Causes of Blindness and Visual Impairment in a Population of Older Americans

The Salisbury Eye Evaluation Study

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Objective: To determine the causes of blindness and visual impairment in a population-based sample of older Americans.

Methods: A random sample of 3821 residents of Salisbury, Md, between the ages of 65 and 84 years was identified from Medicare records. Sixty-six percent (2520 persons) agreed to undergo an eye examination; 26% of the participants were African American. The clinical examination included acuity testing with an Early Treatment Diabetic Retinopathy Study chart and standardized refraction testing for those with a visual acuity worse than 20/30, slitlamp and dilated retinal examination by an ophthalmologist, tonometry, lens and fundus photography, and a suprathreshold visual field test. Visual impairment was defined as a best-corrected acuity in the better-seeing eye worse than 20/40 and better than 20/200, while blindness was acuity in the better-seeing eye of 20/200 or worse. For those with a visual acuity worse than 20/40 in either eye, one or more causes were assigned by an ophthalmologist and a final cause for each eye was confirmed by a panel of 3 subspecialty ophthalmologists (O.D.S., H.A.Q., and S.B.B.) based on all available evidence.

Results: Bilateral presenting acuity worse than 20/40 increased from 4% in the 65- to 74-year age group to 16% in the 80- to 84-year age group. One third of those with presenting acuity worse than 20/40 improved to 20/40 or better with refraction. Overall, 4.5% had a best-corrected acuity worse than 20/40. African Americans were more likely to remain visually impaired than were whites despite refraction (odds ratio [95% confidence interval], 1.7 [1.1-2.6]). Whites were most often impaired or blind from age-related macular degeneration (1.2% vs 0.5%; P = .09). African Americans had higher rates of impairment and blindness from cataract or posterior capsular opacification (2.7% vs 1.1%; P = .006), glaucoma (0.9% vs 0.1%; P = .006), and diabetic retinopathy (1.2% vs 0.2%; P = .004).

Conclusions: More than half of those with visual impairment or blindness had conditions that were either surgically treatable or potentially preventable. African Americans had a disproportionate number of blinding diseases, particularly those amenable to eye care intervention. Targeted interventions for specific populations to increase appropriate eye care use would greatly improve vision and function in older Americans.

PARTICIPANTS AND METHODS

The Health Care Financing Administration Medicare database was used to select a random sample of individuals aged 65 to 84 years as of July 1, 1993. To participate, persons must have resided in the greater Salisbury metropolitan area, were not institutionalized, and were able to communicate and to travel to the study clinic. A Mini-Mental State Examination score greater than 17 was required for participation. To be able to recruit enough subjects from both races to fulfill the study goals, all eligible African Americans and 58% of whites were randomly selected.

Methods for assessing presenting and best-corrected visual acuity have been previously described. In brief, an autorefractometer (Humphrey Auto-Refractor; Humphrey Instruments Inc, San Leandro, Calif) was used as the starting point for a full subjective refraction if the initial visual acuity in either eye was 20/30 or worse. Distance acuity was tested with the Early Treatment Diabetic Retinopathy Study chart at 3 m, illuminated at 130 candela per meters squared. Participants who failed to read the largest letters at 3 m were retested at 1.5 m, then at 1 m. Visual acuity was scored as the total number of letters read correctly, and converted to logMAR units (logarithm in base 10 of minimum angle resolvable). Binocular initial acuity was measured with the participant's habitual distance correction. The best-corrected acuity was measured for each eye. The Lea Symbols Chart was used for 5 participants who were illiterate.

Blindness was defined as a best-corrected acuity of 20/200 or worse in the better-seeing eye, a level consistent with the definition of legal blindness in the United States. Monocular blindness was defined as a best-corrected acuity of 20/200 or worse in one eye and a best-corrected acuity better than 20/200 in the other eye. Visual impairment was defined as a best-corrected visual acuity worse than 20/40 and better than 20/200 in the better-seeing eye. This level of vision is used as a screening criterion for an unrestricted motor vehicle license in many American states.

The causes of visual impairment were determined using the following procedures. When the best-corrected visual acuity was worse than 20/40, the SEE clinic general ophthalmologist performed a dilated ocular examination to establish the primary and secondary causes of visual loss and to identify other contributory causes. Data from each eye with a best-corrected visual acuity worse than 20/40 were reviewed by an expert in the specific field of the presumed primary cause of vision loss. Supporting documents included the clinical examination report findings, stereoscopic fundus photographs of the macula, photographs of the lens, Humphrey visual field results, and ophthalmic history from community ophthalmologists, if available. The panel of expert ophthalmologists included specialists in retinal disease (S.B.B.), glaucoma (H.A.Q.), and anterior segment disorders (O.D.S.). If more than one cause of visual loss was suspected, then the case was reviewed by multiple experts. If a dilated ocular examination could not be performed at the clinic, and photographs could not be obtained, information from the ophthalmic record of the community ophthalmologists was used to determine the cause of visual loss. For this study, the primary cause of visual loss in the better-seeing eye was selected as the cause of vision loss when considering causes of binocular visual impairment.

Prevalence rates of visual impairment and blindness stratified by age and race were calculated. The cause-specific prevalence of blindness and the visual impairment rate stratified by race are provided. The x2 test and the Fisher exact test were used to compare proportions. Logistic regression models were used to compare the relation of blindness and visual impairment with race and to compare cause-specific rates of visual impairment and blindness with race, adjusting for age and sex. Odds ratios and 95% confidence intervals are given. The prevalence of blindness and visual impairment from other studies was compared with that in SEE by applying the age-sex-race-specific rates from the other studies to the SEE population structure.

RESULTS

Of the 3821 eligible individuals contacted, 24% refused to participate and 76% agreed to an extensive home interview. After the interview was completed, an appointment for the clinic examination was scheduled. The home interview and clinic examination were completed by 2520 (66.0%) of the 3821 eligible persons. The demographic comparison of those with complete examinations and the refusal group demonstrated that refusers were more likely to be older and to have fewer years of education. Details of differences between refusers and participants are described elsewhere. The overall distribution of self-reported vision status was similar in both groups, with no significant (P = .73) differences once age and sex were adjusted. There was no differential response by race: 64.7% of the eligible whites and 64.0% of the eligible African Americans participated in the study. Of the participants, 26% were African American; 58%, women; and 32%, aged 75 to 84 years.

The prevalence rates of binocular presenting acuity and binocular best-corrected acuity worse than 20/40 stratified by age group and race are shown in Figure 1. Within race, the proportion of participants with presenting acuity worse than 20/40 was similar in the younger 2 age categories (65-69 and 70-74 years), 3% for whites and 7% for African Americans. This proportion doubled among the individuals aged 75 to 79 years and then increased to 13% for whites and to 20% for African Americans among the group aged 80 to 84 years. In Figure 1, the difference in height between the light and dark bars corresponds to the proportion of visually impaired or blind individuals whose disability was corrected with refraction. Thirty-four percent of the individuals with presenting acuity worse than 20/40 improved to 20/40 or better after refraction; this proportion was similar across age groups.

Visual impairment increased with age for both races, with African Americans having a higher prevalence of visual impairment in every age group (Table 1). The preva-
lence of bilateral blindness was low for both races in the first 2 age categories. Similar rates were observed for African Americans and whites in the 75- to 79-year-old age group, but 4.4% of African Americans were blind compared with 1.5% of whites aged 80 to 85 years. Overall, African Americans were more likely to be blind than whites (age-adjusted \( P = .008 \)). Stratification by race (Figure 1) indicates that African Americans were more likely to be visually impaired by presenting or best-corrected acuity criterion than whites. In multivariate models, adjusted for age, sex, and score on the Mini-Mental State Examination, African Americans were 1.5 times more likely than whites to have presenting acuity worse than 20/40 (95% confidence interval, 1.1-2.2) and 1.7 times more likely to have a best-corrected acuity worse than 20/40 (95% confidence interval, 1.1-2.6). No differences in the proportion of visually impaired or blind persons were found by sex.

Among those with an initial visual acuity of 20/40 or worse (n=159), 14% improved by 1 line, 19% by 2 or 3 lines, and 11% by 4 or more lines (Figure 2). Most of the improvements occurred in individuals whose visual acuity was between 20/40 and 20/70. A total of 71 individuals improved by 1 line or more, among whom 16 (23%) had presenting acuity of 20/70 or worse. Only 23% of the

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**Figure 1.** Prevalence of initial and best-corrected visual acuity worse than 20/40 by race and age.

**Table 1. Best-Corrected Acuity in the Better-Seeing Eye by Age Group and Race**

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>No. of Persons</th>
<th>Best-Corrected Acuity</th>
<th>Best-Corrected Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whites</td>
<td>20/40–20/200</td>
<td>≤20/200</td>
</tr>
<tr>
<td>65-69</td>
<td>547</td>
<td>1.8 (0.9-3.4)</td>
<td>0.0 (0.0-1.7)</td>
</tr>
<tr>
<td>70-74</td>
<td>624</td>
<td>1.3 (0.6-2.5)</td>
<td>0.2 (0.0-1.0)</td>
</tr>
<tr>
<td>75-79</td>
<td>421</td>
<td>3.1 (1.5-5.2)</td>
<td>1.2 (0.4-2.8)</td>
</tr>
<tr>
<td>80-84</td>
<td>261</td>
<td>7.3 (4.4-11.4)</td>
<td>1.5 (0.4-3.9)</td>
</tr>
<tr>
<td>Total</td>
<td>1853</td>
<td>2.7 (2.0-3.6)</td>
<td>0.5 (0.3-1.0)</td>
</tr>
</tbody>
</table>

*Data are given as percentage (95% confidence interval) unless otherwise indicated.

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**Figure 2.** Gain in lines of visual acuity after refraction among individuals with an initial acuity of 20/40 or worse.

African Americans with presenting acuity worse than 20/40 were able to improve their acuity to 20/40 or better after refraction compared with 34% of the whites (\( P = .16 \)).
Overall, 21 individuals (0.83%) were bilaterally blind (Table 2). In 9 (43%) of the 21 blind persons, the primary cause was ARMD; 2 were African Americans. In 3 persons, optic atrophy caused bilateral blindness; 2 were blind from each of the following: glaucoma, diabetic retinopathy, trauma, and non-ARMD retinal diseases. In 1 person, blindness was attributable to cataract.

In 85 persons, cataract was the leading cause of bilateral visual impairment, accounting for 42% (36 persons), followed by ARMD (20% [17 persons]), diabetic retinopathy (12% [10 persons]), and glaucoma and other retinal causes (7% each [6 persons each]) (Table 2). Posterior capsule opacification in pseudophakic eyes was responsible for 2.4% (2/85) of visual impairments, while other causes were corneal opacity, optic atrophy, Duane retraction syndrome, retrolubar neuritis, and undetermined causes (4.7% [4 persons]).

When the causes of visual impairment were stratified by race, cataract was the leading cause in whites (40%) and African Americans (46%) (Figure 3). Most of those impaired by ARMD were white (16 of 17 persons) (Table 2). African Americans were 4 times more likely to be impaired by diabetic retinopathy compared with whites. Glaucoma also affected African Americans disproportionately, representing 5 of 6 impaired persons, with a race-specific prevalence of visually impairing glaucoma 15 times higher than in whites.

The cause- and race-specific prevalences of visual impairment or of blindness were grouped into 3 categories, based on the availability of therapeutic or preventive measures (Table 2). These were (1) reversible by cataract surgery or capsulotomy, (2) potentially preventable (glaucoma and diabetic retinopathy), and (3) all others for whom visual loss is irreversible and low vision assis-
tance may be indicated (retinal and other causes). African Americans had more than twice the race-specific prevalence of impairment from operable cataract or capsule opacification compared with whites (2.70% vs 1.13%; age-adjusted \( P = .006 \)). In the preventable category, African Americans were nearly 9 times more likely to be impaired or blind than whites, combining race-specific data for glaucoma and diabetes (0.9% vs 0.1% for glaucoma and 1.2% vs 0.2% for diabetic retinopathy; \( P = .006 \) and \( P = .004 \), respectively). Among the diseases for which low vision rehabilitation may be useful, ARMD was the largest category; visual loss from ARMD was higher in whites (impairment plus blindness, 1.20% vs 0.45%; age-adjusted \( P = .09 \)).

Monocular blindness (best visual acuity 20/200 or worse in only one eye) occurred in 4.4% of those examined (110 persons), with African Americans more often blind in one eye than whites (6.2% vs 3.7%; \( P < .01 \)). One third of the cases of monocular blindness occurred in individuals whose fellow eye was also impaired. Age-related macular degeneration accounted for 20.1% of monocular blindness, with a higher proportion in whites and in participants whose fellow eye was impaired (Table 3). Trauma was responsible for 12.7% of those with monocular blindness; however, the fellow eye in 13 of 14 persons had an acuity of 20/40 or better.

In an older population in a semirural area, 7% of the subjects had presenting acuity worse than 20/40 in the better-seeing eye. One third of these individuals improved to a best-corrected visual acuity of 20/40 or better with refraction alone. This observation confirms the results of several studies in the United States and abroad, in that a high proportion of the general population may have improved visual acuity with proper refraction. Overall, 45% of the population with a visual acuity of 20/40 or worse improved by 1 or more lines after refraction was performed, and only 23% of the improvements occurred in individuals whose presenting acuity was 20/70 or worse. From a public health perspective, it is unclear what impact correcting minimal residual refractive error has on overall function, particularly when this generally yields only 1 or 2 lines of acuity improvement.

The proportion of individuals who improved with refraction cannot be compared directly with proportions reported in some other studies because we did not attempt refractions on persons whose presenting acuity was better than 20/30. Differences in results between studies may reflect differences in the refraction protocols. However, the use of eye care in the different communities, and the changes in eye care use that may have occurred during the past decade, may also contribute to the relative lower prevalence of uncorrected refractive error identified in the Salisbury community. In Salisbury, 64% of the population aged 65 years and older had seen an eye care provider in the previous year.

The prevalence of bilateral blindness in the SEE sample (0.89%) is lower than that found in other population-based studies in developed countries and dramatically lower than that found in the developing world. To allow appropriate comparison between our data and the data in prior reports, we applied the age-race-specific prevalences from other surveys to the SEE population age-race distribution (Table 4). The prevalences of impairment and blindness are similar between whites in Salisbury and those in 2 recent studies in Australia and the Netherlands. However, compared with Salisbury, the rates were twice as high in the Baltimore and Beaver Dam studies. Since these studies were conducted a decade before SEE, it is possible that a decrease in rates of visual impairment and blindness has occurred over time. Trends toward increased use of cataract services support this possibility and suggest a temporal trend in the prevalence of blindness and visual impairment, at least in developed countries.

The lower prevalence of visual impairment in Salisbury could have other explanations. First, visual impairment and blindness have been associated with lower socioeconomic status. While Salisbury is not an affluent area, it has fewer persons at the extremely low end of the income scale. This is unlikely to explain differences with data from Beaver Dam. Second, eligibility re-

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**Table 3. Primary Causes of Monocular Blindness Stratified by Race and Best-Corrected Acuity of the Fellow Eye**

<table>
<thead>
<tr>
<th>Primary Cause</th>
<th>Race</th>
<th>Visual Acuity of the Fellow Eye</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White (69 Eyes)</td>
<td>African American (41 Eyes)</td>
</tr>
<tr>
<td></td>
<td>≥20/40 (77 Eyes)</td>
<td>&lt;20/40 (33 Eyes)</td>
</tr>
<tr>
<td>Macular degeneration</td>
<td>20 (29.0)</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>Retinal pathological diseases†</td>
<td>12 (17.4)</td>
<td>7 (17.1)</td>
</tr>
<tr>
<td>Trauma</td>
<td>10 (14.5)</td>
<td>4 (9.8)</td>
</tr>
<tr>
<td>Amblyopia</td>
<td>10 (14.5)</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>1 (1.4)</td>
<td>9 (22.0)</td>
</tr>
<tr>
<td>Cataract</td>
<td>6 (8.7)</td>
<td>4 (9.8)</td>
</tr>
<tr>
<td>Corneal causes</td>
<td>2 (2.9)</td>
<td>4 (9.8)</td>
</tr>
<tr>
<td>Optic atrophy</td>
<td>1 (1.4)</td>
<td>3 (7.3)</td>
</tr>
<tr>
<td>Diabetic retinopathy</td>
<td>2 (2.9)</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>Uveitis</td>
<td>0</td>
<td>1 (2.4)</td>
</tr>
<tr>
<td>Other</td>
<td>5 (7.2)</td>
<td>3 (7.3)</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage) of eyes.
†Other than age-related macular degeneration, diabetic retinopathy, and trauma.
Blindness and visual impairment were higher among African Americans compared with whites, similar to the results of previous studies. In addition, the distribution of the causes of blindness and impairment differed between the 2 racial groups. Among whites, ARMD was the major cause of these outcomes, producing 70% of the cases of bilateral blindness and 33% of the cases of bilateral vision impairment. In contrast, among African Americans, the main causes of blindness were evenly distributed among ARMD, optic atrophy, diabetic retinopathy, and other retinal pathological diseases. Furthermore, African Americans were rarely visually impaired due to ARMD. Cataract was the leading cause of visual impairment among African Americans, although it was also commonly seen as a cause of impairment in whites (47% vs 40%). Glaucoma and diabetic retinopathy were also common causes of impaired vision in African Americans, accounting for 14% and 17% of the impairments, respectively, whereas these only accounted for 2% and 8% of vision-impaired whites, respectively. Since each of these 3 conditions can be approached medically or surgically to minimize vision loss, efforts should be made to screen and treat individuals at risk of vision loss from these disorders.

Cataract was the leading cause of visual impairment other than refractive error in African Americans and whites, and the prevalence in African Americans was twice as high as that in whites. However, only one participant was blind from cataract, and the resultant blindness prevalence of 0.15% for African Americans was lower than that found for African Americans older than 60 years in the Baltimore Eye Survey (0.94%). This suggests greater use of cataract surgical services in the ensuing 10 years between the studies. Indeed, when age-race-specific rates of cataract surgery for individuals aged 70 years and older in the Baltimore Eye Survey were applied to the SEE population, we found higher observed than expected rates, 26% vs 13% for whites and 13% vs 8% for African Americans.

Glaucoma and diabetic retinopathy were important causes of impairment and blindness that were 7 times more likely to affect African Americans. Glaucoma was the cause of impairment or blindness in 9 times more African Americans than whites. This morbidity difference was twice as high as the prevalence difference between African Americans and whites estimated in the Baltimore Eye Survey. Wang et al found that African American Medicare recipients underwent proportionately fewer operations and had fewer office visits for glaucoma than did white recipients. Recent clinical trials suggest a high rate of success in the preservation of vision in persons with glaucoma, even at advanced stages, in both racial groups. Yet, only half of those with glaucoma are identified and under care, as shown by several studies.

Diabetic retinopathy followed ARMD and cataract as cause of visual impairment in whites and was second to cataract among African Americans. Laser treatments have not only been shown to be clinically effective but are also cost-effective for society. While there may have been increased delivery of treatment for diabetic eye disease, the high rate, particularly among African Ameri-
Blindness from ARMD among whites occurred in individuals aged 70 years and older, with a prevalence of 0.38% in those aged 70 to 79 years and of 1.15% in those aged 80 to 84 years. The rate in the younger age group was similar to the rate reported by the Baltimore Eye Survey of 0.32% for whites in the group aged 70 to 79 years. The lack of treatment options to prevent or limit severe vision loss in most individuals affected with ARMD may be the reason for the similarity of the rates reported in studies conducted almost 10 years apart.

When the causes of impairment and blindness are grouped, 37% can be classified as surgically treatable, 19% have treatments that may prevent vision loss, and 44% are categorized as targets for low vision remediation. It is not clear how many of those whose impairment would be amenable to cataract surgery were unaware that surgery could improve vision or how many did not choose surgery due to absence of functional loss, fear, or financial barriers.

Unlike the situation in developing countries, the eye care system in the United States has the capacity to deliver the needed services. However, the means by which effective screening and public education could enhance delivery of eye care services are not yet extant. Finally, there appears to be a large, unmet need to explore the potential benefit of low vision services to those who are irreversibly impaired and blind.

Accepted for publication November 27, 1999.

This study was supported by grant AG10184 from the National Institute on Aging, National Institutes of Health, Bethesda, Md, and the Olga Keith Weiss Research to Prevent Blindness Special Scholars Award (Dr Bressler). Dr West is a Senior Scientific Investigator for Research to Prevent Blindness Inc, New York, NY.

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REFERENCES


