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Vision Impairment and Blindness Prevalence in the United States:

Variability of Vision Health Responses across Multiple National Surveys

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Abstract

Purpose: To support survey validation efforts by comparing prevalence rates of self-reported and examination evaluated presenting visual impairment (VI) and blindness measured across national surveys.

Design: Cross-sectional comparison.

Participants: Participants in the 2016 American Community Survey, the 2016 Behavioral Risk Factor Surveillance System, the 2016 National Health Interview Survey, the 2005–2008 National Health and Nutrition Examination Survey (NHANES), and the 2016 National Survey of Children's Health.

Methods: We estimated VI and blindness prevalence rates and confidence intervals for each survey measure and age group using the Clopper-Pearson method. We used inverse variance weighting to estimate the central tendency across measures by age-group, fitted trend lines to age-group estimates, and used the trend-line equations to estimate the number of United States persons with VI and blindness in 2016. We compared self-report estimates with those from NHANES physical evaluations of presenting VI and blindness.

Main Outcome Measures: Variability of prevalence estimates of VI and blindness.

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Conception and design: Rein, Lamuda, Wittenborn, Swenor, Saaddine, Lundeen
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HUMAN SUBJECTS: No human subjects were included in this study. The requirement for informed consent was waived by NORC Institutional Review Board because of the retrospective nature of the study.
No animal subjects were included in this study.

Results: Self-report estimates of blindness varied between 0.1% and 5.6% for those younger than 65 years and from 0.6% to 16.6% for those 65 or older. Estimates of VI varied between 1.6% and 24.8% for those younger than 65 years and between 2.2% and 26.6% for those 65 years or older. For summarized survey results and NHANES physical evaluation, prevalence rates for VI increased significantly with increasing age group. Blindness prevalence increased significantly with increasing age group for summarized survey responses but not for NHANES physical examination. Based on extrapolations of NHANES physical examination data to all ages, we estimated that in 2016, 23.4 million persons in the United States (7.2%) had VI or blindness, an evaluated presenting visual acuity of 20/40 or worse in the better-seeing eye before correction. Based on weighted self-reported surveys, we estimated that 24.8 million persons (7.7%) had presenting VI or blindness.

Conclusions: Prevalence rates of VI and blindness obtained from national survey measures varied widely across surveys and age groups. Additional research is needed to validate the ability of survey self-report measures of VI and blindness to replicate results obtained through examination by an eye health professional.

Keywords

vision; vision impairment; blindness; presenting visual acuity; self-reported vision problems; low vision; prevalence; survey; NHANES; NHIS; BRFSS; ACS; NSCH

This article demonstrates the high variability of existing vision-related responses to survey item responses with the intent of providing motivation for future survey validation and harmonization efforts on eye and vision health measures. The 2016 National Academies of Science, Engineering, and Medicine's report, "Making Eye Health a Population Health Imperative: Vision for Tomorrow," calls for a national eye and vision health surveillance system to understand trends, risk factors, comorbidities, and costs associated with vision loss.[1] To support surveillance, national survey data have been analyzed to provide information on the prevalence of both self-reported and examination-based visual impairment (VI) and blindness. For example, Ryskulova et al[2] analyzed data from the 2002 National Health Interview Survey (NHIS) and reported that an estimated 9.3% of noninstitutionalized United States adults self-reported VI and 0.3% were blind. Crews et al[3] analyzed NHIS data collected from 2010 through 2014 to estimate the association between VI and 13 chronic conditions among United States adults 65 years of age and older, reporting a prevalence of self-reported VI and blindness of 13.6%.

Similarly, several researchers have analyzed data from the National Health and Nutrition Examination Survey (NHANES) to estimate self-reported and physical examination-determined prevalence of VI and blindness. Zebardast et al[4] used the NHANES examination data to estimate the relationship between sociodemographic factors and presenting near VI, defined as presenting near vision worse than 20/40 (could not see lines 4 and 5 on the near vision card), and functional near VI, defined as having at least moderate difficulty with reading a newspaper or doing work up close. Using data from 1999 through 2008, they estimated that 13.6% of adults 50 years of age and older had presenting near VI and 12.3% had functional near VI. Vitale et al[5] also used NHANES data (1999–2002) to estimate the prevalence of VI among United States civilians 12 years of age and older. Based on a VI

definition of presenting distance visual acuity of 20/50 or worse in the better-seeing eye, they estimated that 6.4% of the United States population 12 years of age and older have VI but that as much as 80% of this impairment could be corrected with proper refraction. Ko et al[6] used NHANES examination data collected between 2005 and 2008 to estimate a prevalence of VI and blindness (visual acuity worse than 20/40 in the better-seeing eye after correction) of 1.7%. Similarly, Swenor et al[7] used NHANES to examine VI and estimated that 5.31 million Americans 20 years of age and older had uncorrectable VI (a visual acuity after autorefraction worse than 20/40 in the better-seeing eye), equivalent to a prevalence of 1.78%.

Before the National Academies of Science, Engineering, and Medicine report, an expert panel on vision surveillance convened by the Centers for Disease Control and Prevention (CDC) concluded that national survey data on VI and blindness were an essential component of any future vision surveillance system. However, the panel also noted that consensus was lacking on which survey measures best identified VI and blindness and that additional analyses were needed to compare results across surveys, by question wording and method of collection.[8,9]

For example, the American Community Survey (ACS)[10] and the Behavioral Risk Factor Surveillance System (BRFSS)[11] both ask, “Is this person blind or does he/she have serious difficulty seeing even when wearing glasses?” However, the NHANES Vision Questionnaire asks the respondent to self-report, “Are you/Is survey participant blind in both eyes?” and additional functional questions in some years.[12] The NHANES also includes a physical examination evaluation of visual acuity both before and after autorefraction correction. The NHIS asks the sample adult, “Are you blind or unable to see at all?”[13] Both the NHANES and NHIS include self-report questions related to functional outcomes of vision, often using scaled responses, with minor differences in wording across surveys. To address this variability, the CDC expert panel suggested systematically comparing survey questions as part of developing future surveillance systems.[8] In this article, we compare survey responses across surveys using consistent analytic methods and present prevalence estimates for similar age groups to demonstrate the high variability that these questions generate. Future work is needed to develop questions that result in lower variability.

Methods

Based on input from clinical experts, we analyzed all measures that could beused to estimate the prevalence of VI and blindness from the ACS, BRFSS, NHANES, NHIS, and the National Survey of Children’s Health (NSCH). The requirement for informed consent was waived by the NORC Institutional Review Board because of the retrospective nature of the study. These surveys were selected because they capture the most commonly used survey indicators and offer some of the largest sample sizes among federally funded, nationally representative surveys. Each of the surveys captures measures of “severe difficulty seeing even with glasses,” which we use as a measure of blindness, and NHANES and NHIS capture additional questions with scaled severity measures that we used to measure VI. Results for some of the measures we analyzed are also available publicly on the CDC’s Vision and Eye Health Surveillance Sys-tem.[14] We report the survey and questions analyzed,

the years of data collection, and whether we categorized a response as related to VI or blindness (Table 1; each question is given a label, such as NHIS-1, to indicate survey source and researcher-assigned question number if the survey included more than one vision indicator, for subsequent use in the text). Estimates for ACS, BRFSS, NHIS, and NSCH were generated using the 2016 survey data, and sampling weights were used to obtain national estimates. To increase the sample size of NHANES, we pooled data from 2 waves of data collection (2005–2006 and 2007–2008, the years when vision data were collected) and adjusted the sampling weights to account for multiple years. The NHIS survey fielded a vision supplement in 2016 that was administered to sample adults and is the source for 6 of the 9 NHIS questions reported (Table 1). The NHANES did not include any visual acuity measures after 2008. Although the NHANES data are older than those of other sources, we believe that they are likely comparable because endorsement of the ACS vision measure did not change substantially between 2008 and 2016: 2.4% of ACS respondents reported “being blind or having serious difficulty seeing even when wearing glasses” in 2008, compared with 2.3% in 2012 and 2.5% in 2016.[15]

For binary response questions, we defined the prevalence rate as the number of persons who gave an affirmative response divided by the total number of respondents then multiplied by 100 to obtain a percentage. For scaled responses in the NHANES and NHIS (for example, in the NHIS, not at all difficult, some difficulty, a little difficult, somewhat difficult, and can’t do at all because of eyesight) participants were classified as being blind if the respondent selected the 2 highest-scaled response options, classified as being visually impaired but not blind if they selected the next 2 response options, and classified as being unimpaired if they selected no problems. For evaluated vision measures in the NHANES, respondents were classified as visually impaired if their physical examination presenting visual acuity (collected among persons 20 years of age or older) was between 20/40 and 20/200 in the better-seeing eye and were classified as blind if the visual acuity in the better-seeing eye was 20/200 or worse. The NHANES respondents were also considered blind for physical examination and self-reported items if they responded affirmatively to an initial question asking if they could not see at all, which resulted in the survey skipping all subsequent visual acuity and visual function tests.

We estimated the prevalence rate, standard error, and upper and lower confidence intervals for each rate using the Clopper-Pearson method, as recommended by CDC’s National Center for Health Statistics for calculating proportions.[16] Weights and variance estimation variables were used in accordance with each survey’s technical documentation. Estimates were calculated using the SAS SURVEYFREQ procedure (SAS software version 9.4., SAS Institute, Inc, Cary, NC) for each of the following age categories: 0 to 17 years of age, 18 to 39 years of age, 40 to 64 years of age, 65 to 84 years of age, and 85 years of age or older. If applicable, estimates with a relative standard error of more than 25% were suppressed.

To explore the central tendency across all survey responses, we calculated the inverse variance weighted mean prevalence rate (IVWMPR) for VI and blindness for each age group using self-reported responses from the 5 surveys, creating separate estimates for VI and blindness. This provides a weighted mean prevalence of VI and blindness observed across

all surveys. We report estimates in tabular form and visually present them using scatterplots by survey-weighted average age within each of the 5 age groups.

We estimated trend lines to fit the IVWMPR and the NHANES physical evaluation of presenting visual acuity rates as a function of population weighted mean age across the included survey measures or the participants in NHANES; tested the linear, second-order polynomial, logarithmic, and exponential functions for best fit as determined by the highest coefficient of determination (R^2); and estimated the statistical significance of the function using an F test. We used these functions to estimate the prevalence rate of VI and blindness at each year of age between 0 and 100 years and multiplied these estimated prevalence rates by United States Census 2016 population estimates to calculate the total number of persons with VI and blindness in the United States, first as estimated using the IVWMPR of survey self-reports and second as estimated using the NHANES-evaluated presenting visual acuity.

Results

Blindness

Nineteen variables across the 5 surveys measured blindness. Of these, 18 were self-report and 1 (NHANES-8) was evaluation based. The prevalence of blindness trended upward with age, with the highest prevalence rates among those 85 years of age and older (Table 2). Blindness estimates varied between 0.2% and 1.6% for ages 0 to 17 years, between 0.1% and 2.6% for ages 18 to 39 years, between 0.3% and 5.6% for ages 40 to 64 years, between 4 0.6% and 5.6% for ages 65 to 84 years, and between 1.7% and 16.6% for ages 85 years and older. The NHIS question from the sample adult and sample child files—Are you/Is child blind or unable to see at all?—showed the smallest estimated prevalence rate for 4 of the 5 age categories and the second lowest in the remaining age category (18–39 years). The highest estimates of blindness in each of the 5 age categories came from 5 different questions.

The IVWMPR of blindness self-report measures were 0.7% at 8.6 years of age (the mean age of the age bin across the included survey measures), 0.9% at 28.5 years of age, 2.4% at 51.4 years of age, 4.2% at 75.4 years of age, and 12.5% at 88.8 years of age. The physical examination prevalence of presenting blindness (NHANES-8) was 1.1% at 28.6 years of age (the population-weighted mean age across the participantsevaluatedper agebin),0.3%at50.4years ofage,0.8% at 71.3 years of age, and 5.4% at 83.5 years of age (Table 2; Fig 1).

The exponential function provided the best fit for the trend lines for both the IVWMPR and the NHANES-evaluated prevalence rate of blindness. The estimated age trend describing the IVWMPR of blindness was $0.4344 \times e^{0.0342 \times \text{age}}$ ($F = 14.3$; $P < 0.05$), and the estimated age trend describing the NHANES-evaluated prevalence rate of presenting blindness was $0.235 \times e^{0.0265 \times \text{age}}$ ($F = 0.82$; $P = 0.44$). These functions resulted in R^2 values of 0.94 for weighted survey blindness and 0.29 for NHANES-evaluated. When extrapolated to the United States population 0 to 100 years of age, these trend lines predict that 7.2 million Americans would self-report blindness based on survey responses and that 2.5 million would have presenting blindness based on NHANES evaluation.

Visual Impairment

Sixteen variables across 2 surveys (NHANES and NHIS) measured VI. One (NHANES-9) was a physical examination result; the remainder were self-report with only 1 that measured VI in persons 0 to 17 years of age (NHIS-9). Estimates of VI generally increased with age group (Table 3). The only survey estimate available for 0 to 17 years of age (NHIS-9) was 3.1%. For 18 to 39 years of age, estimates ranged between 1.6% and 9.5%; for 40 to 64 years of age, estimates ranged from 2.8% to 24.8%; for 65 to 84 years of age, estimates ranged from 2.2% to 21.7%; and for 85 years of age and older (NHANES is top coded at 85 years), estimates ranged from 3.0% to 26.6%. Questions about whether vision created problems driving (NHANES-7 and NHIS-7) resulted in the lowest estimate in each of the 4 age categories in which they were measured. Questions asking whether vision created problems reading newsprint (NHANES-2 and NHIS-4) resulted in the highest estimates in each of the same 4 age categories.

The IVWMPR of VI (excluding NHANES-9, presenting visual acuity) were 3.1% at 8.6 years of age, 3.6% at 28.8 years of age, 6.6% at 51.3 years of age, 8.6% at 75.5 years of age, and 15.0% at 88.8 years of age. Evaluated presenting visual acuity prevalence rates from NHANES-9 were 7.8% at 28.6 years of age, 6.8% at 50.4 years of age, 12.5% at 71.3 years of age, and 25.9% at 83.5 years of age (Table 3; Fig 2). Self-reported measures resulted in higher rates of blindness and lower rates of VI as compared with physical examinations from NHANES.

The exponential function also provided the best fit for the trend lines for both the IVWMPR and the NHANES-evaluated prevalence rates of VI. The estimated age trend that described IVWMPR of VI was $2.3681 \times e^{0.0191 \times \text{age}}$ ($F = 41.70$; $P < 0.01$),andtheestimatedagetrend that described the NHANES-evaluated prevalence rate of presenting VI was $3.26 \times e^{0.021 \times \text{age}}$ ($F = 5.56$; $P < 0.10$), resulting in R^2 of 0.95 for weighted survey VI and 0.73 for NHANES-evaluated VI (Fig 2). Extrapolating this trend line to all ages 0 to 100 years resulted in an estimate of 17.6 million persons with self-reported VI based on survey responses and 20.8 million persons with presenting VI based on NHANES evaluation.

Combined Blindness and Visual Impairment Measures

Summing the estimated number of blind and visually impaired persons predicted by each trend line at each age results in a 2016 population prevalence of any VI or blindness of 24.8 million persons based on the IVWMPR of all self-reported responses and of 23.4 million persons based on NHANES evaluations; this equates to a population prevalence rate of 7.7% based on mean survey responses and 7.2% based on NHANES physical examination.

Discussion

Estimates of self-reported and evaluation-based blindness, VI, or both in 5 federally funded, nationally representative surveys varied widely but generally increased with participant age group. Across surveys, responses varied significantly even among questions with similar wording. Within the same survey response, the confidence intervals for blindness often

overlapped between age groups, whereas significant differences between adjacent age groups were observed more commonly for self-reported survey VI rates.

Prevalence rates measured across surveys using the IVWMPR resulted in more stable and predictable estimates. When prevalence rates were summarized for each age group using the IVWMPR across the self-reported measures, prevalence increased with age exponentially in a statistically significant pattern for both blindness and VI, indicating that individual survey measures are likely measuring a consistent signal related to visual functionality. The NHANES-evaluated measure of presenting blindness and VI also increased exponentially with age. However, this effect was statistically insignificant for blindness and significant only at the 10% level for VI, indicating that these age trends may be artifacts of the sample. The NHANES-evaluated prevalence rate for presenting blindness was lower for groups 40 to 64 years of age and 65 to 85 years of age than the rate for those 18 to 39 years of age. This counterintuitive result was also previously observed using earlier waves of NHANES data.[17] Speculatively, this result could be driven by factors including health services use or early mortality among young persons with blindness, but it does not yet have an adequate explanation.

Applying our estimated equations to the United States population 0 to 100 years of age resulted in a prevalence of any impairment (an evaluated visual acuity of 20/40 or worse in the better-seeing eye before correction or a self-report of any visual problems) of 23.4 million persons based on NHANES evaluations and 24.8 million persons based on the IVWMPR of all self-reported responses, which corresponds to a population prevalence of 7.2% based on NHANES evaluations or 7.7% based on mean survey responses. Vitale et al[5] estimated a population prevalence of presenting VI of 6.4% among persons 12 years of age and older based on a more restrictive definition of impairment of 20/50 or worse in the better-seeing-eye and estimated a total population prevalence of 14.1 million persons with impairment of those 12 years of age and older. When restricting our analyses to those 12 years of age and older, in 2016, we estimate that 21.5 million persons (7.8%) had a presenting visual acuity of 20/40 or worse in the better-seeing eye based on NHANES data and that 23.2 million persons (8.4%) would report some degree of visual problems on self-reported measures. Differences in the threshold for VI, changes in population size, race and ethnicity composition, age distribution, and our use of more recent data may account for the differences between the estimates.

Some commonalities across surveys were found with regard to the wording and phrasing of the questions. The ACS, NHIS-1, and BRFSS questions are similarly worded and ask whether the participant is blind. After asking if the participant is blind, the NHIS-1 adds “or unable to see at all,” whereas the ACS and the BRFSS questions ask if the respondent has “serious difficulty seeing, even when wearing glasses?” The NSCH survey asks a similar question: “Does child have blindness or problems with seeing, even when wearing glasses?” These questions ask about severe visual disorders but do not allow clinically defined blindness to be distinguished from severe VI. Although the questions were worded similarly, they resulted in substantially different prevalence rates. In all age categories in which they were measured commonly, the NHIS-1 measure resulted in the lowest prevalence rate, the BRFSS resulted in the highest, and the ACS results were in the middle of those 2 rates;

however, age groups from the BRFSS could not be compared directly with those age 65 and older from other surveys. In the youngest age group, the ACS resulted in a prevalence estimate that was approximately half that of the NSCH. The NHANES does not include this question.

In interpreting the varied results to this similar question, it is instructive to consider differences in the data collection procedures and response rates across these 4 surveys. When adults are sampled in the NHIS and BRFSS, the respondents are asked to respond for themselves, whereas the ACS asks about the household member who is sometimes the survey respondent, and the NHIS (for sample children) and NSCH are administered to the parent or guardian of the child. The ACS is administered via multiple methods (interview, mail, phone, and in-person visits), its sampling frame includes group quarters such as nursing homes, and it achieved a response rate of 94.7% in 2016 because Americans are legally required to participate.[18] The BRFSS was administered via landline and cell phone, excluded grouped-quartered residents, and achieved a response rate of approximately 47% in 2016.[19] The NHIS survey uses an in-person household interview to represent the civilian noninstitutionalized United States population and reported a 54.3% and 61.9% response rate in 2016 sample adults and sample children, respectively.[20] Finally, the NSCH is administered via web survey, paper, and follow-up telephone call; does not include group-quartered children; and achieved a response rate of 40.7% in 2016.[21] In terms of sample size, the ACS was fielded with approximately 5 times the number of respondents as the BRFSS, the next largest survey. Based on these characteristics, the ACS measure seems to be the best available source for measuring responses to this question, given its greater number of data collection methods, inclusion of group-quartered persons, high response rate, and large sample size, although the household proxy response structure is a limitation.

The NHANES (NHANES-2 to -7) and NHIS (NHIS-3 to -8) also ask a series of similar questions about eye health in relation to performing functional activities. On both surveys, for most age groups, the question that asked about whether a respondent’s vision created difficulties in reading newsprint resulted in the highest estimates of VI, and those that asked about whether vision created problems with daytime driving resulted in the lowest estimates of VI. These results may be explained in part by the high prevalence of age-related presbyopia, which results in hyperopia without corrective lenses, or by a reluctance to admit to yourself or others that vision affects one’s driving.[22]

Self-reported outcomes may not be able to detect adequately differences between VI and blindness. However, when evaluated together, these measures may be able to adequately capture the envelope of cumulative VI and blindness. After testing multiple decision rules regarding the categorization of self-report scale measures into categories of VI and blindness, we adopted a rule that assigned the top 2 most severe responses to blindness and the next 2 most severe responses to VI. Using this scoring system, when comparing the IVWMPR of self-response items to the NHANES-evaluated measure of presenting visual acuity, we found that the survey responses resulted in a higher prevalence rate of blindness and lower prevalence rate of VI. However, we also found that the combined prevalence rate of self-reported VI and blindness was very similar to that found by the NHANES evaluation of presenting visual acuity for the 3 oldest age categories. The low prevalence of blindness

and qualitative wording of many survey questions may complicate the ability of surveys to differentiate reliably between VI and blindness. In the ACS, the survey with the largest sample size and highest response rates, approximately 7.75 million persons in the United States population self-reported being blind or having serious difficulty seeing even with glasses, a prevalence of 2.4%. Although we interpreted this estimate as indicating blindness, it may be a more accurate estimate of individuals with severe VI or blindness as defined by clinical evaluation.

This study is limited by at least the following factors. First, the survey items themselves measure subjective assessments of vision-related concepts that are poorly defined, likely driving the high variability in responses. For example, the ACS, BRFSS, NHIS, and National Center for Health Statistics all ask a version of the question “Is the respondent blind or have serious difficulty seeing, even when wearing glasses?” This question requires each respondent to internally define “serious difficulty seeing” and then apply that definition to themselves over a range of possible life situations. The NHIS item results in the lowest estimated prevalence, suggesting that the inclusion of the anchoring clause “or unable to see at all” reduces the proportion of persons who subjectively assess that they have serious difficulty seeing. The high variability in responses across these surveys indicates that differences in sample inclusion, method of administration, and variations in wording are likely influencing responses. Additional resources devoted to developing and psychometrically testing vision health indicators are needed to develop more reliable survey measures.

Second, although we attempted to evaluate similar VI and blindness measures across surveys, these measures were not administered among the same respondents. We do not know whether persons classified as having VI or blindness based on one survey measure would have answered in a concordant way had they been asked another form of the measure on a different survey and therefore cannot definitively determine if differences were driven by question wording, sampling variation, or differences in collection methodology. Potentially, future studies could attempt to address this issue by fielding all survey measures to all respondents, but randomizing the order in which the questions appear, and then comparing these responses with those obtained through clinical eye examinations.

Third, because we view this as an initial analysis intended to assess and compare possible measures of VI, we included all possible indicators of VI in our evaluation. Some measures, such as difficulty driving or reading, may be capturing respondent characteristics other than VI, and estimates generated from the IVWMPR would be different if only selected measures were included in the analysis.

Fourth, we used data collected from the NHANES between 2005 and 2008 but used data from 2016 for the ACS, BRFSS, NHIS, and NSCH. The NHANES visual data have not been collected since 2008, and considerable need exists for new NHANES data collection of the same measures. We chose to use 2016 data for other data sources to provide more recent data available to readers and because NHIS redeployed scaled responses (allowing for differentiation between VI and blindness) in 2016 (Appendix, available at www.aaojournal.org for NHIS details). However, because of this limitation, we are unable to

say whether differences between NHANES measures and other measures are related in part to noneage-related changes that may have occurred between the data collection period of the NHANES and that of the other surveys. However, results from published studies using earlier years of the NHIS suggest that differences between the NHIS and NHANES measurements were present in earlier years of analysis as well.[2,3] Additionally, evaluations of the ACS measure do not reveal changes in the prevalence of that measure over time.

In conclusion, questions measuring VI and blindness are fielded with regularity across federal, population-representative surveys, but they result in widely differing prevalence rates. After averaging multiple questions from multiple surveys by their inverse variance, the mean of the self-reported measures provided similar estimates of combined VI and blindness as the NHANES evaluation of presenting visual acuity, at least for individuals 50 years of age and older. At a national level, the ACS measures of blindness and low vision seem to be the best available current measures of severe vision loss based on its large sample size, high response rate, and ability to produce state-level estimates. This measure may prove especially valuable in the near future to evaluate the potential mortality impact of the SARS-CoV-2 pandemic on persons with self-reported vision loss.

No self-reported measure seems adequate to differentiate between VI and blindness, and the ACS measure may underestimate the prevalence of less severe stages of VI because of its wording and lack of a scaled response. Additional research using data collected for this study will evaluate the impact of survey question attributes on the variability of survey responses. Additional research is currently underway to test the validity of the self-reported measures included in this study as compared with visual acuity evaluations conducted by eye health professionals and to compare the validity of these measures with each other and with more defined and longer-form questions. The high variability of survey responses demonstrated in this manuscript highlights the importance of developing new questions with greater reliability and validity and less sensitivity to method of administration. Any newly proposed questions to measure self-reported vision loss should be demonstrated empirically to be superior to existing questions as compared with a gold standard, as well as parsimonious enough to be included in national United States health surveys.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations and Acronyms

ACS	American Community Survey
BRFSS	Behavioral Risk Factor Surveillance System

CDC	Centers for Disease Control and Prevention
IVWMPR	inverse variance weighted mean prevalence rate
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NSCH	National Survey of Children's Health
VI	visual impairment

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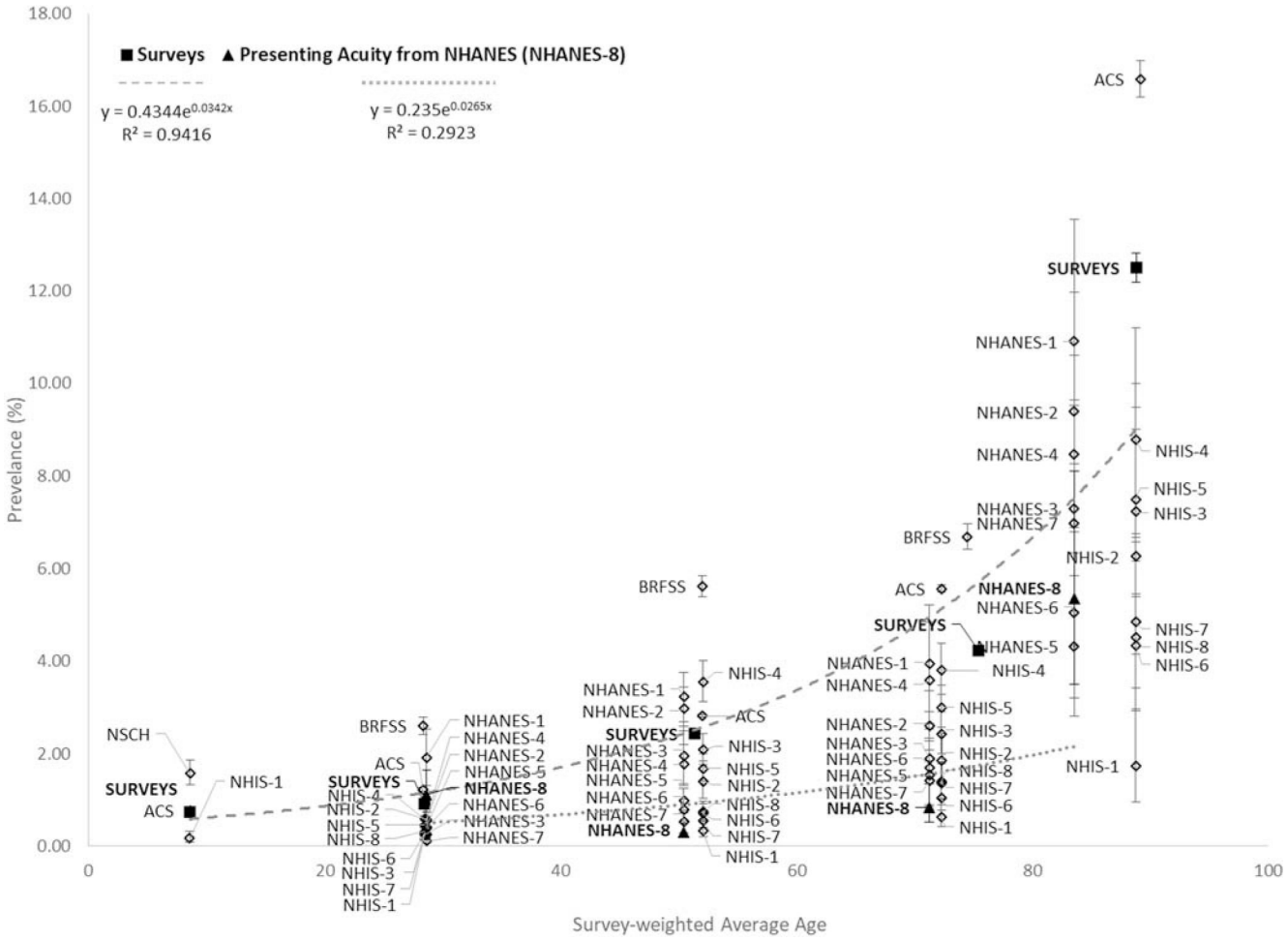

Figure 1.

Graph showing blindness prevalence as measured by each national survey measure plotted by survey-weighted average age and a weighted prevalence using inverse weighting across self-report questions (SURVEYS). Average age from American Fact Finder Census data was used to plot Behavioral Risk Factor Surveillance System (BRFSS) data. Two trend lines—SURVEYS and presenting acuity from the National Health and Nutrition Examination Survey (NHANES)—were fitted to the weighted prevalence of self-report questions and physical evaluation of presenting visual acuity in the better-seeing eye of 20/200 or worse. ACS = American Community Survey; NHIS = National Health Interview Survey; NSCH = National Survey of Children's Health.

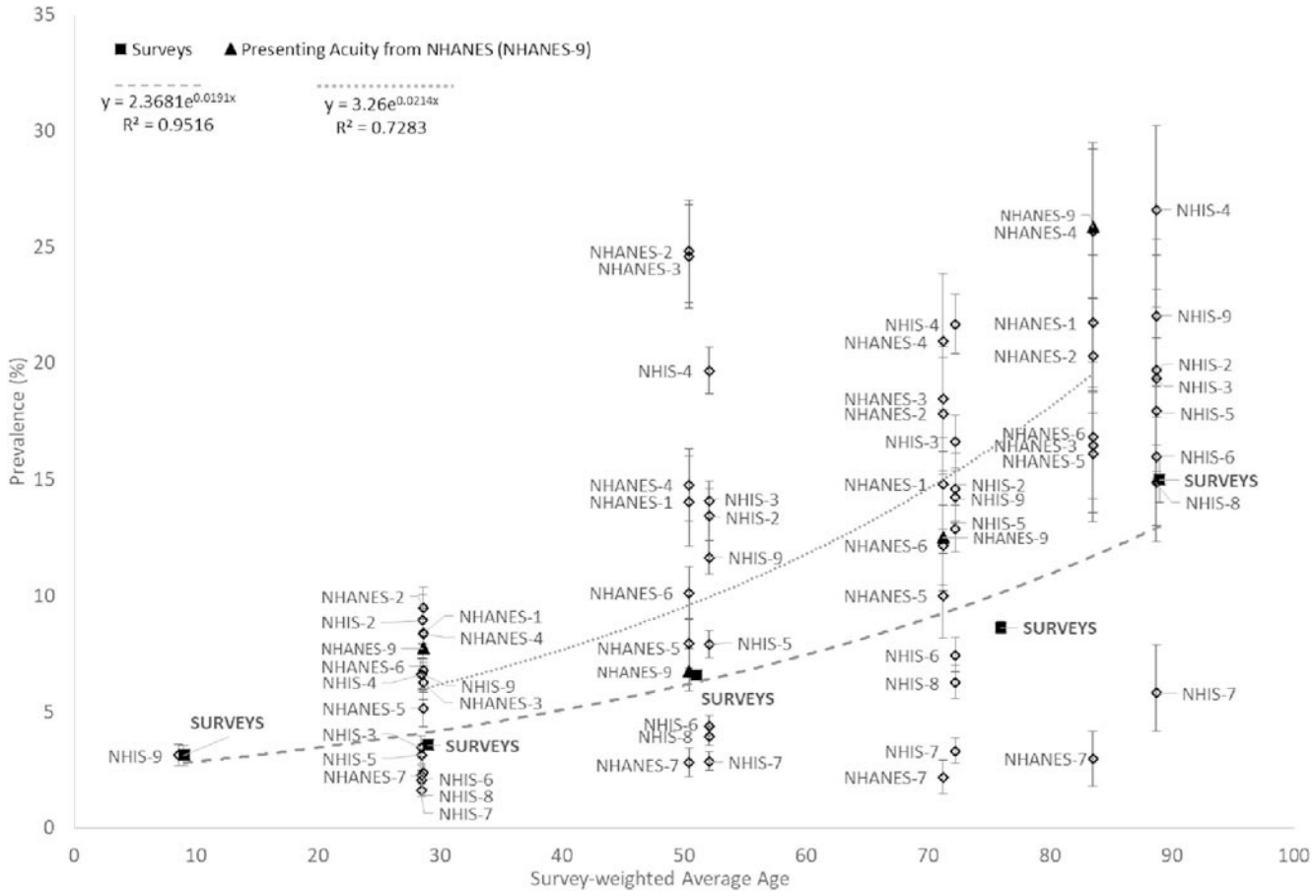

Figure 2.

Graph showing vision impairment prevalence as measured by each national survey measure plotted by survey-weighted average age and a weighted prevalence using inverse weighting across self-report questions (SURVEYS). Two trend lines—SURVEYS and presenting acuity from the National Health and Nutrition Examination Survey (NHANES)—were fitted to the weighted prevalence of self-report questions and physical evaluation of presenting visual acuity between 20/40 and 20/200 in the better-seeing eye. NHIS — National Health Interview Survey.

Table 1.

Selected Federally Funded Surveys Used in the Analysis to Assess Blindness and Vision Impairment

Survey	Year(s)	Sample Size*	Blindness	Vision Impairment	Question Identification	Question (Response of Interest)
ACS	2016	2 522 359	✓		ACS	Is this person blind or does he/she have serious difficulty seeing even when wearing glasses? (yes)
BRFSS	2016	486 303	✓		BRFSS	Are you blind or do you have serious difficulty seeing, even when wearing glasses? (yes)
NHANES	2005–2008	Approximately 5000/yr	✓	✓	NHANES-1	Next I have general questions about [your/SP's] vision. At the present time, would you say your eyesight, with glasses or contact lenses if you wear them, is excellent, good, fair, poor, or very poor? (blindness = very poor and poor; visual impairment = fair)
			✓	✓	NHANES-2	How much difficulty do you have reading ordinary print in newspapers? (blindness = unable to do because of eyesight and extreme difficulty; visual impairment = moderate difficulty and a little difficulty)
			✓	✓	NHANES-3	How much difficulty do you have doing work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house, or using hand tools? (blindness = unable to do because of eyesight and extreme difficulty; visual impairment = moderate difficulty and a little difficulty)
			✓	✓	NHANES-4	How much difficulty do you have going down steps, stairs, or curbs in dim light or at night? (blindness = unable to do because of eyesight and extreme difficulty; visual impairment = moderate difficulty and a little difficulty)
			✓	✓	NHANES-5	How much difficulty do you have noticing objects off to the side while you are walking? (blindness = unable to do because of eyesight and extreme difficulty; visual impairment = moderate difficulty and a little difficulty)
			✓	✓	NHANES-6	How much difficulty do you have finding something on a crowded shelf? (blindness = unable to do because of eyesight and extreme difficulty; visual impairment = moderate difficulty and a little difficulty)
			✓	✓	NHANES-7	How much difficulty do you have driving during the daytime in familiar places? (Blindness = Unable to do because of eyesight & Extreme difficulty; Visual impairment = Moderate difficulty & A little difficulty)
			✓		NHANES-8	Presenting visual acuity: blind
				✓	NHANES-9	Presenting visual acuity: visual impairment
NHIS	2016	Adults: 13 325†	✓	✓	NHIS-2	Do you have difficulty seeing, even when wearing glasses? (blindness = cannot do at all/unable to do and a lot of difficulty; visual impairment = somewhat difficult)
		Adult: 33 028	✓	✓	NHIS-3	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to do work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house or using hand tools (blindness = can't do at all because of eyesight and very difficult; visual impairment = somewhat difficult and only a little difficult)
			✓	✓	NHIS-4	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to read ordinary print in newspapers? (blindness = can't do at all because of eyesight and very difficult; visual impairment = somewhat difficult and only a little difficult)

Survey	Year(s)	Sample Size*	Blindness	Vision Impairment	Question Identification	Question (Response of Interest)
			✓	✓	NHIS-5	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to go down steps, stairs, or curbs in dim light or at night? (blindness = can't do at all because of eyesight and very difficult; visual impairment = somewhat difficult and only a little difficult)
			✓	✓	NHIS-6	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to find something on a crowded shelf? (blindness = can't do at all because of eyesight and very difficult; visual impairment = somewhat difficult and only a little difficult)
			✓	✓	NHIS-7	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to drive during daytime in familiar places? (blindness = can't do at all because of eyesight and very difficult; visual impairment = somewhat difficult and only a little difficult)
			✓	✓	NHIS-8	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to notice objects off to the side while you are walking along? (blindness = can't do at all because of eyesight and very difficult; visual impairment = somewhat difficult and only a little difficult)
		Adults: 33 028	✓		NHIS-1	Are you blind or unable to see at all? (yes)
		Children: 11 107		✓	NHIS-9	Do you have any trouble seeing, even when wearing glasses or contact lenses? (yes)
NSCH	2016	50 212	✓		NSCH	Does child have blindness or problems with seeing, even when wearing glasses? (yes)

ACS = American Community Survey; BRFSS = Behavioral Risk Factor Surveillance System; NHANES = National Health and Nutrition Examination Survey; NHIS = National Health Interview Survey; NSCH = National Survey of Children's Health.

This table presents the surveys selected; the survey year; the sample size for the selected vision questions; whether the question measured blindness, vision impairment, or both; the question identification used in the article; and the full question with the survey responses contributing to estimates of blindness and vision impairment.

*Sample size for the vision-related questions.

†NHIS-2 comes from the functioning and disability supplement (question VIS_SS2), which is administered to half of sample adults in the NHIS.

Table 2.

Blindness Prevalence Estimates from the Selected Surveys by Age Categories

Question Identification	Survey Years Included		Survey Question (Response(s) included in estimate)	Prevalence Estimate of Blindness by Age Categories (yrs), % (Confidence Interval)				
	Start	*End*		*0–17*	*18–39*	*40–64*	*65–84*	*85+*
NSCH	2016	2016	Does child have blindness or problems with seeing, even when wearing glasses? (yes)	1.6 (1.3–1.9)	N/A [*]	N/A [*]	N/A [*]	N/A [*]
ACS	2016	2016	Is this person blind or does he/she have serious difficulty seeing even when wearing glasses? (yes)	0.8 (0.7–0.8)	1.2 (1.2–1.3)	2.8 (2.78–2.85)	5.6 (5.5–5.7)	16.6 (16.2–17.0)
BRFSS	2016	2016	Are you blind or do you have serious difficulty seeing, even when wearing glasses? (yes)	N/A [*]	2.6 (2.4–2.8)	5.6 (5.4–5.8)	6.7 (6.4–7.0) [†]	
NHIS-1	2016	2016	Are you/Is child blind or unable to see at all? (yes)	0.2 (0.1–0.3)	0.3 (0.1–0.4)	0.3 (0.2–0.5)	0.6 (0.4–0.9)	1.7 (0.9–2.9)
NHIS-2	2016	2016	Do you have difficulty seeing, even when wearing glasses? (cannot do at all/unable to do)	N/A [*]	0.6 (0.3–0.9)	1.4 (1.0–1.8)	1.8 (1.4–2.4)	6.3 (4.2–9.0)
NHANES-1	2005	2008	At the present time, would you say your eyesight, with glasses or contact lenses if you wear them, is excellent, good, fair, poor, or very poor? (very poor and poor)	N/A [*]	1.9 (1.3–2.5) [‡]	3.2 (2.7–3.8)	3.9 (2.7–5.2) [§]	10.9 (8.3–13.6) [‖]
NHANES-2	2005	2008	How much difficulty do you have reading ordinary print in newspapers? (unable to do and extreme difficulty)	N/A [*]	0.5 (0.3–0.8) [‡]	3.0 (2.5–3.4)	2.6 (1.8–3.4) [§]	9.4 (6.8–12.0) [‖]
NHANES-3	2005	2008	How much difficulty do you have doing work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house, or using hand tools? (unable to do and extreme difficulty)	N/A [*]	0.3 (0.1–0.4) [‡]	1.9 (1.3–2.6)	1.9 (0.9–2.9) [§]	7.3 (5.1–9.5) [‖]
NHANES-4	2005	2008	How much difficulty do you have going down steps, stairs, or curbs in dim light or at night? (unable to do and extreme difficulty)	N/A [*]	0.6 (0.3–0.8) [‡]	1.8 (1.3–2.2)	3.6 (2.3–4.8) [§]	8.5 (6.3–10.6) [‖]
NHANES-5	2005	2008	How much difficulty do you have noticing objects off to the side while you are walking? (unable to do and extreme difficulty)	N/A [*]	0.4 (0.2–0.6) [‡]	1.0 (0.7–1.3)	1.5 (0.8–2.3) [§]	4.3 (2.8–5.8) [‖]
NHANES-6	2005	2008	How much difficulty do you have finding something on a crowded shelf? (unable to do and extreme difficulty)	N/A [*]	0.4 (0.1–0.6) [‡]	0.8 (0.5–1.0)	1.7 (0.8–2.5) [§]	5.1 (3.2–6.9) [‖]
NHANES-7	2005	2008	How much difficulty do you have driving during the daytime in familiar places? (unable to do and extreme difficulty)	N/A [*]	0.1 (0.0–0.2) [‡]	0.5 (0.3–0.8)	1.4 (0.8–2.1) [§]	7.0 (4.3–9.7) [‖]
NHANES-8	2005	2008	Presenting visual acuity: blind	– [¶]	1.1 (0.7–1.6) [‡]	0.3 (0.2–0.5)	0.8 (0.5–1.3) [§]	5.4 (3.5–8.1) [‖]
NHIS-3	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to do work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house or using hand tools (can't do at all because of eyesight)	N/A [*]	0.3 (0.17–0.4)	2.1 (1.8–2.4)	2.4 (2.0–2.9)	7.2 (5.4–9.5)
NHIS-4	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to read ordinary print in newspapers? (can't do at all because of eyesight)	N/A [*]	0.6 (0.4–0.8)	3.5 (3.1–4.0)	3.8 (3.3–4.4)	8.8 (6.8–11.2)

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Question Identification	Survey Years Included		Survey Question (Response(s) included in estimate)	Prevalence Estimate of Blindness by Age Categories (yrs), % (Confidence Interval)				
	Start	*End*		*0–17*	*18–39*	*40–64*	*65–84*	*85+*
NHIS-5	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to go down steps, stairs, or curbs in dim light or at night? (can't do at all because of eyesight)	N/A*	0.4 (0.3–0.7)	1.7 (1.4–2.0)	3.0 (2.6–3.5)	7.5(5.4–10.0)
NHIS-6	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to find something on a crowded shelf? (can't do at all because of eyesight)	N/A*	0.3 (0.1–0.5)	0.7 (0.5–0.9)	1.0 (0.8–1.4)	4.3 (2.9–6.2)
NHIS-7	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to drive during daytime in familiar places? (can't do at all because of eyesight)	N/A*	0.3 (0.1–0.5)	0.5 (0.4–0.7)	1.4 (1.0–1.8)	4.9 (3.4–6.7)
NHIS-8	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to notice objects off to the side while you are walking along? (can't do at all because of eyesight)	N/A*	0.3 (0.2–0.5)	0.7 (0.6–1.0)	1.4 (1.0–1.8)	4.5 (3.0–6.6)
IVWMPR	NA	NA	Inverse variance weighted mean of self-reported survey measures of severe difficulty seeing (i.e., excluding NHANES-8).	0.74 (0.71–0.77)	0.91 (0.88–0.93)	2.43 (2.40–2.46)	4.22 (4.15–4.29)	12.50 (12.18–12.82)

ACS = American Community Survey; BRFSS = Behavioral Risk Factor Surveillance System; IVWMPR = inverse variance weighted mean prevalence rate; NHANES = National Health and Nutrition Examination Survey; NHIS = National Health Interview Survey; NSCH = National Survey of Children's Health.

This table presents the prevalence estimates of blindness for each of the survey questions from the NSCH, ACS, BRFSS, NHIS, and NHANES identified to be measuring blindness. Prevalence estimates are presented for 5 age categories: 0 to 17 years, 18 to 39 years, 40 to 64 years, 65 to 85 years, and 85 years of age or older. Additionally, the table includes the inverse variance weighted mean prevalence rate (IVWMPR) for blindness using self-reported responses from the 5 surveys.

*Survey question was not administered to participants in these age groups.

†Includes participants 65 years of age or older. The BRFSS right-censors age reporting at age 80 years.

‡Includes participants 20 to 39 years of age.

§Includes participants 65 to 79 years of age.

‖Includes participants 80 years of age or older.

¶Did not include 12- to 17-year-olds in analysis.

Table 3.

Vision Impairment Prevalence Estimates from the Selected Surveys by Age Categories

Question Identification	Survey Years Included		Survey Question (Response(s) Included in Estimate)	Prevalence Estimate of Visual Impairment by Age Categories (yrs), % (Confidence Interval)				
	Start	*End*		*0–17*	*18–39*	*40–64*	*65–84*	*85+*
NHANES-1	2005	2008	At the present time, would you say your eyesight, with glasses or contact lenses if you wear them, is excellent, good, fair, poor, or very poor? (fair)	N/A [*]	8.4 (7.3–9.5) [†]	14.1 (12.1–16.0)	14.8 (12.9–16.8) [‡]	21.7 (18.8, 24.7) [§]
NHANES-2	2005	2008	How much difficulty do you have reading ordinary print in newspapers? (moderate difficulty and a little difficulty)	N/A [*]	9.5 (8.6–10.4) [†]	24.8 (22.6–27.0)	17.8 (15.4–20.3) [‡]	20.3 (17.8–22.8) [§]
NHANES-3	2005	2008	How much difficulty do you have doing work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house, or using hand tools? (moderate difficulty and a little difficulty)	N/A [*]	6.3(5.6–7.0) [†]	24.6 (22.4–26.8)	18.5 (16.2–20.7) [‡]	16.5 (14.2–18.7) [§]
NHANES-4	2005	2008	How much difficulty do you have going down steps, stairs, or curbs in dim light or at night? (moderate difficulty and a little difficulty)	N/A [*]	8.4 (7.1–9.6) [†]	14.8 (13.2–16.3)	20.9 (18.0–23.8) [‡]	25.7 (21.8–29.5) [§]
NHANES-5	2005	2008	How much difficulty do you have noticing objects off to the side while you are walking? (moderate difficulty and a little difficulty)	N/A [*]	5.2 (4.4–6.0) [†]	7.9 (6.9–9.0)	10.0 (8.2–11.8) [‡]	16.1 (13.2–19.0) [§]
NHANES-6	2005	2008	How much difficulty do you have finding something on a crowded shelf? (moderate difficulty and a little difficulty)	N/A [*]	6.8 (5.9–7.7) [†]	10.2 (9.0–11.3)	12.2 (10.5–13.9) [‡]	16.8 (13.6–20.1) [§]
NHANES-7	2005	2008	How much difficulty do you have driving during the daytime in familiar places? (moderate difficulty and a little difficulty)	N/A [*]	2.4 (1.7–3.1) [†]	2.8 (2.2, 3.4)	2.2 (1.5–2.9) [‡]	3.0 (1.8–4.2) [§]
NHANES-9	2005	2008	Presenting visual acuity: visual impairment	_ [//]	7.8 (6.7–9.0) [†]	6.8 (5.9–7.7)	12.5 (10.2–15.2) [‡]	25.9 (22.8–29.2) [§]
NHIS-2	2016	2016	Do you have difficulty seeing, even when wearing glasses? (some difficulty)	N/A [*]	9.0 (7.9–10.1)	13.5 (12.4–14.6)	14.6 (13.2–16.1)	19.7 (15.3–24.7)
NHIS-3	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to do work or hobbies that require you to see well up close such as cooking, sewing, fixing things around the house or using hand tools (somewhat difficult and only a little difficult)	N/A [*]	3.5 (3.0–4.0)	14.1 (13.3–15.0)	16.6 (15.5–17.8)	19.3 (16.5–22.4)
NHIS-4	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to read ordinary print in newspapers? (somewhat difficult and only a little difficult)	N/A [*]	6.6 (6.0–7.3)	19.7 (18.7–20.7)	21.7 (20.4–23.0)	26.6 (23.2–30.2)
NHIS-5	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to go down steps, stairs, or curbs in dim light or at night? (somewhat difficult and only a little difficult)	N/A [*]	3.2 (2.8–3.6)	7.9 (7.3–8.5)	12.9 (11.9–13.9)	17.9 (15.1–21.1)

Question Identification	Survey Years Included		Survey Question (Response(s) Included in Estimate)	Prevalence Estimate of Visual Impairment by Age Categories (yrs), % (Confidence Interval)				
	Start	*End*		*0–17*	*18–39*	*40–64*	*65–84*	*85+*
NHIS-6	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to find something on a crowded shelf? (somewhat difficult and only a little difficult)	N/A*	2.3 (1.9–2.7)	4.4 (4.0–4.9)	7.4 (6.7–8.2)	16.0 (13.0–19.3)
NHIS-7	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to drive during daytime in familiar places? (somewhat difficult and only a little difficult)	N/A*	1.6 (1.4–2.0)	2.9 (2.5–3.3)	3.3 (2.8–3.9)	5.8 (4.2–7.9)
NHIS-8	2016	2016	Even when wearing glasses or contacts lenses, because of your eyesight, how difficult is it for you to notice objects off to the side while you are walking along (somewhat difficult and only a little difficult)	N/A*	2.1 (1.7–2.5)	4.0 (3.6–4.4)	6.3 (5.6–7.0)	14.9 (12.4–17.7)
NHIS-9	2016	2016	Do you/does child have any trouble seeing, even when wearing glasses or contact lenses? (yes)	3.1 (2.7–3.6)	6.6 (6.0–7.3)	11.7 (11.0–12.4)	14.3 (13.2–15.4)	22.0 (19.0–25.3)
IVWMPR	NA	NA	Inverse variance weighted mean of self-reported survey measures of less severe difficulty seeing (i.e., excluding NHANES-9).	3.13 (2.69–3.58)	3.58 (3.44–3.72)	6.60 (6.42–6.78)	8.64 (8.39–8.88)	15.00 (14.02–15.98)

IVWMPR = inverse variance weighted mean prevalence rate; NHANES = National Health and Nutrition Examination Survey; NHIS = National Health Interview Survey; VI = visual impairment. This table presents the prevalence estimates of VI for each of the survey questions from the NHANES and NHIS and identified to be measuring VI. Prevalence estimates are presented for 5 age categories: 0 to 17 years, 18 to 39 years, 40 to 64 years, 65 to 85 years, and 85 years of age or older. Additionally, the table includes the IVWMPR for VI using self-reported responses from the 5 surveys.

*Survey question was not administered to participants in these age groups.

†Includes participants 20 to 39 years of age.

‡Includes participants 65 to 79 years of age.

§Includes participants 80 years of age or older.

‖Did not include 12- to 17-year-olds in analysis.