Sight is an important indicator of health and quality of life. Individuals with impaired vision may be at increased risk of injuries and are more likely to curtail or stop driving. Visually impaired elderly persons are at increased risk of falls and fractures and depression. The most common reason for impaired vision may be refractive error, a condition usually correctable with eyeglasses or contact lenses.

Vision was assessed in the First National Health and Nutrition Examination Survey (NHANES I) and in the Hispanic Health and Nutrition Examination Survey. Since then, the US population has aged and become more racially and ethnically diverse and rates of myopia (nearsightedness) have increased worldwide. Accordingly, visual acuity assessment was reinstated as an NHANES component in 1999. We estimated the number of US individuals with impaired vision aged 12 years or older and the proportion of individuals who can achieve good distance vision with refractive correction.

METHODS

Data from NHANES 1999-2002 were used. NHANES is a nationally representative survey of the US civilian population, conducted on an ongoing basis by the National Center for Health Statistics, Centers for Disease Control and Prevention. Each year, approximately 7000 individuals are interviewed in their homes and are invited to undergo a comprehensive health examination in a mobile examination center (MEC), comprising functional assessments, collection of biological samples, and laboratory test results. Ethnicity is assessed in NHANES to provide estimates of health conditions within specific ethnic groups. The NHANES 1999-2002 protocol was reviewed and approved by the National Center for Health Statistics research ethics review board.

Context The prevalence of visual impairment in the US public has not been surveyed nationally in several decades.

Objective To estimate the number of US individuals aged 12 years or older who have impaired distance vision due to uncorrected refractive error.

Design, Setting, and Participants The National Health and Nutrition Examination Survey (NHANES), using a multistage probability sampling design, included a vision evaluation in a mobile examination center. Visual acuity data were obtained from 13,265 of 14,203 participants (93.4%) who visited the mobile examination center in 1999-2002. Visual impairment was defined as presenting distance visual acuity of 20/50 or worse in the better-seeing eye. Visual impairment due to uncorrected refractive error was defined as (presenting) visual impairment that improved, aided by automated refraction results, to 20/40 or better in the better-seeing eye.

Main Outcome Measures Presenting distance visual acuity (measured with usual corrective lenses, if any) and distance visual acuity after automated refraction.

Results Overall, 1,190 study participants had visual impairment (weighted prevalence, 6.4%; 95% confidence interval [CI], 6.0%-6.8%), and of these, 83.3% could achieve good visual acuity with correction (95% CI, 80.9%-85.8%). Extrapolating these findings to the general US population, approximately 14 million individuals aged 12 years or older have visual impairment (defined as distance visual acuity of 20/50 or worse), and of these, more than 11 million individuals could have their vision improved to 20/40 or better with refractive correction.

Conclusions Visual impairment due to uncorrected refractive error is a common condition in the United States. Providing appropriate refractive correction to those individuals whose vision can be improved is an important public health endeavor with implications for safety and quality of life.

JAMA. 2006;295:2158-2163

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tion were measured for each eye using the ARK-760 (Nidek Co Ltd, Tokyo, Japan), an autorefractor containing built-in visual acuity charts with 20/20, 20/25, 20/30, 20/40, 20/50, 20/60, 20/80, and 20/200 lines.

Presenting visual acuity was assessed using the participant’s usual distance vision correction, if any. The 20/50 line was presented first. At least 4 of the 5 characters (numbers, letters, or both) had to be read correctly to advance to the next line (with smaller characters). If the participant was unable to read the 20/50 line, the 20/200 line was presented. Participants were asked to read each line until they missed more than 1 character per line, for 2 lines in a row. Visual acuity was recorded as the last line for which 4 or more characters were read correctly. For eyes with presenting visual acuity of 20/30 or worse, visual acuity was also measured aided by the automated refraction result (corrected visual acuity). Simple (character recognition) literacy was required for visual acuity testing. Visual acuity was not tested in participants who were too cognitively or physically impaired to undertake the vision examination. The autorefractor was calibrated weekly.

Visual impairment was defined as presenting distance visual acuity of 20/50 or worse in the better-seeing eye. We defined visual impairment due to uncorrected refractive error as (presenting) visual impairment that improved, aided by the automated refraction results, to 20/40 or better in the better-seeing eye. Persons with missing presenting or corrected visual acuity for either eye were excluded from analyses (unless 1 eye had presenting visual acuity of 20/40 or better, in which case the participant was classified as not having visual impairment). Participants who did not bring their distance corrective lenses (eyeglasses or contact lenses) to the MEC were classified as not using distance correction.

SUDAAN version 9.0.0 (Research Triangle Institute, Research Triangle Park, NC) was used to compute weighted prevalence estimates accounting for the multistage probability sampling design and nonresponse to the MEC examination. Estimates were age-standardized to the US 2000 Census population.

RESULTS
A total of 15 193 individuals aged 12 years or older participated in NHANES 1999-2002. Of these participants, 14 203 (93.5%) reported to the MEC and 13 265 (93.4%) had complete visual acuity data (Figure). Those participants with incomplete visual acuity data were more likely to be older, black, poor, and have fewer years of education, and were less likely to have private health insurance compared with those with complete visual acuity data (Table 1).

Overall, 1190 NHANES participants presented with visual impairment (weighted prevalence, 6.4%; 95% confidence interval [CI], 6.0%-6.8%) (Table 2). Rates of visual impairment were highest among persons who were Hispanic or other (includes Asian or mixed race) ethnicity, were poor, had diabetes mellitus, lacked private health insurance, or had fewer years of education. The majority (83.3%; 95% CI, 80.9%-85.8%) of the 1190 persons with visual impairment could achieve good corrected visual acuity (20/40 or better in the better-seeing eye) using autorefractor correction. The prevalence of visual impairment due to uncorrected refractive error in the total NHANES population (n=13 265) was 5.3% (95% CI, 4.9%-5.7%).

Extrapolating the NHANES findings to the general US population, approximately 14 million persons aged 12 years or older would be projected to have visual impairment (Table 3). Of these individuals, more than 11 million could achieve good visual acuity with refractive correction. Of the estimated 2 million persons with presenting visual acuity of 20/200 or worse in the better-seeing eye, 1.4 million could achieve good vision with refractive correction.

COMMENT
National surveys, such as the NHANES, provide data to track the health status of the US population for public health planning and policy purposes. We estimated that 93.6% of individuals aged 12 years or older have good presenting visual acuity (20/40 or better in the better-seeing eye). Of the remaining 6.4% of persons with visual impairment, the vast majority, 83%, could achieve good visual acuity with refractive correction.

Our results are consistent with those of population-based studies con-
Table 1. Comparison of Characteristics of NHANES Participants With and Without Complete Visual Acuity Data

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Complete Visual Acuity Data (n = 13,265)</th>
<th>Incomplete Visual Acuity Data (n = 938)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Participants</td>
<td>Weighted % (SE)</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-19</td>
<td>4564</td>
<td>14.3 (0.4)</td>
</tr>
<tr>
<td>20-39</td>
<td>3200</td>
<td>34.4 (0.8)</td>
</tr>
<tr>
<td>40-59</td>
<td>2648</td>
<td>32.7 (0.8)</td>
</tr>
<tr>
<td>≥60</td>
<td>2853</td>
<td>18.6 (0.6)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>6656</td>
<td>51.5 (0.4)</td>
</tr>
<tr>
<td>Male</td>
<td>6409</td>
<td>48.5 (0.4)</td>
</tr>
<tr>
<td>Race/ethnicity†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>2939</td>
<td>10.8 (1.2)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4391</td>
<td>14.3 (2.0)</td>
</tr>
<tr>
<td>White</td>
<td>5459</td>
<td>70.0 (1.7)</td>
</tr>
<tr>
<td>Other</td>
<td>476</td>
<td>4.8 (0.6)</td>
</tr>
<tr>
<td>Education (aged ≥20 y)‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;High school</td>
<td>2628</td>
<td>21.2 (0.8)</td>
</tr>
<tr>
<td>High school</td>
<td>2030</td>
<td>25.8 (1.0)</td>
</tr>
<tr>
<td>Some college</td>
<td>3828</td>
<td>53.0 (1.3)</td>
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<tr>
<td>Income§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below poverty level</td>
<td>2706</td>
<td>15.1 (0.8)</td>
</tr>
<tr>
<td>At poverty level up to 2× poverty level</td>
<td>3125</td>
<td>21.1 (1.1)</td>
</tr>
<tr>
<td>2× poverty level or above</td>
<td>6136</td>
<td>63.8 (1.6)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>796</td>
<td>5.8 (0.3)</td>
</tr>
<tr>
<td>No</td>
<td>12,343</td>
<td>94.2 (0.3)</td>
</tr>
<tr>
<td>Health insurance</td>
<td></td>
<td></td>
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<tr>
<td>&lt;65 y</td>
<td></td>
<td></td>
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<tr>
<td>Uninsured</td>
<td>2738</td>
<td>19.2 (1.1)</td>
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<tr>
<td>Private (plus other coverage)</td>
<td>6486</td>
<td>70.6 (1.3)</td>
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<td>Medicaid (no private coverage)</td>
<td>1148</td>
<td>5.7 (0.5)</td>
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<tr>
<td>Medicare and/or other federal coverage</td>
<td>544</td>
<td>4.4 (0.4)</td>
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<tr>
<td>≥65 y</td>
<td></td>
<td></td>
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<tr>
<td>Uninsured</td>
<td>47</td>
<td>1.0 (0.2)</td>
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<tr>
<td>Private only</td>
<td>192</td>
<td>9.0 (1.1)</td>
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<tr>
<td>Private plus Medicare</td>
<td>855</td>
<td>46.8 (2.1)</td>
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<tr>
<td>Medicare and/or other federal coverage</td>
<td>898</td>
<td>40.8 (2.0)</td>
</tr>
<tr>
<td>Medicaid and/or other federal coverage</td>
<td>83</td>
<td>2.4 (0.5)</td>
</tr>
</tbody>
</table>

Abbreviations: MEC, mobile examination center; NA, not applicable; NHANES, National Health and Nutrition Examination Survey.

*Prevalence estimates (weighted %) are computed using the MEC examination weights to provide estimates for the total US population and are age-standardized to the US 2000 Census population.
†Other race includes Asian or mixed race.
‡Younger individuals may not have completed their formal education.
§Defined using poverty income ratio, which accounts for family size.
¶Defined as the better-seeing eye with usual correction.
‖Defined as the vision criterion used to determine eligibility for a driver’s license in most states, we are reluctant to call this normal vision.

We found that prevalence of visual impairment was higher in persons who were of black, Hispanic, or other ethnicity, or who were poor, less educated, or lacked private health insurance. Although these findings are not unexpected, they suggest that health care access and resources may be important barriers to consider in addressing the need for refractive correction of visual impairment.

Our analyses are subject to several limitations. The MEC vision examination was conducted by trained operators using standardized protocols under stringent quality control procedures. Nevertheless, visual acuity measured by an autorefractor is not equivalent to visual acuity assessed in a clinical ophthalmic setting (precluded by logistical constraints in NHANES). We are unaware of studies validating the visual acuity measured using autorefractor charts and are therefore unable to address the accuracy of the NHANES measurements. Although similar autorefractors have been shown to be valid and reliable, the automated refraction obtained in NHANES is not equivalent to a subjectively refined refraction. Our corrected visual acuity is therefore not comparable with best-corrected visual acuity used in other studies. Despite these methodological limitations, our estimates are similar to results from previous epidemiological studies of visual impairment due to refractive error.

Our results may be influenced by nonparticipation in the vision examination. We followed the NHANES...
### Table 2. Prevalence of Visual Impairment and Visual Impairment Due to Uncorrected Refractive Error

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No. of Participants in NHANES 1999-2002</th>
<th>Estimated Prevalence in US Population Based on All NHANES Participants With Visual Acuity Data, % (95% CI)</th>
<th>US Population With Visual Impairment Whose Impairment Is Due to Uncorrected Refractive Error, % (95% CI)§</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With Visual Acuity Data</td>
<td>With Visual Impairment</td>
<td>With Visual Impairment Due to Uncorrected Refractive Error</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13,265</td>
<td>1190</td>
<td>994</td>
</tr>
<tr>
<td><strong>Age, y</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-19</td>
<td>4564</td>
<td>530</td>
<td>493</td>
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<tr>
<td>20-39</td>
<td>3200</td>
<td>210</td>
<td>191</td>
</tr>
<tr>
<td>40-59</td>
<td>2648</td>
<td>135</td>
<td>123</td>
</tr>
<tr>
<td>60+</td>
<td>2853</td>
<td>315</td>
<td>187</td>
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<tr>
<td><strong>Sex</strong></td>
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<td></td>
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<tr>
<td>Female</td>
<td>6856</td>
<td>631</td>
<td>521</td>
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<tr>
<td>Male</td>
<td>6409</td>
<td>559</td>
<td>473</td>
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<td><strong>Race/ethnicity</strong></td>
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<tr>
<td>Black</td>
<td>2939</td>
<td>303</td>
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<td>Hispanic</td>
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<td>Other</td>
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<td>49</td>
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<tr>
<td><strong>Education (aged ≥20 y)</strong></td>
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<td>High school</td>
<td>3828</td>
<td>305</td>
<td>221</td>
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<tr>
<td>Some college</td>
<td>2030</td>
<td>158</td>
<td>118</td>
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<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below poverty level</td>
<td>2706</td>
<td>337</td>
<td>285</td>
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<tr>
<td>At poverty level up to 2x poverty level</td>
<td>3125</td>
<td>365</td>
<td>295</td>
</tr>
<tr>
<td>2x poverty level or above</td>
<td>6136</td>
<td>365</td>
<td>311</td>
</tr>
<tr>
<td><strong>Diabetes mellitus</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>796</td>
<td>99</td>
<td>60</td>
</tr>
<tr>
<td>No</td>
<td>12,343</td>
<td>1084</td>
<td>932</td>
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<td><strong>Health insurance</strong></td>
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<tr>
<td>&lt;65 y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uninsured</td>
<td>2738</td>
<td>282</td>
<td>251</td>
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<tr>
<td>Private (plus other coverage)</td>
<td>6486</td>
<td>397</td>
<td>374</td>
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<td>Medicaid (no private coverage)</td>
<td>1148</td>
<td>153</td>
<td>140</td>
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<tr>
<td>Medicare and/or other federal coverage</td>
<td>544</td>
<td>67</td>
<td>58</td>
</tr>
<tr>
<td>≥65 y</td>
<td></td>
<td></td>
<td></td>
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<td>Uninsured</td>
<td>47</td>
<td>13</td>
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<td>Private only</td>
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<td>Private plus Medicare</td>
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<tr>
<td>Medicare and/or other federal coverage</td>
<td>898</td>
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<td>66</td>
</tr>
<tr>
<td>Medicaid and/or other federal coverage</td>
<td>83</td>
<td>16</td>
<td>12</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; MEC, mobile examination center; NHANES, National Health and Nutrition Examination Survey.

*Prevalence estimates are computed using MEC examination weights to provide estimates for the total US population and are age-standardized to the US 2000 Census population.

Some subgroup numbers with visual acuity data do not total to 13,265 due to missing data on income, diabetes mellitus, or health insurance. Individuals younger than 20 years were excluded from the education subgroups, resulting in a smaller total for the education category. Visual impairment is defined as presenting visual acuity 20/50 or worse in the better-seeing eye with usual correction. Visual impairment due to uncorrected refractive error is defined as having both presenting visual acuity 20/50 or worse in the better-seeing eye with usual correction and visual acuity of 20/40 or better using automated refraction results. See Table 1 for definitions of characteristics.

†Based on number of participants with visual impairment divided by number of participants with visual acuity data.
‡Based on number of participants with visual impairment due to uncorrected refractive error divided by number of participants with visual acuity data.
§Based on number of participants with visual impairment due to uncorrected refractive error divided by number of participants with visual impairment.
analytic guidelines to adjust for non-response (to the MEC examination) by using sampling weights. However, our results indicate that persons without visual acuity data were more likely to be poor, less educated, and of nonwhite ethnicity. These characteristics were also associated with higher rates of visual impairment in our sample; therefore, prevalence of visual impairment may be underestimated in our study.

We elected to include in our analysis the 765 persons (5.8% of the total sample) who informed NHANES personnel they had refractive correction for distance but forgot to bring their lenses to the MEC; 29% of these persons were found to need refractive correction to have visual acuity of 20/40 or better. If these individuals were excluded, prevalence of visual impairment would decrease to 5.1% (vs 6.4%) and prevalence of visual impairment due to refractive error would decrease to 4.1% (vs 5.3%). Although we think it is appropriate to include these individuals in estimates of visual impairment based on presenting visual acuity, their inclusion may result in an overestimate of the prevalence of visual impairment due to refractive error.

In conclusion, the results of this study suggest that approximately 14 million individuals aged 12 years or older were estimated to be visually impaired. More than 11 million of these individuals could attain visual acuity good enough to qualify them for a driver’s license in most states with refractive correction. The provision of corrective lenses to those individuals in need will be an important public health endeavor with implications for safety and quality of life.

**Author Contributions:** Dr Vitale had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Vitale, Cotch, Sperduto. Acquisition of data: Vitale, Cotch. Analysis and interpretation of data: Vitale, Cotch, Sperduto. Drafting of the manuscript: Vitale, Cotch. Critical revision of the manuscript for important intellectual content: Vitale, Cotch, Sperduto. Statistical analysis: Vitale. Obtained funding: Cotch, Sperduto. Administrative, technical, or material support: Cotch, Sperduto.

**Financial Disclosures:** None reported. Funding/Support: This study was supported by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention. Additional funding for the National Health and Nutrition Examination Survey (NHANES) Vision Component was provided by Intramural Research Program grant Z01-EY000402 from the National Eye Institute, National Institutes of Health. The NCHS has contracted with Westat Inc to conduct the field operations and data collection for NHANES.

### Table 3. Total Projected Number of US Individuals (≥12 Years) Who Are Visually Impaired and Need Refractive Correction to Achieve Good Vision*

<table>
<thead>
<tr>
<th>Presenting Visual Acuity†</th>
<th>Projected No. (in Thousands) of US Population With This Level of Visual Impairment</th>
<th>US Population Who Can Be Corrected to Good Vision, % (95% CI)‡</th>
<th>Estimated No. (in Thousands) of US Population Who Need Refractive Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate visual impairment (20/50-20/80)</td>
<td>11,910</td>
<td>85.26 (82.28-88.24)</td>
<td>10,154</td>
</tr>
<tr>
<td>Severe visual impairment (20/200 or worse)</td>
<td>1982</td>
<td>71.76 (61.84-81.69)</td>
<td>1422</td>
</tr>
<tr>
<td>Total</td>
<td>13,892</td>
<td>83.33 (80.87-85.79)</td>
<td>11,576</td>
</tr>
</tbody>
</table>

*Estimated No. (in Thousands) of US Population Who Need Refractive Correction

**REFERENCES**


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