The Incidence of Visual Impairment due to Cataract, Diabetic Retinopathy and Trachoma in Indigenous Australians within central Australia: The Central Australian Ocular Health Study

Short Running Title: (Incident Visual Impairment in Indigenous Australians)

by

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ABSTRACT

**Objective:** To estimate the incidence and causes of visual impairment for the purposes of service provision, among the indigenous Australian population within central Australia from its most common causes, namely cataract, diabetic retinopathy and trachoma.

**Design:** Clinic-based cohort study.

**Participants:** 1,884 individuals aged ≥20 years living in one of 30 remote communities within the statistical local area of ‘Central Australia’.

**Methods:** From those initially recruited, 608 (32%) participants were reviewed again between 6 months and 3 years (median 2 years). Patients underwent snellen visual acuity testing and subjective refraction. Following this, an assessment of their anterior and posterior segments was made. Baseline results were compared with those who were reviewed.

**Main Outcome Measures:** The annual incidence rates and causes of visual impairment (vision worse than Snellen visual acuity 6/12 in at least one eye).

**Results:** The incidence of visual impairment in at least one eye was 6.6%, 1.2% and 0.7% per year for cataract, diabetic retinopathy and trachoma respectively (7.9%, 1.5% and 0.7% per year for those aged ≥40 years). Advancing age was the main risk factor common to all three.

**Conclusion:** It is important to be mindful not only of the prevalence of disease in a community, but also of the rate at which new cases are occurring when allocating resources to address the ocular health needs of this region. Compared with historical data diabetic retinopathy is emerging as a new and increasing threat to vision in this population.
Vision loss reduces ability of individuals to function independently. In Australia, when Snellen visual acuity is reduced to worse than 6/12, a person may not be eligible to hold a drivers licence. However, visual impairment may also have consequences for a person’s ability to earn an income, and has been found to impact significantly on quality of life to a similar degree as a major medical condition such as stroke. This outcome association has been found in a number of studies including those which assessed indigenous populations in other parts of the world.

Central Australia is an area with a unique population requiring targeted service provision. There are distinct barriers to access found in few other places in Australia, which must be overcome before issues related to health and well-being may be addressed. Although patients may be assessed in the remote communities, much of the service provision must be delivered centrally at Alice Springs Hospital. There exist substantial logistic challenges in relation to conveying patients to the service centre and dispensing health services in a manner which is culturally acceptable. However, as ophthalmic care is one service among many, it has often been de-emphasized and as a result, the delivery of services has not kept pace with the requirements of the region. For many years a paucity of accurate data prevented informed service planning.

Within the indigenous population of remote central Australia, bilateral visual impairment occurs in over 25% of those aged 40 year or older (a prevalence almost 4 times that of the non-indigenous population). The most common causes for this after refractive error were cataract, diabetic retinopathy and trachoma. In order to develop effective strategies to address the underlying causes of visual impairment it is important to understand not only the prevalence, but also the rate at which it is continuing to occur. Bilateral visual impairment places legal restrictions on an
individual’s abilities; however consideration of unilateral visual impairment is important as it enumerates the total number in need of ophthalmic intervention.

The Central Australian Ocular Health Study has been designed to estimate the prevalence of ocular morbidity among the indigenous Australian population living in remote central Australia. The study ran over 3 years, and as such, a proportion of the participants were examined on more than one occasion. This allowed an estimation of the incidence of ocular morbidity to be determined. The purpose of this paper was to determine the incidence of the most common causes of visual impairment in at least one eye among indigenous Australians living in central Australia.

METHODS

The Central Australian Ocular Health Study took place in the 30 largest remote communities within the statistical local area of ‘Central Australia’, excluding those living within and around the city of Alice Springs (target population of 5,173 persons aged ≥20 years)(Figure). Ethical approval from the Central Australian Human Research Ethics Committee was obtained and conformed to the tenets of the Declaration of Helsinki.

A total of 1884 individuals who identified themselves as indigenous Australians, were recruited between July 2005 and June 2008 as they presented to the remote clinics at each of these communities. The aims of the study were explained, with an interpreter whenever necessary and written informed consent was obtained. **Routine review appointments were then made for every patient between 6 and 12 months later, depending on when the next remote clinic visit was scheduled.** Their baseline data provided prevalence estimates of ocular morbidity for this population.
During the following 36 month time period, a proportion was reviewed more than once. Those who were reviewed between 6 months and 3 years after their baseline examination, were compared with their baseline data in order to determine the incidence of ocular morbidity within this region.

Best corrected visual acuity (BCVA) following refractive correction was determined using a tumbling E acuity chart at 3 metres in a well-lit room. If the patient could not read the top letter (6/120 equivalent), they were recorded as either counting fingers at 2 metres or 1 metre, hand movements, light perception or no light perception. A slit-lamp examination of the anterior segment was performed and grading of trachomatous corneal opacification was performed using the WHO simplified grading system. Pupils were then dilated with tropicamide 1.0% and phenylephrine 2.5% and lens grading was performed using the modified Lens Opacities Classification System III. Slit-lamp fundoscopy was performed using a 90D fundoscopy lens. This included a clinical assessment of the posterior pole and the peripheral retina to estimate the presence and degree of diabetic retinopathy using the Early Treatment of Diabetic Retinopathy Study adaptation of the modified Airlie House classification of diabetic retinopathy.

Visual impairment in an eye was defined as a BCVA of less than 6/12. If an eye was found to have acuity at this level, then the examining ophthalmologist made an assessment regarding the major cause of visual impairment in each eye. These review data were then compared with those obtained at baseline among groups who had a BCVA of 6/12 or better in either eye in order to establish the incidence of visual impairment in one or both eyes from cataract, diabetic retinopathy or trachoma. If a patient presented to the clinics more than twice during the recruitment period, the entry recorded was the first time point at which the patient was found to meet the
definition threshold of worse than 6/12. If this was not found at any time point, the entry recorded was the last time that they were seen. The annual incidence rate was calculated from the incidence density rate, whereby the total number of years for which each patient was followed, was divided into the number of incident cases that developed during these person-years. The resultant rate per person-years was then converted into a rate per year.

Statistical Analysis System 9.1 (SAS Institute Inc, Cary, NC) was used for statistical analysis including descriptive statistics, student t-test, chi-squared test and cox proportional hazards model. Age was considered as a continuous variable. Sex, visual impairment, blindness, diabetes and hypertension were considered as categorical variables. Test statistics, 95% confidence intervals and p values are presented. A p value of <0.05 was considered statistically significant.

RESULTS

The original sample contained 1884 participants, which included 689 (36.6%) males and 1195 (63.4%) females, the average age of which were 49 years (SD 15yrs; range: 20 to 93 years). Of these, 1040 had self-reported diabetes. From this original sample, 366 were excluded, either because they could not be assessed due to media opacity, or because their visual acuity was worse than 6/12 in both eyes. Of the remaining 1518 who were assessable and had a visual acuity of 6/12 or better in one or both eyes, 1011 were diabetic.

608 of the original sample of 1884 participants (32%) were reviewed between 6 months and 3 years (median 2 years) after their initial assessment. Compared with the original sample, the group which was reviewed contained a higher proportion of
females, (203 of these were male (33.4%) and 405 females (66.6%), $\chi^2=3.95$; $P=0.047$), and was older (53 years (SD 14yrs), $t=5.81; P<0.0001$). 461 (of the original 1518) were assessable and had a visual acuity of 6/12 or better in one or both eyes at baseline, 335 of whom were diabetic.

Cataract

During the follow-up period, 51 participants were found to have developed visual impairment in one or both eyes due to cataract. This equated to an annual incidence in the sample of 6.63% (95% C.I 4.36 to 8.90%), and for those aged ≥40 years of 7.85%; (95% C.I 5.06 to 10.64%) per year. As expected, advancing age was found to be associated with the development of visual impairment due to cataract, with the risk increasing by 20% with each decade of life (Hazard ratio=1.2, 95% C.I 1.1-1.3; $P<0.0001$). Sex, diabetes and hypertension were not found to be associated with incident cataract.

Diabetes

9 participants with diabetes were found to have developed visual impairment in one or both eyes due to diabetic retinopathy. This equates to an incidence of 1.24% in the whole sample (95% C.I 0.05 to 2.43%), and 1.53% (95% C.I 0.04 to 3.08%) in those aged ≥40 years per year. Those who developed visual impairment due to diabetes were older (56 years versus 49 years, $t=2.35; P=0.047$), however this was no longer significant after adjustment for sex and hypertension.
Trachoma

5 participants developed visual impairment in one or both eyes due to trachoma during the follow-up period, equating to an annual incidence of 0.65% in the whole sample (95% C.I 0.00 to 1.38%), and 0.84% for those aged ≥40 years (95% C.I 0.00 to 1.79%) per year. These participants were older (62 years versus 49 years, \( t=2.33; \ P=0.08 \)) and were all female. None of the individuals who developed trachoma had hypertension and 2/335 (0.6%) had diabetes versus 3/123 (2.4%) without (\( \chi^2=2.36; \ P=0.13 \)). Numbers were too small to do an adjusted analysis.

DISCUSSION

Developing visual impairment has significant implications to the individual, relating to loss of drivers licence\(^2\) and employment,\(^1\) loss of independence\(^1\) and self-esteem.\(^4,5\) Poorer self-rated quality of life measures have been consistently found among those with unilateral\(^11\) and bilateral visual impairment.\(^3\) We have found that for those aged 40 years or older, visual impairment occurred in at least one eye at rates of 7.9% per year, 1.5% per year and 0.7% per year due to cataract, diabetic retinopathy and trachoma respectively.

Cataract is the most common, non-refractive cause of incident visual impairment in Australia.\(^7,12,13\) We have found previously that 17% of indigenous Australians aged 40 years or older are visually impaired in one or both eyes from cataract.\(^14\) We have now shown that this figure increases by 7.9% each year. If this were applied to the whole population living in remote central Australia, approximately 120 extra patients per year (or 10 patients per month) potentially requiring cataract surgery would be added to the 350 already present in the
During the time period in which the data was collected, resources allocated to providing cataract services to central Australia allowed for only 120 cataract procedures to be performed per year. Therefore, based on our estimate of incidence, at the rate which cataract surgery was being performed, there would have been no changes in the underlying prevalence in the community. Although, since then service provision has doubled; at the same time, in recent years the rate at which patients are being booked has continued to be twice the rate at which operations are being performed. Therefore, although the current rate of cataract procedures may have exceeded the incidence of cataract development, increased case finding has ensured no change in the cataract waiting list.

Diabetes is a highly prevalent disease among indigenous Australians, affecting over 40% of the population and possibly more than 50% given that the prevalence has not been estimated in over 10 years. Within remote central Australia diabetic retinopathy is now the most common cause of non-refractive visual impairment after cataract. If our estimates of incident visual impairment were applied to this population, it would mean that 34 patients each year (or 3 patients per month) would become visually impaired from diabetes. This figure is of a similar magnitude to that quoted in other studies of Caucasian populations. Given that each patient may require ongoing treatments including laser, intravitreal injections and/or surgery, service delivery should be planned accordingly or else treatment delays may result in irreversible blindness.

Within Australia, trachoma is only prevalent among the indigenous community and is the most common cause of non-refractive blindness after cataract. Our incidence estimate of 0.7% per year for the entire sample (31 new patients per year) is in the same order of magnitude as that found in other countries where
Trachoma is endemic.\textsuperscript{18} There was a trend towards an association with gender and age, which have been demonstrated before in previous work.\textsuperscript{18,19}

Our study was limited by the method in which participants with vision loss were identified. Recruitment and follow-up required voluntary presentation to one of the remote clinics. Therefore, presentation may have been motivated by symptoms relating to vision loss, increasing our estimates of incident vision impairment. However, each patient had a routine review appointment made between 6 and 12 months, depending on when the next remote clinic visit was scheduled. As has been mentioned before, the clinics only occurred once or twice per year at each remote community, therefore the health workers in the communities would actively encourage every resident to attend the clinics regardless of their symptoms. In fact, 95\% of those originally recruited, presented to the clinic for a “check-up” and not due to symptoms.\textsuperscript{20} This was also the case for those who were followed up. Participants who were originally recruited were more likely to be female, a trend which was also found in our follow-up group. Males are less likely to present to a health professional,\textsuperscript{21} a phenomenon which has been observed in previous work involving non-indigenous populations\textsuperscript{22} and there is evidence that this may translate over to the indigenous Australian population.\textsuperscript{23,24} Compared with our target population, our original sample was older than the target population.\textsuperscript{20} We collected data on 36\% of the population within the central Australian statistical subdivision who were aged 20 years or older and this recruitment increased with age, such that 67\% of those aged 40 years or older and 75\% of those age 50 years or older were included.\textsuperscript{20} However, as a result, the original recruitment sample became more representative of the target population from remote central Australia with advancing age, as younger people were less likely to present to the remote clinics. In a similar way, our follow-up sample was
older than those originally recruited. However, given that most comparisons being made with non-indigenous Australian groups are among those aged 40 years or older,\textsuperscript{12,13} we feel that the over-representation of older participants in our follow-up sample should ensure that our data closely reflects the true incidence among the older members of our target population. Participants were followed up gradually over a period of between 6 months to 3 years and it is possible that a participant reviewed early in the follow-up period may have developed vision loss later in the follow-up period, but this would not have been recorded. This would be an unavoidable consequence of our method of data entry. \textit{Furthermore, although the possibility exists that our estimates may have been affected by selection bias, given that 95\% of presentations occurred independent of symptoms}, we are confident that our results represent the best available estimate of the incidence of vision loss in this population.

This study has estimated the annual incidence of visual impairment among the indigenous Australian population within central Australia in at least one eye from its most common causes, namely cataract, diabetic retinopathy and trachoma. It is important to mindful of this information when allocating resources to address the future ocular health needs of this region. This is particularly important when considering increases in the prevalence of diabetes, but also increases in health standards and life expectancy; all of which will enhance the demand for appropriate and accessible ocular health services.
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FIGURE LEGEND

Figure

Schematic map of the central Australian statistical local area. (▲) Communities visited during the study.