Five-Year Incidence of Bilateral Cause-Specific Visual Impairment in the Melbourne Visual Impairment Project

Peter N. Dimitrov,1 Bickol N. Mukesh,1,2 Catherine A. McCarty,1,5 and Hugh R. Taylor1

PURPOSE. To describe the age-, gender-, and cause-specific 5-year incidence of bilateral visual impairment in participants in the Melbourne Visual Impairment Project, Victoria, Australia.

METHODS. Participants aged 40 years and older were recruited from Melbourne, Victoria, Australia, by random cluster sampling. The mean age of the 3271 (85% of the eligible) participants was 59 ± 12 (SD) years. Of the participants, 54% were female. The initial baseline study (1992–1994) was followed by a 5-year incidence study (1997–1999). At both time points of the study, participants underwent a standardized testing procedure. Distance and near vision was tested using logarithm of the minimum angle of resolution (logMAR) charts, followed by refraction if needed. Visual fields were assessed by the 24-2 Humphrey field test (FastPac, Humphrey Field Analyzer; Carl Zeiss Meditec, Dublin, CA). Also, intraocular pressure, ocular motility, dilated ophthalmoscopy, and photography of the lens and the fundus were conducted. Furthermore, an interview included demographic characteristics, history of eye disease, medical history, and medication use. For classification of visual impairment, both visual acuity (VA) and visual fields (VF) examination results were used. Four levels of bilateral presenting visual impairment were defined: mild (VA, <20/40–20/60, and/or VF, homonymous hemianopia), moderate (VA, <20/60–20/200, and/or VF, constriction <20° to 10° from fixation), severe (VA, <20/200–10/200, and/or VF, constriction <10° to 5° from fixation), and profound (VA, <10/200, and/or VF, constriction <5° from fixation). For all participants found to be visually impaired, the major cause was identified.

RESULTS. Of the 3040 eligible people to attend follow-up 2594 (85%) participated. Data were available for 2530 (98%) participants. In 105 participants (4.22%; 95% confidence limit 2.58–5.85) some degree of visual impairment developed. The main causes were undercorrected refractive error (5%), age-related macular degeneration, cataract and neuro-ophthalmic disorders (7% each), glaucoma (3%), and diabetic retinopathy (1%). The main cause of severe and profound visual impairment was age-related macular degeneration (37%).

CONCLUSIONS. Undercorrected refractive error was the primary cause of new cases of visual impairment in this population. Further research is needed to understand the origin of this and to develop appropriate prevention measures. Age-related macular degeneration is the primary cause of severe or profound visual loss in Australia. This disease requires further investigation for effective cure and preventive strategies. (Invest Ophthalmol Vis Sci. 2003;44:5075–5081) DOI:10.1167/iovs.02-0457

Visual impairment has a significant impact on the quality of life in the aged population.1 Impaired vision threatens the independence of elderly people;2 is associated with depression,3 falls,4–6 and car accidents;7 and increases the risk of death.8 Previously published prevalence reports show that 3.9% to 4.7% of Australians older than 40 years are visually impaired.9–11 Elderly people are the fastest growing part of the population in Western countries.12,13 In Australia, the number of people older than 65 years is expected to double in the next 25 years.12,13 Therefore, reports on the incidence of visual impairment are crucial measures for planning eye care services and for further research in regard to effective treatment and prevention of the diseases leading to blindness. The Melbourne Visual Impairment Project (VIP) is a population-based study that reflects the Australian community as a whole.14,15 This article describes the age-, gender- and cause-specific 5-year incidence of visual impairment in the participants of the Melbourne VIP.

METHODS

The MVIP is a population-based study of age-related eye disease. The analyses in this report included only the urban cohort of the original Melbourne VIP study group. The baseline study was conducted from 1992 to 1994 and the follow-up study from 1997 to 1999. The recruitment and examination procedures were standardized. The protocol was approved by the Human Research and Ethics Committee of the Royal Victorian Eye and Ear Hospital and complied with the Declaration of Helsinki for research involving human subjects. The detailed methodology has been published.8,14,15

Briefly, the participants were recruited from nine adjacent pairs of census collector districts randomly selected from the Melbourne statistical division. The requirements for eligibility were residence of 6 months or longer at the current address and older than 40 years in the calendar year of recruitment. The eligible participants were identified during a door-to-door private household census. Basic demographic characteristics were collected, and the participants were invited to the local examination center.

A standardized examination of approximately 90 minutes’ duration was performed at both time points of the study. This included an ophthalmic examination and an interview regarding detailed socio-
mographic characteristics, history, and current symptoms of eye disease, medical history, and medication use. Interpreters were used for non-English-speaking participants. The ophthalmic examination comprised assessment of visual acuity; a functional test of vision; assessment of ocular motility, visual fields, and intraocular pressure (IOP); slit lamp examination, and dilated ophthalmoscopy, including photograph of the lens and the fundus. All participants gave signed informed consent for examination after receiving an explanation of the testing procedure. Home visits were conducted when participants were unable to attend the local examination center.

Presenting distance and near vision were tested under standardized illumination using a 4-m logarithm of the minimum angle of resolution (logMAR) chart and a word-reading near logMAR test, respectively.16-17 Both distance and near vision were tested with the refractive correction currently being used by the participant. The power of the correction(s) was measured with a lens analyzer (Carl Zeiss Meditec, Dublin, CA) and recorded. The distance visual acuity was assessed in each eye separately. In cases in which visual acuity could not be assessed at 4 meters, the distance was reduced to 2 or 1 m, or, alternatively, counting fingers, hand movements, and light perception approaches were used. If the presenting distance visual acuity was less than 53 letters ([10.0(−2)] = [1.00(−2)] = [(6/6(−2)] = [20/(20(−2))]),10 autorefraction was conducted followed by a subjective refinement. Near vision was tested binocularly at a distance that was most comfortable for the participant. This distance was recorded in centimeters. Presbyopic correction was adjusted for participants with presenting near visual acuity of less than 45 words (0.6 = N 8).17 An E 4-m logMAR chart and an E word-reading near logMAR chart were used for illiterate or non-English-speaking participants.

Visual fields were assessed with a Humphrey Field Analyzer (Carl Zeiss Meditec). The FastPac 24-2 statistical package was used for the test. Refractive error was corrected during the test according to the English-speaking participants.

Visual impairment was determined by presenting visual acuity and visual field defect(s) in the better eye. In cases in which the presenting visual acuity was improved by subjective refraction up to five letters or more on the 4-m logMAR chart (equivalent to one line) to the best corrected visual acuity, refractive error was assigned as the cause of visual impairment. If presenting visual acuity in the better eye was either not improved by subjective refraction or improved to less than five letters on the 4-m logMAR chart, then the accompanying disease in this eye was then assigned as the cause of the visual impairment. If there was more than one pathologic condition in the better eye, the disease with the most clinically significant and irreversible influence was chosen as the primary cause.18 For example, if the better eye was affected by macular degeneration and cataract, macular degeneration was chosen as the primary cause, because if cataract surgery were performed, the eye would still have visual impairment.

Cataract was diagnosed according to the Wilmer cataract grading system.19-21 Clinical biomicroscopic slit lamp grading was complemented by photograting of color stereopair slit lamp photographs for nuclear opacity and black-and-white stereopair retirolumination photographs for cortical and posterior subcapsular opacity.22 All photographs were graded separately by two trained graders with adjudication of discrepancies when necessary. Definitions of cataracts were as follows: nuclear opacity, grade 2.0 or higher; cortical opacity, grade 2.5 or more; posterior subcapsular opacity, grade 3.0 or more. To assess measurement error associated with photograting of the lens, a sample of photographs from baseline was regraded by one of the photograders at follow-up.

Diagnosis of glaucoma was made by a consensus panel of six ophthalmologists, including two glaucoma specialists, using clinical and photographic data of the subjects with suspected glaucoma.24 These subjects had one or more of the following characteristics: IOP greater than 21 mm Hg, visual field glaucoma defect, cup-to-disc ratio greater than 0.7, or asymmetry greater than 0.2. Intraocular pressure was measured using a handheld tonometer (Tono-pen 2; Mentor, Norwell, MA) after instillation of 0.4% oxybuprocaine topical anesthetic. The measurement was repeated if the result was 21 mm Hg or greater. If the result of the repeated measurement was confirmed to be 21 mm Hg or greater, it was checked with a Goldmann applanation tonometer. All IOP measurements were performed between 9 AM and 9 PM. Vertical cup-to-disc ratio was assessed on dilated fundus examination with a slit lamp indirect ophthalmoscope by a trained ophthalmologist and by grading of color stereopair fundus camera photographs using a cup/disc ratio (CDR) grading grid.24 The glaucoma cases were classified as definite, probable, or possible open-angle glaucoma (OAG), ocular hypertension, angle closure glaucoma, secondary glaucoma, and no glaucoma.

Age-related macular degeneration, diabetic retinopathy, and other retinal disease were diagnosed by clinical ophthalmoscopic examination and adjudicated double-grading of color stereopair fundus camera photographs performed by two trained graders followed by adjudication of discrepancies.14-15 Age-related maculopathy was graded according to international classification.25 Diabetic retinopathy was diagnosed according to modification of the Airlie House scheme.26

The neuro-ophthalmic reason for visual impairment was assigned using data of clinical, ophthalmic and orthoptic examinations, interviews, visual field assessments, and additional information obtained by direct contact with the participant’s practitioner if necessary. Neuro-ophthalmic diseases and others causing visual impairment were classified using the International Classification of Diseases, Ninth Revision (ICD-9).27

Four levels of bilateral visual impairment were defined: mild, visual acuity less than 20/40 to 20/60 and/or homonymous hemianopia; moderate, visual acuity less than 20/60 to 20/200 and/or constriction of the visual fields to less than 20° and more than 10° of fixation; severe, visual acuity less than 20/200 to 10/200 and/or constriction of the visual fields to less than 10° and more than 5° of fixation; profound, visual acuity less than 10/200 and/or constriction of the visual fields less than 5° of fixation. In cases when both visual field defect and decrease in the presenting visual acuity in the better eye were present, the category with the most severe disability was assigned as the cause of the visual impairment.

The incidence cases of mild, moderate, severe, and profound visual impairment were defined as those that were acquired during the 5-year follow-up period in the better eye that was free of visual impairment at baseline examination or was visually impaired at a less severe level. Moderate cases did not include participants who had profound visual impairment in the better eye at the baseline examination or participants without visual acuity or visual fields data at either time point of the study.

Statistical analyses were conducted on computer (SAS, ver. 6.0; SAS Institute Inc., Cary, NC) and P < 0.05 was considered statistically significant. Regression analysis according to Cochran methods28 was used to calculate the 95% confidence limits (95% CL) around the incidence estimates of mild and moderate visual impairment, to account for the cluster sampling design. Poisson 95% CL around the incidence of severe and profound visual impairment were calculated. The 95% CL for the age standardized incidence estimate were calculated according to Breslow and Day.29 The total number of Australians affected by each disease was estimated according to 2000 Census data.30

**RESULTS**

Data are expressed as the mean ± SD. The baseline study included 3271 eligible residents, with 83% participation rate (Fig. 1). The mean age at baseline was 59 ± 12 years (range, 40–98), and 54% of the participants were women. The mean
duration between baseline and follow-up examination was 4.5 ± 0.64 years (range, 4–7). Two hundred and thirty-one (7%) participants examined at baseline died before the 5-year follow-up examination. Participants with presenting visual acuity less than 20/40 at baseline were 2.3 times more likely to have died during the 5-year follow-up period. The follow-up participation rate was 85% (2594) of 3040 eligible participants. Non-English speakers, older participants, and people born in Greece, Malta, or Cyprus had a significantly lower follow-up participation rate. There were no other significant differences between the participants included in the follow-up examination and those that were not included. Data on visual field and visual acuity was not available for 64 participants, and they were excluded from the analysis. Data analyses included 2529 participants. The mean age at follow-up examination was 62.5 ± 10.9 years (range, 44–101 years).

The overall 5-year incidence of mild, moderate, severe, and profound visual impairment in the better eye of the Melbourne VIP participants was 4.2% (105 of 2530 follow-up participants; Table 1). Seventy participants (2.8%) became mildly impaired, 24 (0.96%) became moderately impaired, 4 (0.16%) acquired severe impairment and 7 (0.28%) had profound impairment. Transition from mild or moderate visual impairment to severe or profound was observed in 14.9% of cases. There was no significant gender difference in any of the visual impairment categories (all \( P > 0.05 \)).

Visual acuity loss was the major criterion used to define the level of visual impairment (96%; Table 2). The overall incidence of visual impairment based on the visual acuity criterion only was 4.0% (95% CI = 2.6, 5.5). Cases of visual impairment due solely to visual field defects were in the mild (three participants) and moderate (two participants) categories only (Table 2). Therefore, the analyses of the data without using the visual field defect criterion revealed 2.6% (95% CI = 1.7, 3.6) with mild and 0.9% (95% CI = 0.5, 1.3) with moderate visual impairment. The impairment cases due to visual field defects were mainly caused by glaucoma (3% of all incident visual impairment cases) and neuro-ophthalmic disorders (2%; Table 2).

The incidence of mild, moderate, severe, and profound visual impairment increased significantly with age (all \( P < 0.001 \); Table 1). The overall incidence of visual impairment increased from 1.1% of participants aged 40 to 49 years to 20.5% of participants aged 80 years and older. Vision had improved in 118 (4.7%) participants—because of cataract extraction in 25.4% and mainly because of corrected refractive error and other reasons in 74.6%.

The main causes of visual impairment and blindness in the Melbourne VIP over the 5-year period were undercorrected refractive error, age-related macular degeneration, cataract, neuro-ophthalmic disorders, glaucoma, and diabetic retinopathy. Undercorrected refractive error was the major cause of development of new mild, moderate, severe, and profound visual impairment incidence cases, comprising more than half (59%) of all incidences (Fig. 2). Age-related macular degeneration cases comprised 7%, cataract 7%, neuro-ophthalmic disorders 7%, glaucoma 4%, and diabetic retinopathy 1%.

Of the 2529 follow-up participants, 65 had visual acuity less than 20/40 in their better eye at the follow-up examination and their vision improved with subjective refraction up to five letters or more. Six of these participants were not wearing any distance refractive correction at the follow-up assessment. Three of them had never worn any distance correction and were not visually impaired at baseline; however, they had mild visual impairment at follow-up. The other three participants wore their distance refractive corrections at the baseline examination, but forgot to bring their glasses for the follow-up visual acuity assessment and therefore did not meet the inclusion criteria. However, one of them had visual field defects representing mild visual impairment and thus was included. Therefore, there were 65 (2.5% of all follow-up) participants in whom impaired vision developed because of undercorrected refractive error. The two excluded participants did not have any ocular disease, and their visual acuity without glasses corresponded to mild impairment.

The incidence and severity of visual impairment due to undercorrected refractive error increased with age (Fig. 3). The overall incidence due to this cause increased from 0.46% in participants aged 40 to 49 to 7.2% in participants older than 80. The undercorrected vision was mainly of mild impairment in most of the age groups; however, two thirds of the participants aged 80 and older had moderate impairment. Of all follow-up participants, 1.4% did not have any prescribed distance refractive correction before the follow-up assessment, and 47.6% of those who had distance refractive correction did not wear it constantly.

The major cause of severe or profound vision loss acquired over the 5 years in the Melbourne VIP participants was due to age-related macular degeneration (57%). In addition, undercorrected refractive error comprised 18% of all severe or profound impairment cases, 9% was due to glaucoma, 9% to cataract, and 18% to neuro-ophthalmic disorders (Fig. 4).

The estimates of the potential incidence of visual impairment in the Australian population indicated that approximately 342,400 adults aged 40 years and older would acquire some degree of visual impairment over a 5-year period. Of them, 228,500 would acquire mild impairment, 78,100 moderate impairment, 13,000 severe impairment, and 22,800 profound impairment. In an estimated 202,000 Australians, the impairment would be due to undercorrected refractive error. Age-related macular degeneration would cause an estimated 24,000 cases of visual impairment. A similar number of Australians was expected to have impairment due to cataract as well as neuro-
TABLE 1. Five-Year Age- and Gender-Specific Incidence of Mild, Moderate, Severe, and Profound Visual Impairment

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number at Baseline</th>
<th>Gender</th>
<th>Incidence (95% CL)</th>
<th>Number</th>
<th>Gender</th>
<th>Incidence (95% CL)</th>
<th>Number</th>
<th>Gender</th>
<th>Incidence (95% CL)</th>
<th>Number</th>
<th>Gender</th>
<th>Incidence (95% CL)</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–49</td>
<td>650</td>
<td>Male</td>
<td>0.62 (0.11, 1.13)</td>
<td>278</td>
<td>Male</td>
<td>0.36 (0.01, 1.61)</td>
<td>3</td>
<td>Male</td>
<td>0.36 (0.01, 1.07)</td>
<td>3</td>
<td>Male</td>
<td>0.36 (0.01, 1.09)</td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td>Female</td>
<td>0.81 (0.01, 1.61)</td>
<td>372</td>
<td>Female</td>
<td>0.81 (0.01, 1.61)</td>
<td>3</td>
<td>Female</td>
<td>0.81 (0.01, 1.61)</td>
<td>3</td>
<td>Female</td>
<td>0.81 (0.01, 1.61)</td>
<td>3</td>
</tr>
<tr>
<td>50–59</td>
<td>804</td>
<td>Male</td>
<td>1.99 (0.72, 2.07)</td>
<td>359</td>
<td>Male</td>
<td>2.23 (1.16, 3.31)</td>
<td>8</td>
<td>Male</td>
<td>2.23 (1.16, 3.31)</td>
<td>8</td>
<td>Male</td>
<td>2.23 (1.16, 3.31)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>2.02 (1.03, 2.87)</td>
<td>445</td>
<td>Female</td>
<td>1.80 (0.75, 2.85)</td>
<td>8</td>
<td>Female</td>
<td>1.80 (0.75, 2.85)</td>
<td>8</td>
<td>Female</td>
<td>1.80 (0.75, 2.85)</td>
<td>8</td>
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<tr>
<td>60–69</td>
<td>320</td>
<td>Male</td>
<td>3.51 (1.00, 6.03)</td>
<td>320</td>
<td>Male</td>
<td>3.51 (1.00, 6.03)</td>
<td>11</td>
<td>Male</td>
<td>3.51 (1.00, 6.03)</td>
<td>11</td>
<td>Male</td>
<td>3.51 (1.00, 6.03)</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>3.05 (0.42, 5.22)</td>
<td>352</td>
<td>Female</td>
<td>3.05 (0.42, 5.22)</td>
<td>11</td>
<td>Female</td>
<td>3.05 (0.42, 5.22)</td>
<td>11</td>
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<td>3.05 (0.42, 5.22)</td>
<td>11</td>
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<tr>
<td></td>
<td></td>
<td>Female</td>
<td>7.38 (3.21, 11.56)</td>
<td>156</td>
<td>Female</td>
<td>7.38 (3.21, 11.56)</td>
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<td>7.38 (3.21, 11.56)</td>
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<td>7.38 (3.21, 11.56)</td>
<td>11</td>
</tr>
<tr>
<td>80+</td>
<td>28</td>
<td>Male</td>
<td>7.41 (0.01, 16.46)</td>
<td>28</td>
<td>Male</td>
<td>7.41 (0.01, 16.46)</td>
<td>2</td>
<td>Male</td>
<td>7.41 (0.01, 16.46)</td>
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<td>7.41 (0.01, 16.46)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>4.88 (0.0, 11.00)</td>
<td>55</td>
<td>Female</td>
<td>4.88 (0.0, 11.00)</td>
<td>2</td>
<td>Female</td>
<td>4.88 (0.0, 11.00)</td>
<td>2</td>
<td>Female</td>
<td>4.88 (0.0, 11.00)</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>2529</td>
<td>Male</td>
<td>2.81 (0.01, 6.91)</td>
<td>70</td>
<td>Male</td>
<td>2.81 (0.01, 6.91)</td>
<td>18</td>
<td>Male</td>
<td>2.81 (0.01, 6.91)</td>
<td>18</td>
<td>Male</td>
<td>2.81 (0.01, 6.91)</td>
<td>18</td>
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<tr>
<td></td>
<td></td>
<td>Female</td>
<td>2.81 (0.01, 6.91)</td>
<td>105</td>
<td>Female</td>
<td>2.81 (0.01, 6.91)</td>
<td>105</td>
<td>Female</td>
<td>2.81 (0.01, 6.91)</td>
<td>105</td>
<td>Female</td>
<td>2.81 (0.01, 6.91)</td>
<td>105</td>
</tr>
</tbody>
</table>

**DISCUSSION**

This study shows that 4.2% (95% CL = 2.6, 5.9) of the Melbourne VIP population had acquired some degree of visual impairment over 5 years. The data confirm that visual impairment is a major public health problem in Australia. In the Beaver Dam Eye Study (BDES), vision deteriorated to 20/40 or worse over 5 years in 2.9% of the population. The differences in the incidence of visual impairment in these two studies could be due to differences in definitions of visual impairment. The VIP defined visual impairment based on presenting visual acuity, whereas BDES defined it based on best corrected visual acuity. The overall incidence of severe and profound visual impairment was not high (0.4%). However, in participants who were older than 80 at the baseline of the study, incidence of severe and profound visual impairment increased significantly to 4.7%. The BDES estimate of the incidence of severe visual impairment (20/200 or worse in the better eye) was similar (0.3%).

The age-related increase in the incidence of visual impairment in the Melbourne VIP was similar to the age-related increase in the prevalence analyses of Melbourne VIP and other population-based studies. One of five participants aged 80 years and older had visual impairment to some degree and nearly one of four of the participants in this age group became legally blind, mostly due to age-related macular degeneration. There were no gender differences in the incidence or the causes of visual impairment, even though Melbourne VIP prevalence data showed that females were more susceptible than males to the diseases that cause visual impairment. Similar differences between prevalence and incidence data were found in the BDES. The gender balance in the BDES is slightly higher in women, although not significantly.

Neither does the mortality rate in the VIP population explain the differences, because men were more likely to die than women during the 5 years before the follow-up. Further investigation is needed to determine gender differences in prevalence and incidence. This could have implications for effective health service delivery.
The main causes and distribution of causes of the prevalence and incidence of mild, moderate, severe, or profound visual impairment were similar.\textsuperscript{18,32} Undercorrected refractive error was the most frequent cause of the prevalence and the incidence of bilateral visual impairment, 53% and 59% respectively, followed by age-related macular degeneration, 13% and 7%; cataract, 9% and 7%; neuro-ophthalmic disorders, 5% and 7%; glaucoma 5% and 4%; diabetes, 3% and 1%; and other retinal conditions, 6% and 3%.

Undercorrected refractive error, one of the major causes of visual impairment and blindness worldwide, was regarded as one of the priority problem in the program Vision 2020.\textsuperscript{37} This cause could be of major concern in developing countries, although it also seems to be the main cause of functional or presenting visual impairment in developed countries.\textsuperscript{10,32,33,38}–\textsuperscript{40} There were 11 (18%) cases of severe visual impairment due to undercorrected refractive error that constituted legal blindness in Australia. This prominent rate of blindness in the Australian community could be eliminated by appropriate refractive correction.

The VIP baseline data showed that half of the participants had not been assessed by either an optometrist or an ophthalmologist within the past 2 years.\textsuperscript{41} It could be expected, that after the baseline examination, participants’ awareness of the need for a proper refractive correction would have risen; however, the incidence of visual impairment due to undercorrected refractive error was high. There was an age-related increase of visual impairment due to undercorrected vision.\textsuperscript{10,32,38} The delay in correction of deteriorated visual acuity could be a result of the common assumption among the elderly that the deterioration in vision is a normal part of aging or could be related to cosmetic reasons or cost concerns.\textsuperscript{42} Although prescription of the refractive correction is covered by Medicare (national health insurance system) in Australia, the cost of quality spectacle frame and lenses could still be a barrier.

Though high refractive error is certainly the cause of subjective dissatisfaction, low refractive error can be tolerated, and in cases such as low myopia, even be beneficial for presbyopic changes. It is known that a decrease in visual acuity and visual field changes do not always reflect subjective deficiency in visual functioning.\textsuperscript{43} More than half (52.4%) of the follow-up VIP participants who had distance refractive correction stated that they did not wear it all the time. Therefore, further research is needed before appropriate programs to encourage people to test their vision regularly and to wear appropriate refraction can be designed.

Age-related macular degeneration was the most frequent cause of the prevalence and incidence of severe or profound visual impairment: 28% and 37%, respectively. This progressive and irreversible disease is the leading cause of visual impairment and blindness in developed countries.\textsuperscript{10,32,44,45} By 2020, there will be 83,600 Australians aged 70 to 90 with some degree of visual impairment due to age-related macular degeneration.\textsuperscript{32} As there are no preventive treatments available yet, there is little knowledge regarding the cause of age-related macular degeneration. Therefore, this disease requires further imperative detailed investigation.

Cataract was found to be responsible for 7% of all 5-year incidence cases of visual impairment. This disease is still one of the major public health problems in Australia.\textsuperscript{22,23,36} However, as a result of cataract extraction, 1.2% had improved vision at follow-up. In Australia, cataract extraction is the most common ophthalmic surgery.\textsuperscript{46} It serves adequately to provide eradication of visual impairment and blindness due to lens opacity.\textsuperscript{47} During the follow-up period, 5.1% of participants had surgery in at least one eye.\textsuperscript{36}

The strengths of our study include accurate population-based sampling strategy,\textsuperscript{14} high response, similarity between participants and nonparticipants at baseline\textsuperscript{15} and follow up,\textsuperscript{8} and standard examination procedure at both time points of the study.\textsuperscript{8,14} A potential limitation of this study, however, is that the accuracy of the visual impairment incidence data could be affected by the differential mortality, which was 7% during the 5-year follow-up period.\textsuperscript{8} Participants with best corrected visual acuity less than 20/40 were 2.3 times more likely to die.
than those who had better vision. Also, for consistency with the baseline analyses, this study excluded participants with 53% or greater false-negative errors on the visual field assessment. Although the false-negative fixation losses were found to be not indicative of poor performance, the number of participants who did not meet this inclusion criterion was small, consisting of less than 1% of all eligible follow-up participants. The other limitation was missing data on 2% of the follow-up participants, due to incomplete examination as a result of physical or mental constraints. This was a particular problem in elderly participants, who were more likely to have impaired vision. Therefore, this could affect the already small numerator, despite the larger number of participants in the denominator, and would limit statistical power of cause and age-specific estimations.

The estimates of the potential incidence of mild, moderate, severe, or profound visual impairment in Australia indicate that approximately 342,400 adults aged 40 years and older became visually impaired over a 5-year period. Undercorrected refractive error was the primary cause of new cases of visual impairment in this population. Further research is needed to understand the problem before designing appropriate programs to eliminate the cause. The estimates of the potential incidence of severe or profound visual impairment show that 35,800 Australians will be affected over a 5-year period, mostly due to age-related macular degeneration. Further research is needed to facilitate the prevention and treatment of age-related macular degeneration, the leading cause of blindness in the Australian population.

References


**APPENDIX**

**Members of the Glaucoma Consensus Panels**

Centre for Eye Research Australia, University of Melbourne, Australia: Hugh R. Taylor, Julian Rait, Anne Brooks. Royal Victorian Eye and Ear Hospital, Australia: Mark Troski. Centre for Vision Research, Department of Ophthalmology and the Westmead Millennium and Save Sight Institutes, the University of Sydney, Australia: Paul Mitchell. Prince of Wales Hospital, Sydney, Australia: Ivan Goldberg. University of Queensland, Princess Alexandra Hospital, Woolloongabba, Queensland, Australia: Laurie Hirst. Glaucoma Unit Western Sydney Eye Hospital, University Clinic, Western Hospital, NSW, Australia: Paul Healy. Wesley Medical Centre, Auchenflower, Queensland, Australia: Mark Loane.

**Research Staff**