Age-Specific Causes of Bilateral Visual Impairment

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Objectives: To describe the age-specific prevalence of common eye diseases causing bilateral visual impairment and estimate the total number of Australians with cause-specific visual impairment.

Methods: Cluster-stratified random sample of 5147 residents aged 40 years and older from urban and rural areas and aged-care facilities. Participants completed a standardized interview and eye examination. Four levels of bilateral visual impairment were defined: less than 20/40 to 20/60 and/or homonymous hemianopia (mild), less than 20/60 to 20/200 or better and/or less than 20° to 10° radius field (moderate), less than 20/200 to 10/200 and/or less than 10° to 5° radius field (severe), and less than 10/200 and/or less than 5° radius field (profound). The major cause of vision loss was identified for all participants found to be visually impaired.

Results: Uncorrected refractive error was the most common cause of bilateral visual impairment across all decades of life, rising from 0.5% in 40- to 49-year-olds to 13% among those aged 80 years and older. Prevalence of visual impairment due to diabetic retinopathy was 0.7% in 50- to 59-year-olds and 0.8% in those older than 80 years. Visual impairment due to glaucoma had a prevalence of 0.7% among 60-year-olds and rose to 4% of those older than 90 years. The prevalence of visual impairment due to cataract (only present in those aged 70 years or older) rose from 0.6% to 11% in those older than 90 years, and the prevalence of visual impairment due to age-related macular degeneration rose from 0.8% to 16% in those older than 90 years.

Conclusions: The predominant causes of visual impairment change with age. Recognition of these patterns is fundamental for early diagnosis and treatment of eye disease and, where appropriate, referral for rehabilitation.


VISUAL IMPAIRMENT increases with age and is estimated to affect from 3.9 to 4.7%1,2 of Australians older than 40 years. Understanding the age-specific causes of visual impairment is fundamental to eye health care planning. The first point of contact a patient has with the health care system is generally the family physician; thus, it is important that the distribution of eye diseases be understood by a wide array of health care professionals to ensure early diagnosis and appropriate referral. This is especially true among elderly patients, in whom eye disease is often only one of a constellation of age-related illnesses.

The Visual Impairment Project is a population-based study of age-related eye disease among people aged 40 years and older residing in Melbourne and rural Victoria, Australia. The aim of the study is to describe age-specific causes of visual impairment and estimate the number of people affected.

ESULTS

PARTICIPANTS

A total of 5147 people (86% of eligible population) participated in the study: 3271 urban, 1473 rural, and 403 institutionalized. The mean age was 59 years in the urban and rural cohorts and 53% were women. The mean age of institutionalized participants was 83 years and 79% were women. The demographic data are representative of Victoria and Australia.13

Two hundred forty-four participants were observed with mild, moderate, severe, or profound visual impairment in the better eye. An additional 120 noninstitutionalized participants were observed with mild visual impairment in the better eye. For most visually impaired participants (91%), loss of visual acuity was the criteria used to define level of visual impairment (Table 1). Only participants with visual impairment due to glaucoma (27%), diabetic retinopathy (43%), or other causes (30%) were classified as impaired due to visual field loss.

AGE-SPECIFIC PREVALENCE

Less than 1% of people aged 40 to 49 years had visual impairment due to uncorrected refractive error (Figure 1). This increased to more than 13% of those aged 80 years and older. Visual impairment due to uncorrected refractive error most of-
SUBJECTS AND METHODS

Detailed methods are reported elsewhere. Briefly, the sample was drawn from 9 randomly selected clusters composed of adjacent pairs of census districts in Melbourne and from 4 pairs in rural Victoria. Fourteen nursing homes from 104 facilities within a 5-km distance of the Melbourne clusters were randomly selected for inclusion in the sample.

A door-to-door private census identified all residents eligible for participation in the study. Eligibility requirements included age 40 years and older and residence of 6 months or longer at the current address. All identified eligible residents were invited to complete an interview and examination at a local examination center. Interpreters were used when participants did not speak English and home visits were conducted when participants were unable to attend the local examination center.

Participants completed a standardized questionnaire in the door-to-door census and at the local examination center. The interviews elicited data regarding the participant’s sociodemographic characteristics, medical history, history of eye disease, and current visual symptoms. The study was conducted with ethics approval from the Royal Victorian Eye and Ear Hospital. All participants gave signed consent for examination after being informed of the nature of the examination and the use of the data collected.

Visual acuity was assessed using a logMAR chart at 4 m and, if necessary, at 3, 2, and 1 m, on each eye while the participant wore his or her current spectacles (if worn). A directional “E” chart was used for all participants who did not read English and for non–English-speaking participants for whom translators could not be obtained. A sequential testing approach using counting fingers, hand motions, target fixation, and light perception was used in cases where visual acuity could not be assessed using the logMAR chart. Current spectacles were analyzed using Humphrey instruments (Humphrey Instruments Inc, San Leandro, Calif). Subjective refraction was performed where visual acuity was less than 20/20 and the participant’s mental status was adequate to respond to the test.

Visual field assessment was conducted using a Humphrey Field Analyzer (Humphrey Instruments Inc) with the 24-2 Fastpac statistical package. Test results on the Humphrey Field Analyzer were considered inadequate for use in data analysis when there were 20% or greater fixation losses or 33% or greater false-positive or false-negative errors. A Bjerrum tangent screen visual field was performed where Humphrey visual fields were unobtainable. Where this was unobtainable, a confrontation field was assessed. Visual fields that were classified as either homonymous hemianopia or constriction to within 20, 10, or 5 radii of fixation were included in the analysis.

Intraocular pressure was measured after the instillation of 0.4% oxybuprocaine hydrochloride in each eye. The measurement was taken with the Tonopen (Oculab, La Jolla, Calif) and repeated if the result was 21 mm Hg or greater. Confirmed results higher than 21 mm Hg were checked with a Goldmann applanation tonometer. Vertical cup-disc ratios were measured and recorded, as well as any abnormalities of the choroid and retina.

The standardized biomicroscopic ophthalmic examination included clinical lens nucleus grading by visual comparison with a standard photograph. Cortical and subcapsular cataracts were measured and graded visually with biomicroscopic retroillumination by the ophthalmologist. Lens nucleus and retroillumination photographs were taken and graded separately by 2 trained observers and any differences were adjudicated. Vision loss attributed to cataract includes nuclear, cortical, and posterior subcapsular types.

Continued on next page

ten caused mild to moderate visual impairment. All cases of severe and profound visual impairment due to uncorrected refractive error were seen in participants aged 80 years and older.

Age-related macular degeneration was not the cause of visual impairment in any participants younger than 70 years. The prevalence of AMD more than tripled by decade of age (Figure 2). A total of 0.8% of 70- to 79-year-olds had visual impairment due to AMD; more than half of this was mild to moderate impairment. The prevalence rose to more than 16% of those in their 90s, with 6% having severe to profound levels of visual impairment.

Like AMD, cataract was not observed as a cause of visual impairment in participants younger than 70 years. Again, the prevalence triples by decade of age, from 0.5% of those in their 70s to 12% of those in their 90s (Figure 3). Most cases of impairment due to cataract were mild.

The youngest cases of visual impairment due to glaucoma were observed among participants aged 60 to 69 years, where the prevalence was 0.4% (Figure 4). The prevalence among 70- to 79-year-olds was similar (0.6%) and rose substantially among those aged 80 to 89 years (1.4%). The severity of visual impairment due to glaucoma was highest among those older than 90 years, where the prevalence of profound visual impairment due to glaucoma was 0.4%, compared with 0.01% of 60- to 70-year-olds.

The prevalence of visual impairment due to diabetic retinopathy was comparatively low. However, diabetic retinopathy causing visual impairment occurred at a younger age than the causes previously detailed. The youngest cases of visual impairment due to diabetic retinopathy were found among 50- to 59-year-olds (Figure 5). The highest prevalence of visual impairment due to diabetic retinopathy was among 80- to 89-year-olds (0.8%). Diabetic retinopathy was the cause of only mild or moderate visual impairment.

Age-specific prevalence of other causes of visual impairment ranged from 0.2% in 40- to 49-year-olds to 3.5% in 80- to 89-year-olds (Figure 6). Severe and profound bilateral visual impairment due to other causes was seen only in participants older than 80 years.

ESTIMATED NUMBER OF AUSTRALIANS AFFECTED

Of the estimated 345 000 Australians older than 40 years with mild to profound visual impairment, 284 900 cases...
Age-related maculopathy and age-related macular degeneration (AMD) were graded clinically and by photograph graders according to international classification schemes. Vision loss due to AMD includes eyes with geographic atrophy of the retinal pigment epithelium or exudative changes.

Diabetic retinopathy was graded according to a modification of the Airlie House scheme. In this scheme, nonproliferative retinopathy includes the presence of microaneurysms, retinal hemorrhages, lipid exudates, or cotton-wool spots; proliferative retinopathy includes evidence of new vessels and/or vitreous hemorrhage.

Glaucoma diagnosis was defined by a consensus group panel of 6 ophthalmologists who were independent of the research team. The consensus group graded the records of all participants who had 1 or more of the following ocular characteristics: intraocular pressure greater than 21 mm Hg, glucomatous visual field defect, enlarged (>0.07) or asymmetric (>0.02) cup-disc ratio, or a suspected diagnosis of glaucoma according to the research team ophthalmologist. Grading by the ophthalmologists was masked and independent and was based on this information as well as optic disc photographs. Cases were classified as definite, probable, possible, or no glaucoma and discrepancies in the glaucoma grading were adjudicated by the consensus panel. Visual loss due to glaucoma includes open-angle glaucoma, closed-angle glaucoma, and secondary glaucoma.

Other diseases causing visual impairment were classified using the International Classification of Diseases, Ninth Revision (ICD-9). This category includes retinal disease, neuro-ophthalmic disease, and corneal disease other than cataract.

Visual impairment was defined by both visual acuity and visual field criteria. The visual acuity criterion uses the best-corrected visual acuity for the individual. Four levels of bilateral visual impairment were defined: less than 20/40 to 20/60 and/or homonymous hemianopia (mild), less than 20/60 to 20/200 and/or less than 20° to 10° radius field (moderate), less than 20/200 to 1/200 and/or less than 10° to 5° radius field (severe), and less than 10/200 and/or less than 5° radius field (profound). When a participant was observed to have both visual acuity and visual field constriction, the category with the most severe disability was used to classify the participant. For example, if a person had visual acuity of less than 20/40 and less than 10° constriction, the person was classified as having severe visual impairment.

The major predisposing condition for each person by the better eye was assigned as the cause of visual loss. If 2 or more diseases were present, the disease with the most clinically significant and irreversible influence was assigned as the principal cause of visual loss. When the level of visual impairment was the same for both eyes but the causes differed for left and right eyes, consistent clinical principles were used by one of us (M.R.V.) to assign the cause that reflected the principal disease. A case was noted as having uncorrected refractive error when there was an improvement of 1 or more categories of visual impairment from initial visual acuity to best-corrected visual acuity.

Prevalence of visual impairment was weighted to the decade-stratified age distribution of the 1996 Australian Census for the proportion of men and women living in Melbourne, in nursing homes or hostels, and in rural Victoria. The population-weighted numerators are the sum of weighted cases in each cohort by age and sex. The data were then recomputed to calculate prevalence of specific causes of bilateral visual impairment for the entire population. Estimates of the number of Australians affected by each disease were calculated using the age- and sex-specific prevalence for the disease and the number of men and women residing in Australia for each decade-stratified age group.

A estimated 4700 Australians aged 40 to 49 years have bilateral visual impairment due to other causes. A doubling in the number of Australians who have bilateral visual impairment due to other causes is seen for those aged 50 to 59 years and again for those aged 70 to 79 years.

The finding that uncorrected refractive error is a significant cause of visual impairment was unexpected, given that Australians have access to publicly funded optometry examination. However, this result is not unprecedented. Overall, 10% of participants (57% of those with <20/20 initial visual acuity) achieved 1 line or better improvement with refraction. This is similar to the Blue Mountains Eye Study (54% of those with <20/20 initial visual acuity) but less than a quarter of that observed in the Baltimore Eye Study (54% of all participants). Our results indicate that uncorrected refractive error increases steadily with advancing age, in both severity and number of Australians affected. Significant reduction in both the overall prevalence and level of severity of visual impairment in Australia will be achievable only with an updated prescription for spectacles or the provision of spectacles for people not currently wearing...
them. Overall, 60% of participants with visual impairment due to refractive error and 82% of participants with visual acuity of less than 20/40 to 20/60 were not wearing distance correction. Among elderly subjects, our results indicate that 43% of the estimated 151,400 Australians aged 80 years and older with visual impairment could achieve an increase in visual acuity of at least 1 category in impairment with a new or updated prescription for spectacles.

Among younger age groups, diabetic retinopathy and glaucoma were significant causes of bilateral visual impairment in this study. The youngest cases with mild to moderate visual impairment due to diabetic retinopathy were observed among participants aged 50 to 59 years in both the Baltimore Eye Study and our study. Diabetic retinopathy was the principal cause of vision loss for 5.6% of those with mild to moderate visual impair-

Table 1. Visual Impairment Classification by Visual Acuity or Visual Field Loss

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. of Cases of Visual Impairment</th>
<th>No. (%) Classified by Visual Acuity Loss Criteria</th>
<th>No. (%) Classified by Visual Field Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMD*</td>
<td>87</td>
<td>87 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>26</td>
<td>19 (73)</td>
<td>7 (27)</td>
</tr>
<tr>
<td>Cataract</td>
<td>60</td>
<td>60 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Diabetic retinopathy</td>
<td>7</td>
<td>4 (57)</td>
<td>3 (43)</td>
</tr>
<tr>
<td>Other causes</td>
<td>69</td>
<td>48 (70)</td>
<td>14 (30)</td>
</tr>
<tr>
<td>Refractive error</td>
<td>115</td>
<td>115 (100)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>All Causes</td>
<td>364</td>
<td>333 (91)</td>
<td>24 (9)</td>
</tr>
</tbody>
</table>

*AMD indicates age-related macular degeneration.
field loss. In the group of participants with severe to profound visual impairment, a result somewhat higher than those reported in other studies (<1%-3.4%).

While the prevalence of visual impairment due to diabetic retinopathy is relatively low in the population, among diabetics the prevalence of retinopathy may range from 22% to 49%. In our sample, 5% of participants reported a history of diabetes, of whom 21% had retinopathy. A total of 22% of those with nonproliferative, 67% of those with preproliferative, and 83% of those with proliferative retinopathy had previously had laser coagulation surgery. All participants with visual impairment due to diabetic retinopathy had been previously treated with panretinal photocoagulation. The effects of diabetic retinopathy can be minimized with early detection and appropriate treatment of lesions that are causing visual effects. Thus, these results underscore the need for regular ophthalmic examination of all patients with diabetes. Current Australian recommendations are for a minimum of 1 dilated fundus examinations every 2 years for all patients with diabetes.

The youngest patients with mild to moderate visual impairment due to cataract were observed among white participants aged 60 to 69 years compared with those aged 70 to 79 years in the Baltimore Eye Study. Glaucoma was the primary cause of visual impairment in 12% of participants with severe or profound visual impairment. This is somewhat higher than the prevalence reported by 2 other studies (0%-8%) and may reflect our inclusion of cases with visual field loss. In the group of participants with severe to profound visual impairment due to glaucoma, 27% had visual field constriction to within 10° of central fixation with good central visual acuity.

The urban and rural residential groups, 40% of the subjects who had visual impairment due to glaucoma were undiagnosed at the time of the study. All of these had significant visual field loss but relatively good central vision, and 50% had intraocular pressure greater than 21 mm Hg. All of those who reported a history of glaucoma were using medication to lower intraocular pressure, and 20% had had previous surgery. Early detection and treatment, where appropriate, may ameliorate vision loss due to glaucoma. Increased efforts should be directed at identifying both risk factors for glaucoma, especially genetic factors, and cost-effective and efficient screening programs. Current genetic research promises to provide increased insight into identifying high-risk groups.

Among Australians older than 70 years, AMD and cataract are the major causes of visual impairment. Among white populations, AMD is the cause of 30% to 80% of the cases of severe to profound visual loss and 17% to 35% of cases of mild to moderate visual impairment. Our results are comparable; AMD was the cause of vision loss in 42% of the cases with severe to profound visual impairment and 27% of the cases with mild to moderate visual impairment. The Baltimore Eye Study found cases of mild to moderate visual impairment due to AMD in 50- to 69-year-olds, whereas we did not observe visual impairment due to AMD in participants younger than 70 years. The total number of elderly Australians with visual impairment due to AMD is likely to increase dramatically during the next 2 decades, due to the growth of the elderly population. With the exponential growth in prevalence of AMD in patients between the ages of 70 to 90 years observed in this study, we project that 83,600 Australians will have mild to profound visual impairment due to AMD by the year 2020. Our current ability to treat AMD is limited. Therefore, these results identify a definite need for further research into the management and treatment of AMD.

Cataract is a relatively uncommon cause of severe to profound visual impairment in this as well as other studies. However, it remains a significant cause of mild to moderate visual impairment, accounting for 33% to 60% of cases. A total of 7% of the cases of mild and 18% of the cases of moderate visual impairment in this study were due to cataract. As in the Baltimore Eye Study, we observed an exponential increase in the prevalence of mild to moderate visual impairment due to cataract beginning among people aged 60 years and older (Baltimore Eye Study) or 70 years and older (this study).

Overall, 236 (4.6%) of the participants in this study reported previous cataract surgery and 70% of these participants initially had a visual acuity of 20/40 or better. A majority of the visual impairment due to cataract was in the institutional cohort (50 of 61 cases). Although treatable, unoperated cataract presents a clinical dilemma in determining the overall benefit of cataract surgery to institutionalized individuals, many of whom may be affected by multiple diseases and dementia. However, treatment of cataract remains an important strategy for reducing visual impairment among older Australians in both urban and rural communities and may have a profound effect by eliminating sensory deprivation.

Table 2. Age- and Cause-Specific Prevalence of Vision Less Than Driving Vision (Cases/100) and Estimated Number of Australians Affected

| Age Group, y | Uncorrected Refractive Error | Age-Related Macular Degeneration | Cataract | Glaucoma | Diabetic Retinopathy | Other | Total |
|--------------|-------------------------------|---------------------------------|----------|----------|---------------------|-------|-------|-------|
| 40-49        | 0.48 (12 600)                | 0 (0)                           | 0 (0)    | 0 (0)    | 0.16 (4700)         | 0.63 (17 300) |
| 50-59        | 1.04 (21 200)                | 0 (0)                           | 0 (0)    | 0 (0)    | 0.07 (1200)         | 0.44 (8500)  | 1.55 (30 900) |
| 60-69        | 2.69 (37 500)                | 0 (0)                           | 0 (0)    | 0.37 (6400) | 0.26 (3600)         | 0.74 (10 400) | 4.05 (57 900) |
| 70-79        | 4.72 (48 300)                | 0.82 (8300)                     | 0.55 (6100) | 0.57 (3400) | 0.15 (1400)         | 1.81 (20 000) | 5.85 (87 500) |
| 80-89        | 13.00 (55 700)               | 5.36 (23 400)                   | 3.78 (16 400) | 1.44 (6200) | 0.83 (3500)         | 3.48 (15 100) | 27.30 (120 300) |
| ≥90          | 14.54 (10 100)               | 16.56 (10 200)                  | 10.93 (7400) | 0.62 (2100) | 0 (0)               | 1.74 (1400)  | 41.84 (31 200) |
Both the predominate causes and severity of visual impairment change with age. Among younger age groups, glaucoma and diabetic retinopathy are important causes of visual impairment, whereas AMD and cataract predominate in older age groups. Visual impairment due to uncorrected refractive error is an important cause across all age groups. Recognition of these patterns is essential for early diagnosis and treatment of age-related eye diseases, targeting of screening programs, and, where appropriate, early rehabilitation referral in cases where visual impairment is likely to be progressive.

Accepted for publication August 31, 1999.

This study was supported by the National Health and Medical Research Council, Canberra, ACT; Victorian Health Promotion Foundation, the estate of the late Dorothy Edols, and the Ansell Ophthalmology Foundation, Melbourne, Victoria; Ophthalmic Research Institute of Australia, Sydney, New South Wales; and the Jack Brockhoff Foundation, Melbourne.

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