear quality should adhere to local or national guidelines.[37] Protective eyewear which is inappropriate for the task may still expose the patient to risk of injury.[38] In this study, there was poor

compliance with protective eyewear use during work-related tasks. Whilst work-related protective eyewear compliance rates were noted to be higher in the PCS, rates amongst both series were low. It is possible that this difference may be biased by higher self-reporting rates in the PCS. Despite this potential bias, PCS protective eyewear compliance rates remain inadequate.

Only three open-globe injuries were recorded during the RCS period and no open-globe injuries during the prospective recruitment period. The Royal Adelaide Hospital, Australia reviewed 109 open-globe injuries over a four year period, producing an incidence of 3.9 per 100,000 person-years.[9] Incidence rates of open-globe injuries in regional Australia have been reported to be similar, with incidence rates of 4.7 and 3.7 per 100,000 person-years for northern New South Wales and far North Queensland, respectively.[6,10] Our open-globe eye injury incidence estimates are lower than previous reports.

This study had several limitations. There was reliance upon information from medical records in the development of the RCS and part of the PCS. Attempts were made to alleviate reliance upon retrospective data through the addition of prospectively collected information, during telephone follow-up interviews. Secondly, in developing the eye trauma counts, eye trauma managed solely by other hospital emergency departments within the referring region and private ophthalmologist's rooms was unable to be included. It is possible that those cases managed within peripheral hospitals account for the difference in incidence estimates for the Murrumbidgee region and Wagga Wagga. It is likely that these encompassed a less severe spectrum of eye injury which did not represent a significant burden of disease.

The prospective data collection period was limited to a period of 80 days. Despite this short recruitment period, the PCS provides an insight into the value of prospective data collection in studying eye trauma epidemiology. The process of prospective data collection may be assisted via establishment of a national Australian eye trauma registry comparable to the existing United States Eye Injury Registry.[39]

This study demonstrates eye trauma to be an ongoing and significant public health concern. The incidence of eye trauma within Wagga Wagga and the Murrumbidgee region is high. Young males

continue to represent a significant proportion of all eye trauma patients. Technicians and trades workers are an at-risk occupational group, as are those involved in angle-grinding. A large number of eye injuries occur within the workplace and work-related protective eyewear compliance is unacceptably low. Interventions aiming to reduce the burden of eye trauma should target the at-risk populations identified. Future studies should include recruitment of cases beyond public hospital emergency departments.

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Figure legends

Figure 1. Map of the New South Wales, Australia local health districts (Figure 1a). Detailed map of the Murrumbidgee local health district (Figure 1b). (NSW Government. Local Health Districts and Speciality Networks. Available from: http://www.health.nsw.gov.au/lhd/pages/default.aspx. [Last accessed 13 Feb 2014]. Reproduced with permission from NSW Health)

Figure 2. Age distribution within each case series. PCS, prospective case series; RCS, retrospective case series

Figure 3. Injury location for each case series. PCS, prospective case series. RCS, retrospective case series

Figure 4. Primary diagnosis for each case series. FB, foreign body; PCS, prospective case series; RCS, retrospective case series