Prevalence and Causes of Low Vision and Blindness in a Japanese Adult Population

The Tajimi Study

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Objective: To determine the prevalence and causes of low vision and blindness in a Japanese adult population.

Design: Population-based cross-sectional study.

Participants: Randomly selected residents (n = 3870) of Tajimi City, Japan, who were 40 years of age or older.

Methods: Of the 3021 study participants (78.1% of 3870 eligible persons), 2977 (76.9%) underwent a complete ophthalmologic examination including measurement of the best-corrected visual acuity (BCVA) with full subjective refraction using a Landolt ring chart at 5 m. Age- and gender-specific prevalence rates of low vision and blindness were estimated and causes were identified.

Main Outcome Measures: Low vision and blindness were defined as BCVA in the better eye worse than 20/60 to a lower limit of 20/400 and worse than 20/400, respectively (World Health Organization [WHO] criteria) and worse than 20/40 but better than 20/200 and 20/200 or worse, respectively (United States criteria).

Results: The overall prevalence of blindness according to the WHO or U.S. criteria was 0.14% (n = 4; 95% confidence interval [CI], 0.06–0.32). The primary causes were optic atrophy, myopic macular degeneration, retinitis pigmentosa, and uveitis. The overall prevalence of low vision according to the WHO criteria was 0.39% (95% CI, 0.18%–0.60%) and according to the U.S. criteria was 0.98% (95% CI, 0.66%–1.30%), which was significantly greater in women and in the older half of the participants than in the younger half (P = 0.0079 and <0.0001, respectively). The leading causes of low vision in descending order were cataract followed by glaucoma, and those of monocular blindness were myopic macular degeneration, glaucoma, and trauma.

Conclusions: The prevalence of low vision and blindness in Japanese adults was one of the lowest among those reported. The major causes of low vision were cataract and glaucoma, and the leading cause of monocular blindness was myopic macular degeneration. Ophthalmology 2006;113:1354–1362 © 2006 by the American Academy of Ophthalmology.

Low vision and blindness are important public health problems and, according to World Health Organization (WHO) criteria, approximately 45 million people worldwide are thought to experience blindness as the functional end stage of ophthalmologic disorders.1 Previous population-based studies consistently have demonstrated a significant increase in the prevalence of low vision or blindness with increasing age.2–24 In Japan, the rapid growth of the aging population is a major concern from both the medical and the socioeconomic standpoints. At present, the life expectancy


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of Japanese individuals, 78.3 and 85.2 years for males and females, respectively,25 is probably the longest among developed countries; 17.2% of the total Japanese population was older than 65 years in 2000, and this percentage should exceed 25% in 2015.26 Estimating the prevalence of visual impairment, which is highly correlated with aging, should be particularly important in a country such as Japan. The prevalence of visual impairment has been estimated based on population-based studies in Western countries,23,5,8,11,14,18,20,22,24 and Asian countries,3,9,10,12,13,15,17,19,21,23 but not in Japan. We recently conducted the Tajimi Study, a population-based eye study that focused primarily on estimating the prevalence of glaucoma among Japanese persons aged 40 years or older.27,28 The purpose of the present study was to estimate the prevalence of low vision and blindness in the Tajimi Study population.

Patients and Methods

This study was part of a population-based eye study of Japanese persons aged 40 years or older conducted between September, 2000, and October, 2001, in Tajimi City, Japan. The participants and methods are the same as those reported previously.27 Briefly, of 54,165 inhabitants aged 40 years and older in Tajimi City as of August 1, 2000, 4000 persons were selected randomly without stratification and were encouraged to participate in the epidemiologic study. The investigation followed the tenets of the World Medical Association’s Declaration of Helsinki and the municipal statutes of Tajimi City for protecting personal information; the study protocol was approved by the ethics committee of Tajimi City. Written informed consent was obtained from all participants after the details of the study had been explained fully. Among the selected 4000 participants, 48 died and 82 were not actual residents of or had moved from Tajimi City during the screening period. Of the remaining 3870 persons, 3021 participated in the screening examinations, for a response rate of 78.1%.

Ocular Examinations

The details of the screening and definitive examinations were reported previously.27 Briefly, the screening examinations included not only ocular parameters but also parameters such as height, weight, and blood pressure. The ocular examinations included measurement of visual acuity (VA), central corneal thickness using a specular-type pachymeter (SP-2000P; Topcon, Tokyo, Japan), slit-lamp biomicroscopic examination, evaluation of angle width according to the van Herick method, intraocular pressure (IOP) measurement by Goldmann applanation tonometry, fundus examination based on digital color photographs obtained through an undilated pupil using the IMGNet digital fundus camera system (TRC-NW6S, Topcon) with angles of 30° and 45°, and visual field screening using a frequency doubling technology (FDT) screener (Humphrey Instruments, San Leandro, CA) with the C-20-1 screening test. The VA was measured in the right eye first without refractive correction using a Landolt ring chart at a distance of 5 m. The examination then was repeated with full subjective refraction to obtain the best-corrected visual acuity (BCVA), using the result obtained with an autorefractometer (KR-8100PA, Topcon). When participants could not come to the facilities, doctors visited them in their homes or hospitals and performed the necessary examinations, but the VA test at a distance of 5 meters was not carried out. Participants were referred for definitive examination if they were suspected to have ocular disorders or related conditions and if they met 1 or more of the following criteria: corrected VA less than 20/20; abnormal findings during the slit-lamp examination or on fundus photographs; IOP more than 19 mmHg; angle width grade 2 or less (van Herick method); findings in the optic disc, retinal, or both suggestive of glaucoma or other ocular diseases; and at least 1 abnormal test point in the FDT visual field test.

A total of 1065 participants were referred for definitive examinations after the initial screening, carried out on separate days, but 14 failed to undergo definitive examinations. The definitive examination included slit-lamp examination, gonioscopy, and optic nerve head and posterior pole fundus evaluation with a Goldmann 2-mirror lens (Haag-Streit, Koeniz, Switzerland); applanation tonometry; and visual field testing with the Humphrey Perimeter Central 30-2 Swedish Interactive Threshold Algorithm (SITA) Standard program (Humphrey Instruments). On slit-lamp examination, cornea opacity was graded as 1+ (mild), 2+ (moderate), and 3+ (severe), and cataract was graded as 1+ (mild nuclear cataract), 2+ (moderate nuclear cataract), and 3+ (severe nuclear cataract) with or without cortical cataract or subcapsular opacity. Unless gonioscopy revealed an occludable angle, the pupil was dilated to obtain stereoscopic disc photographs (3-DX NM; Nidek, Gamagori, Japan) and to observe the ocular fundus in detail by indirect ophthalmoscopy. When the angle was thought to be occludable, the same examinations were carried out with undilated pupils.

Definitions of Low Vision and Blindness

To compare easily the current results with those of previous population-based visual impairment projects, we adopted 2 definitions of low vision and blindness that are used widely. Low vision was defined as BCVA in the better eye that was worse than 20/60 (decimal VA, 0.3 or worse) but 20/400 or better (decimal VA, 0.05), and blindness was defined as BCVA in the better eye worse than 20/400 (decimal VA, 0.05); this definition is the same as the WHO criteria.29 Low vision was defined as BCVA in the better eye worse than 20/40 (decimal VA, 0.5) but better than 20/200 (decimal VA, 0.1), and blindness as BCVA in the better eye of 20/200 or worse (decimal VA, 0.1; United States criteria).2,30

Although there is no standard method to categorize visual field loss from the standpoint of visual disability, an individual with a visual field constricted within 10° of fixation bilaterally, as measured with the I/4 isoper of Goldmann perimetry, is considered to be visually impaired because of visual field damage, according to the criteria of the Japanese Ministry of Health, Labor and Welfare.31 The I/4 isoper of Goldmann perimetry corresponds to 20 dB with the Humphrey Perimeter Full Threshold program (target size III).31 Therefore, an individual with constriction of a 20-D area with the Humphrey Perimeter Central 30-2 SITA Standard program within 10° of fixation was considered to be visually impaired from the standpoint of visual field damage, although 20 dB with the Humphrey Perimeter SITA Standard program should correspond to a sensitivity slightly lower than 20 dB with the Humphrey Perimeter Full Threshold program.32,33

Causes of Low Vision or Blindness

The principal cause of visual impairment in the eye in question was determined by a panel of 6 expert ophthalmologists based on clinical records obtained from all examinations and available past history and records of the participant. In eyes with 2 or more disorders that might have caused the visual impairment, the disorder with the presumed greatest clinical impact on the VA was considered the principal cause after discussion using all available documentation.
The BCVA was worse than 20/400 in all eyes in which the posterior fundus and optic disc could not be observed because of disorders in the transparent media. When these eyes had a history of ocular surgery, the disorder for which the surgery was carried out, for example, glaucoma, retinal detachment (RD), or diabetic retinopathy, was considered the principal cause of visual impairment. Glaucoma was diagnosed based on the appearance of the optic disc and nerve fiber layer, visual fields, and related ocular conditions. When the results of fundus examination and visual field testing were unavailable and the IOP was more than the 99.5 percentile for Japanese, that is, 23 mmHg or higher without a history of ocular surgery, glaucoma was considered the principal cause. Otherwise, the main disorder causing the opacity, such as corneal disorders or cataract, was assigned as the principal cause. Nonglaucomatous optic nerve atrophy and retinal and choroidal diseases were diagnosed based on the findings of indirect ophthalmoscopy, fundus examination with a Goldmann 2-mirror lens, and digital fundus photographs with angles of 30° and 45°.

All information was maintained in a confidential manner at the Data Analysis Center of the Tajimi Municipal Hospital. The data were double checked and validated through inspection and analyzed using SAS version 8.02 software (SAS Institute Japan, Tokyo, Japan) on a personal computer. Differences between the 2 groups were evaluated using the Student t test or chi-square test. When the number of participants with low vision or blindness in a category was fewer than 5, a 95% confidence interval (CI) of the prevalence rate was calculated using a method correcting the influence of a small number.

The prevalence of low vision and blindness and the CIs were calculated both as a percentage of participants (the better eye in each participant) and as a percentage of all eyes examined. Although the principal cause of visual impairment may be the same for both eyes in most participants, a small percentage of participants may have different principal causes for each eye. For this reason, the prevalence of various causes of visual impairment was calculated both as a percentage of participants (the better eye of each participant) and as a percentage of all eyes examined.

## Results

Of the 3870 eligible residents, 3021 participated in the Tajimi Study. The age of 849 nonparticipants (57.5 ± 14.5 years) was similar to that of participants (58.4 ± 11.8 years), but the age of 475 male nonparticipants (55.1 ± 10.2 years) was significantly younger than that of 374 female nonparticipants (60.6 ± 14.9 years; P < 0.0001), although no significant difference was found between the age of 1334 male and 1687 female participants (58.2 ± 11.3 years vs. 58.6 ± 12.2 years). There were 2977 participants (1318 men, 1659 women; 76.9% of the eligible participants) in the present study, excluding 44 participants who were examined at home or hospital and could not undergo a subjective VA examination or give reliable answers during a subjective VA examination. The average age of these 44 participants (16 males and 28 females, respectively) was 80.3 ± 9.4 years (78.5 ± 8.2 years and 81.5 ± 9.8 years, respectively). No subjective responses could be obtained from 26 of the 44 because of cognitive problems, and reliable responses could not be obtained from 18 because of physical or mental problems, or both. The average age of the 2977 participants (58.1 ± 11.6 years), but not gender ratio, was significantly different from that of the 44 participants (P < 0.0001). A total of 14 participants failed to be examined in the definitive examination, but the screening examination revealed that none of the eyes of these 14 participants showed BCVA lower than 20/40.

### Table 1. Prevalence (%) and 95% Confidence Interval of Bilateral Low Vision According to the World Health Organization Criteria

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–49</td>
<td>0.30 (0.05–1.66)</td>
<td>—</td>
<td>0.13 (0.02–0.72)</td>
</tr>
<tr>
<td>50–59</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>60–69</td>
<td>—</td>
<td>—</td>
<td>1.73 (0.68–4.37)</td>
</tr>
<tr>
<td>70–79</td>
<td>—</td>
<td>—</td>
<td>4.30 (1.69–10.54)</td>
</tr>
<tr>
<td>80+</td>
<td>2.08 (0.37–10.90)</td>
<td>3.55 (0.50–6.60)</td>
<td></td>
</tr>
<tr>
<td>40&lt;</td>
<td>0.15 (0.04–0.55)</td>
<td>0.48 (0.15–0.81)</td>
<td></td>
</tr>
<tr>
<td>40&lt;</td>
<td>0.17 (0.05–0.56)</td>
<td>0.61 (0.28–0.94)</td>
<td></td>
</tr>
<tr>
<td>40&lt;†</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

—, no participants fulfilling the criteria.

*Standardized according to the age (and gender) distribution in Tajimi City.
†P = 0.0636.

### Table 2. Prevalence (%) and 95% Confidence Interval of Bilateral Blindness According to the World Health Organization and United States Criteria

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–49</td>
<td>0.59 (0.16–2.13)</td>
<td>—</td>
<td>0.26 (0.07–0.93)</td>
</tr>
<tr>
<td>50–59</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>60–69</td>
<td>0.62 (0.17–2.24)</td>
<td>0.28 (0.05–1.56)</td>
<td></td>
</tr>
<tr>
<td>70–79</td>
<td>1.08 (0.19–5.84)</td>
<td>0.71 (0.13–3.91)</td>
<td></td>
</tr>
<tr>
<td>80+</td>
<td>0.08 (0.01–0.43)</td>
<td>0.18 (0.06–0.53)</td>
<td></td>
</tr>
<tr>
<td>40&lt;</td>
<td>0.08 (0.02–0.35)</td>
<td>0.20 (0.08–0.51)</td>
<td></td>
</tr>
<tr>
<td>40&lt;†</td>
<td>0.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

—, no participants fulfilling the criteria.

*Standardized according to the age (and gender) distribution in Tajimi City.
†Standardized according to the age distribution of the world population.
and gender-adjusted prevalence rates of bilateral blindness and low vision in the study participants aged 40 years or older were 0.14% (95% CI, 0.06–0.32) and 0.39% (95% CI, 0.18–0.60) according to the WHO criteria and were 0.14% (95% CI, 0.06–0.32) and 0.98% (95% CI, 0.66–1.30) according to the U.S. criteria. Four participants were blind based on both the WHO and the U.S. criteria, because no participants happened to show BCVA that was 20/400 or better and 20/200 or worse in the better seeing eye; the causes of blindness in these 4 participants were optic atrophy resulting from methyl alcohol, retinitis pigmentosa, myopic macular degeneration, and uveitis.

The causes of low vision in 10 participants according to the WHO criteria were cataract (4/10), glaucoma (2/10), myopic macular degeneration, corneal opacity, amblyopia, and optic atrophy (1/10, each) and those in 25 participants according to the U.S. criteria were cataract (11/25), glaucoma (3/25), myopic macular degeneration, chorioretinal degeneration, corneal opacity, diabetic retinopathy (2/25, each), amblyopia, optic atrophy, and uveitis (1/25, each). Table 4 shows the cause-specific prevalence of visual impairment, including both blindness and low vision, according to the U.S. criteria.

Although the number of participants who were blind bilaterally according to both criteria was too small to demonstrate a correlation with age or gender, the prevalence of bilateral low vision according to the WHO criteria tended to be significantly greater in women (P = 0.0079), and the prevalence rates of bilateral low vision according to both criteria were significantly higher in the older half of the participants than in the younger half of the participants (P = 0.0093 and P < 0.0001, respectively). The cause of blindness and low vision was thought to be the same for both eyes of those 29 participants.

Sixty-one participants had monocular low vision according to the WHO criteria with VA in the fellow eye of 20/40 or better, and 36 participants had monocular blindness according to the WHO criteria (n = 76 eyes) were cataract (35.5%), glaucoma (10.5%), myopic macular degeneration (9.2%), amblyopia, age-related macular degeneration (6.6% each), corneal opacity, diabetic retinopathy, trauma (5.3% each), and others (15.6%), and those of bilateral and monocular blindness (n = 49 eyes) were myopic macular degeneration (22.4%), glaucoma, trauma (12.2% each), retinitis pigmentosa, congenital anomaly (8.2% each), cataract, amblyopia, corneal opacity, optic atrophy, retinal bleeding, RD, uveitis (4.1% each), and others (8.0%), as shown in Figure 1 (available at http://aaojournal.org).

Table 4. Cause-Specific Prevalence (%) and 95% Confidence Interval of Visual Impairment (Low Vision Plus Blindness) According to the United States Criteria

<table>
<thead>
<tr>
<th>Cause</th>
<th>40&lt;</th>
<th>40&lt;*</th>
<th>40&lt; †</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cataract</td>
<td>0.37</td>
<td>(0.15–0.59)</td>
<td>0.44 (0.23–0.65)</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>0.10</td>
<td>(0.03–0.30)</td>
<td>0.11 (0.04–0.31)</td>
</tr>
<tr>
<td>Myopic macular degeneration</td>
<td>0.10</td>
<td>(0.03–0.30)</td>
<td>0.10 (0.03–0.29)</td>
</tr>
<tr>
<td>Corneal opacity</td>
<td>0.07</td>
<td>(0.02–0.24)</td>
<td>0.09 (0.03–0.28)</td>
</tr>
<tr>
<td>Diabetic retinopathy</td>
<td>0.07</td>
<td>(0.02–0.24)</td>
<td>0.06 (0.02–0.24)</td>
</tr>
<tr>
<td>Optic atrophy</td>
<td>0.07</td>
<td>(0.02–0.24)</td>
<td>0.07 (0.02–0.24)</td>
</tr>
<tr>
<td>Uveitis</td>
<td>0.07</td>
<td>(0.02–0.24)</td>
<td>0.08 (0.02–0.26)</td>
</tr>
<tr>
<td>Chorioretinal degeneration</td>
<td>0.07</td>
<td>(0.02–0.24)</td>
<td>0.09 (0.03–0.28)</td>
</tr>
<tr>
<td>Retinitis pigmentosa</td>
<td>0.03</td>
<td>(0.01–0.19)</td>
<td>0.03 (0.01–0.19)</td>
</tr>
<tr>
<td>Amblyopia</td>
<td>0.03</td>
<td>(0.01–0.19)</td>
<td>0.04 (0.01–0.21)</td>
</tr>
</tbody>
</table>

*aStandardized according to the age and gender distribution in Tajimi City.
†Standardized according to the age distribution of the world population.

Discussion

In the current study, there were 849 nonparticipants of 3870 eligible residents. The current study demonstrated that the prevalence of low vision in this population was higher in females and in older participants. Although the average age of nonparticipants was similar to that of participants, the number of female nonparticipants was less than that of male nonparticipants, whereas the number of female participants was more than that of male participants. Thus, the prevalence of low vision in the nonparticipants may be somewhat less than that among the participants. Further, BCVA could not be determined in both eyes of 44 participants who were examined at home or hospital because of cognitive, physical, or other mental problems, or a combination thereof. Because these 44 participants were significantly older than other participants, the prevalence rates of low vision or blindness in these 44 participants may be higher than that obtained in other participants. In these 44 participants, however, fundus examination by direct and indirect ophthalmoscopy was possible, and no apparent ocular disorders that might cause blindness, that is, macular degeneration, optic atrophy, dense corneal opacity, or cataract, were found. However, there might have been instances in which VA examination could not be performed well enough to determine the true BCVA in other participants. These points...
must be taken into consideration in interpreting the prevalence rates obtained.

The present study reported for the first time population-based data on the prevalence of low vision and blindness in an adult Japanese population in Tajimi City, a suburb of Nagoya City in central Japan. If we apply the age-specific prevalence of adult Japanese individuals aged 40 years or older residing in Tajimi City, a suburb of Nagoya City, we can estimate the prevalence of low vision and blindness in the adult Japanese population in Tajimi City. The prevalence rates of low vision and blindness obtained in the present study are expected to increase in the near future, which necessitates medical and socioeconomic countermeasures.

Tables 5 and 6 summarize the age-specific and overall prevalence of low vision and blindness in previous population-based studies in which the age range of the participants and the definitions of low vision and blindness were the same as in the present study. To facilitate comparison, prevalence rates standardized to the age distribution of the world population (40–49 years, 12 000; 50–59 years, 9000; 60–69 years, 7000; 70–79 years, 3000; more than 80 years, 1000) are also added to these tables. The prevalence rates of low vision or blindness according to the WHO and U.S. criteria, and approximately 640 000 and 90 000 have bilateral low vision and blindness, respectively, according to the U.S. criteria. Many population-based studies, including the current one, have reported that the prevalence rates of low vision and blindness are age dependent and that the number of individuals who are living longer is rapidly increasing in Japan. Thus, the numbers of people with bilateral low vision or blindness also are expected to increase in the near future, which necessitates medical and socioeconomic countermeasures.
Table 6. Comparison of Age-Specific Prevalence (%) of Low Vision and Blindness According to the United States Criteria

<table>
<thead>
<tr>
<th>Visual Acuity Charts</th>
<th>Age Categories (yrs)</th>
<th>Overall</th>
<th>World*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40–49</td>
<td>50–59</td>
<td>60–69</td>
</tr>
<tr>
<td><strong>Low vision</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles (Latino)†</td>
<td>0.3</td>
<td>0.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Proyecto (Latino)‡</td>
<td>0.3</td>
<td>0.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Barbados (black and mixed)§</td>
<td>1.0</td>
<td>2.5</td>
<td>9.3</td>
</tr>
<tr>
<td>Baltimore (black)¶</td>
<td>0.6</td>
<td>1.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Baltimore (white)¶</td>
<td>0.2</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Tajimi (Japanese)¶</td>
<td>0.3</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Blindness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles (Latino)†</td>
<td>0.2</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Proyecto (Latino)‡</td>
<td>0.0</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Barbados (black and mixed)§</td>
<td>0.5</td>
<td>0.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Baltimore (black)¶</td>
<td>0.6</td>
<td>0.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Baltimore (white)¶</td>
<td>0.6</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Beaver Dam (white)***</td>
<td>Not mentioned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tajimi (Japanese)¶</td>
<td>0.0</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

ETDRS = Early Treatment of Diabetic Retinopathy Study.

*Standardized according to the age distribution of the world population.


Dam study, whereas the prevalence of blindness according to the WHO criteria in the participants in the current study was similar to that reported for white persons in Melbourne. Hsu et al reported that the prevalence rates of low vision according to the WHO criteria in elderly Chinese residing in Shihpai, Taiwan, were 3.25%, 3.75%, and 8.33% in the age ranges of 70 to 74 years, 75 to 79 years, and more than 80 years, respectively, and that according to the U.S. criteria the rates were 6.11%, 11.99%, and 18.33%, respectively. The prevalence of low vision according to the WHO criteria in the current study was 0.95% and 3.55% in the age ranges of 70 to 74 years and more than 80 years, respectively, and the prevalence rates according to the U.S. criteria were 1.69% and 9.22%, respectively. Together with the results reported in Singapore and Taipei, the prevalence of low vision in our Japanese participants is lower than that in Chinese in developed countries. The prevalence rates of low vision and blindness in our Japanese participants also tended to be lower than those reported in other ethnic groups, although a direct comparison with these results may be difficult because of differences in age stratification, the criteria for low vision and blindness, or both.

The relatively low prevalence of low vision and blindness in Japan may be attributed partly to rapid post-World War II economic development, public awareness of treatable ocular diseases, and the medical insurance system in Japan that covers most diseases regardless of individual economic status. Many of the recent ophthalmic epidemiologic studies used logarithm of the minimum angle of resolution scales such as Early Treatment of Diabetic Retinopathy Study (ETDRS) charts in testing VA, whereas Landolt rings charts were used in the current study, which may serve as a confounding factor in comparing the current results with those obtained using ETDRS charts. There is a limitation in using ETDRS charts in a population-based study in Japan, however, because a significant portion of participants, especially aged participants, cannot read alphabet letters (alphabet barrier). The National Academy of Sciences-National Research Council Committee adopted the Landolt rings as standards, but Landolt rings charts were not recommended for use during routine VA testing because of difficulty in tracking them on a row. To cope with the fact that it is difficult to track Landolt rings on a row, we used Landolt charts in which each Landolt ring can be presented one by one using a controller by an examiner. A study carried out in Mongolia also adopted Landolt rings charts. A recent paper by Ruamviboonsuk et al reported that VA measurement using a testing system where Landolt rings were presented one by one on a monitor screen showed results comparable with those of ETDRS charts. So, it seems unlikely that VA obtained in the current study was significantly different from the one that might have been obtained using ETDRS charts in participants who were familiar with alphabet letters.

The reported major causes of bilateral blindness (WHO or U.S. criteria) are glaucoma, age-related macular degeneration (AMD), and cataract. Age-related macular degeneration tends to be the leading cause of bilateral blindness in white persons, glaucoma in nonwhite persons, and cataract in African Americans and those in developing countries. In the Japanese
participants in the present study, only 4 met the WHO or U.S. criteria for bilateral blindness, the causes of which were optic atrophy resulting from methyl alcohol intake, retinitis pigmentosa, uveitis (Vogt-Koyanagi-Harada disease), and myopic macular degeneration. These 4 ocular disorders have not been reported as major causes of bilateral blindness in other ethnic groups, except that myopic macular degeneration was reported to be 1 of the 3 predominant causes of blindness in the Rotterdam study. The absence of AMD as a major cause of bilateral blindness or low vision and the major cause of monocular blindness or low vision in Japanese participants may be attributed partly to the relatively low prevalence of AMD in Japanese persons compared with Europeans or Americans or dietary, habitual, or racial differences between Japanese and Americans or Europeans. Similar findings also have been reported in other Asian countries.

Glaucoma is reported to be the leading cause of blindness in Chinese individuals in Singapore, Mexican Americans in Arizona, and African Americans in Barbados, and 1 of 2 leading causes of blindness in Mongolia. The prevalence of glaucoma in Japanese is thought to be much higher than in Singapore Chinese or white persons. Compatible with this high prevalence of glaucoma in Japanese, glaucoma is a major cause of bilateral low vision, monocular blindness, or monocular low vision. The absence of glaucoma as a cause of bilateral blindness in the current Japanese participants, however, is worthy of note. In Japanese individuals, the prevalence of open-angle glaucoma (OAG) with normal IOP, 3.6%, is almost 10 times higher than that of OAG with elevated pressure, 0.3%. Mayama et al found that in late-stage OAG, the lower central visual field is less damaged in OAG with normal IOP than in OAG with high IOP. Because less damage in the lower central visual field should be associated with less damage to the fixation point, this may explain in part our finding that glaucoma was not a cause of bilateral blindness in our Japanese participants.

Cataract often is a major cause of bilateral blindness in developing countries, but in developed countries, it is usually a major cause of bilateral or monocular low vision. In our Japanese participants, however, cataract was a predominant cause of bilateral low vision. Because approximately 800,000 cataract surgeries are performed annually in Japan, this finding is rather unexpected, suggesting the possibility that some people who would benefit from cataract surgery escaped the attention of ophthalmologists. Some elderly people may consider that low VA is a normal part of aging, as suggested in elderly Chinese in Taiwan persons, or may have difficulty keeping ophthalmology appointments. There also may be a regional imbalance between the rapid growth of the elderly population and the number of available ophthalmologic facilities.

Myopic macular degeneration was the third leading cause of bilateral low vision and the leading cause of monocular blindness in our Japanese participants. In diagnosing myopic macular degeneration, AMD was carefully excluded, and all eyes thought to have myopic macular degeneration as the cause of blindness or low vision were associated with high myopia (<−6.0 diopters [D] and averaging −15.4 D of spherical equivalent), tessellated fundus, myopic peripapillary atrophy, and diffuse or local chorioretinal atrophy, or both. The prevalence of myopia is higher in Japanese individuals. In fact, the percentage of eyes with a spherical equivalent of −5.0 D or less was approximately 8% in the current eyes of participants who had not undergone ocular surgeries, whereas that in the Blue Mountain Eye Study in Australia was approximately 2%. Further, the percentage of eyes with a spherical equivalent of −5.0 D or less tended to be higher in younger participants: 15.3% of those in the fifth decade of life, 7.7% in the sixth decade of life, 4.0% in the seventh decade of life, 1.3% in the eighth decade of life, and 2.0% in the ninth decade of life. A similar finding also was reported in a large study carried out in Japan, suggesting that the prevalence of myopia-induced low vision or blindness may be even higher in the future in this country. The relatively high prevalence of myopic macular degeneration as a major cause of low vision has been reported rarely in white persons, except that myopic macular degeneration was one of the major causes of low vision before age 75 years in the Rotterdam study. However, the current finding agrees with that reported for Chinese persons in developed countries, such as Taiwan or Hong-Kong, suggesting that there may be some ethnic or cultural factor, or both, responsible for the higher prevalence of high myopia and consequently myopic macular degeneration.

The prevalence of diabetes is relatively high in Japan. Diabetic retinopathy as a major cause of bilateral low vision according to the U.S. criteria may be compatible with the relatively high prevalence of the disease. However, diabetic retinopathy was not a major cause of bilateral or monocular blindness. A similar finding also was reported in other population-based studies and recent intensive control of hemoglobin A1c in patients with diabetes may be one of the reasons.

In the current study, only the BCVA and the central 30° of the visual field were measured, and no other components of visual function, such as contrast or glare sensitivity, stereacuity or peripheral visual field, or participant- assessed quality of vision, were evaluated. However, information on the prevalence of low vision, blindness, and causative eye diseases based on the BCVA is still important for facilitating adequate countermeasures to visual disability. The ocular diseases that cause bilateral blindness found in this population—except for Vogt-Koyanagi-Harada disease—that is, optic atrophy resulting from methyl alcohol intake, retinitis pigmentosa, and myopic macular degeneration, are difficult to treat. However, the leading cause of bilateral low vision, that is, cataract, is easily treated and results in great improvement in the quality of vision. Many ocular diseases that cause low vision, such as glaucoma, uveitis, diabetic retinopathy, or corneal opacity, also are treatable, suggesting that the prevalence of low vision may decrease in the future.

In summary, the age- and gender-adjusted prevalence rates of bilateral low vision and blindness in adult Japanese participants aged 40 years or older in Tajimi City, a typical suburb in central Japan, were 0.39% and 0.14%, respec-
tively, according to the WHO criteria, and the corresponding figures according to the U.S. criteria were 0.98% and 0.14%, respectively. Cataract was the leading cause of bilateral low vision followed by glaucoma, and myopic macular degeneration was the leading cause of monocular blindness followed by glaucoma.

References

Figure 1. A, Pie chart showing the distribution of causes of bilateral or monocular low vision (World Health Organization [WHO] criteria) in 76 eyes. B, Pie chart showing the distribution of causes of bilateral or monocular blindness (WHO criteria) in 49 eyes. AMD = age-related macular degeneration.

Figure 2. A, Pie chart showing the distribution of causes of bilateral or monocular low vision (United States criteria) in 107 eyes. B, Pie chart showing the distribution of causes of bilateral or monocular blindness (U.S. criteria) in 75 eyes. AMD = age-related macular degeneration.