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# Association Between Social Determinants of Health and Examination-Based Vision Loss vs Self-reported Vision Measures

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**IMPORTANCE** Recent evidence suggests that social determinants of health (SDOH) affect vision loss, but it is unclear whether estimated associations differ between clinically evaluated and self-reported vision loss.

**OBJECTIVE** To identify associations between SDOH and evaluated vision impairment and to assess whether these associations hold when examining self-reported vision loss.

**DESIGN, SETTING, AND PARTICIPANTS** This population-based cross-sectional comparison included participants 12 years and older in the 2005 to 2008 National Health and Nutrition Examination Survey (NHANES), participants of all ages (infants and older) in the 2019 American Community Survey (ACS), and adults 18 years and older in the 2019 Behavioral Risk Factor Surveillance System (BRFSS).

**EXPOSURES** Five domains of SDOH that are based on Healthy People 2030: economic stability, education access and quality, health care access and quality, neighborhood and built environment, and social and community context.

**MAIN OUTCOMES AND MEASURES** Presenting vision impairment of 20/40 or worse in the better-seeing eye (NHANES) and self-reported blindness or serious difficulty seeing, even with glasses (ACS and BRFSS).

**RESULTS** Of 3 649 085 included participants, 1 873 893 were female (51.1%) and 2 504 206 were White (64.4%). SDOH across domains of economic stability, educational attainment, health care access and quality, neighborhood and built environment, and social context were significant predictors of poor vision. For example, higher income (poverty to income ratio [NHANES]: OR, 0.91; 95% CI, 0.85-0.98; [ACS]: OR, 0.93; 95% CI, 0.93-0.94; categorical income [BRFSS:<$15 000 reference]: $15 000-$24 999; OR, 0.91; 95% CI, 0.91-0.91; $25 000-$34 999: OR, 0.80; 95% CI, 0.80-0.80; $35 000-$49 999: OR, 0.71; 95% CI, 0.71-0.72; ≥$50 000: OR, 0.49; 95% CI, 0.49-0.49), employment (BRFSS: OR, 0.66; 95% CI, 0.66-0.66; ACS: OR, 0.55; 95% CI, 0.54-0.55), and owning a home (NHANES: OR, 0.85; 95% CI, 0.73-1.00; BRFSS: OR, 0.82; 95% CI, 0.82-0.82; ACS: OR, 0.79; 95% CI, 0.79-0.79) were associated with lower odds of vision loss. The study team identified no differences in the general direction of the associations when using either clinically evaluated or self-reported vision measures.

**CONCLUSIONS AND RELEVANCE** The study team found evidence that associations between SDOH and vision impairment track together when using either clinically evaluated or self-reported vision loss. These findings support the use of self-reported vision data in a surveillance system to track trends in SDOH and vision health outcomes within subnational geographies.

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Supplemental content

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Studies investigating how social determinants of health (SDOH) affect vision loss suggest that race and ethnicity, income, educational attainment, and food security are associated with vision outcomes.[1-6] However, with a few exceptions,[1,4,5] these studies rely on self-reported data. Self-reported data are collected more frequently than examination-based data and the sample size can support state and county estimates. However, few studies evaluate the correspondence of self-reported vision loss with examination-based vision impairment.[7]

Studies that evaluate the consistency of associations of self-reported vision loss and SDOH to those found when using examination measures are needed. Associations between SDOH and self-reported vision loss that mirror those between SDOH and examination-measured vision impairment would support the use of self-reported data, such as the Behavioral Risk Factor Surveillance System (BRFSS) and American Community Survey (ACS) to evaluate SDOH and vision loss at the state and county level.

In this article, we estimate associations between SDOH and examination-based visual acuity loss using the National Health and Nutrition Examination Survey (NHANES) and then test whether these associations hold for self-reported vision loss from the BRFSS and the ACS. We first estimate the SDOH that predict examination-based vision impairment in NHANES. We then extend this model to 2 self-reported data sources (BRFSS and ACS). Additionally, we discuss the value of self-reported data in tracking associations between SDOH and vision loss.

### Key Points

**Question** How are social determinants of health (SDOH) associated with vision loss and do these associations differ when using examination-based vs self-reported vision measures?

**Findings** In this cross-sectional study, SDOH across multiple domains were associated with vision loss. The study team observed no differences in associations when comparing examination-based and self-reported measures.

**Meaning** Associations between SDOH and vision impairment track together when using either clinically evaluated or self-reported vision loss, suggesting that using self-reported vision data can be used as a proxy measure to monitor SDOH and vision at the local level and over time.

## Methods

### Data

We used 3 nationally representative data sets to examine associations between SDOH and vision loss (**Table 1**): NHANES, BRFSS, and ACS. As this study was a secondary data analysis of publicly available data, the NORC institutional review board acknowledged that this study did not require review and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines. NHANES contains self-reported data on sociodemographic characteristics and health conditions and behaviors and examination data from medical evaluations of participants. NHANES conducted visual acuity testing in participants 12 years and older who reported being able to see light.[9] Our NHANES outcome is presenting visual acuity loss, defined as visual acuity of 20/40 or worse in the better-seeing eye (**Table 2**) while wearing existing contacts or eyeglasses. We used presenting visual acuity rather than best-corrected visual acuity (BCVA) because it is more analogous to self-reported vision loss. We included those who reported being unable to see light as having visual acuity loss. We used NHANES data from 2005 through 2008, which are the most recent years for which visual acuity was measured.

BRFSS is a state-administered telephone survey that includes adults 18 years and older and asks participants: "Are you blind or do you have serious difficulty seeing, even when wearing glasses?"[10] We used 2019 BRFSS data for 49 states and Washington, DC.[11] ACS is a multimode survey that uses the same vision question as BRFSS. We used the 2019 ACS Public Use Microdata Sample for all 50 US states and Washington, DC. One key difference between ACS and BRFSS is that ACS asks the head of household to report for each member of the household while BRFSS asks the respondent to report only for themselves. We included all participants (ie, infants and older) in our analysis.

We examined SDOH measures in each survey that aligned with the Healthy People 2030[12] SDOH concepts: economic stability (income, employment status, food security status), education access and quality (educational attainment), health care access and quality (health insurance, having a primary care physician or routine place to go for health care), neighborhood and built environment (owning a home, urban or rural residence), and social and community context (marital status). We sought to use consistent SDOH measures across data sets while leveraging strengths of each survey. Nonetheless, not all measures are available across data sets. Only NHANES includes food security status and only BRFSS includes rural or urban residence. For ACS, we used access to high-speed internet as a proxy for rural/urban residence, as urban areas are more

Table 1. Vision Loss Definitions[a]

| Term | Definition | Examination based | Self-reported |
|---|---|---|---|
| Vision loss | Umbrella term to refer to either examination-based or self-reported visual difficulty or impairment | x | x |
| Visual acuity loss | 20/40 or worse visual acuity | x | |
| Vision impairment | 20/40 to 20/160 visual acuity | x | |
| Blind or serious difficulty seeing (shortened to vision problems) | Respondent reported being blind or having serious difficulty seeing (ACS and BRFSS) or reported having fair, poor, or very poor vision with glasses or contacts if worn (NHANES) | | x |

Abbreviations: ACS, American Community Survey; BRFSS, Behavioral Risk Factor Surveillance System; NHANES, National Health and Nutrition Examination Survey.

[a] From Rein et al (2021).[8]

Table 2. Selected Nationally Representative Survey Data to Measure Vision Loss

| Survey | Year(s) | Survey items used to indicate vision loss |
|---|---|---|
| ACS | 2019 | Questionnaire: Is this person blind or does he/she have serious difficulty seeing even when wearing glasses? (yes) |
| BRFSS | 2019 | Questionnaire: Are you blind or do you have serious difficulty seeing, even when wearing glasses? (yes) |
| NHANES | 2005-2008 | Examination measure: Presenting visual acuity (20/40 or worse in the better-seeing eye) |
| NHANES | 2005-2008 | Questionnaire: With both eyes open, can you see light? (no) |
| NHANES[a] | 2005-2008 | Examination measure: Best-corrected visual acuity (20/40 or worse in the better-seeing eye) |
| NHANES[a] | 2005-2008 | Questionnaire: Would you say your eyesight, with glasses or contact lenses if you wear them, is excellent, good, fair, poor, or very poor? (vision loss defined as fair, poor, very poor) |

Abbreviations: ACS, American Community Survey; BRFSS, Behavioral Risk Factor Surveillance System; NHANES, National Health and Nutrition Examination Survey.

[a] Used in supplementary analysis only.

likely than rural areas to have internet access.[13] Rural/urban indicators are only available for NHANES data through the NCHS Research Data center and are not included in web data releases. We also controlled for self- or respondent-reported sociodemographic indicators (sex, age, race and ethnicity). We followed a framework similar to Wagner and Rein[14] who found clear differences in eye care use by diabetes status. Also, because diabetic retinopathy is a leading cause of vision loss,[15] we controlled for whether the respondent reported being diagnosed with diabetes where possible.

### Analysis

We restricted the sample to participants with complete data on vision measures. In NHANES, 10.8% of the sample were missing presenting visual acuity data for at least 1 eye. In BRFSS, 3.2% were missing data on self-reported vision loss. All respondents in ACS had data on vision loss. We examined summary statistics of vision loss, SDOH, and sociodemographic characteristics in each analytic data set. We used bivariate regression (continuous SDOH variables) and $\chi^2$ tests (categorical SDOH variables) to identify differences between those with and without vision loss. For NHANES, we used logistic regression to estimate the association between examination-based visual acuity loss or blindness and 8 SDOH: (1) poverty to income ratio (PIR), (2) currently working, (3) household food security, (4) educational attainment, (5) health insurance, (6) having a routine place to go to for health care, (7) owning their home, and (8) marital status. NHANES also includes general health status, which we included as a covariate (eMethods in Supplement 1).

For ACS and BRFSS, we used geographic identifiers to estimate the impact of unmeasured area effects on self-reported vision using a generalized linear mixed model (GLMM). BRFSS includes state of residence and ACS includes public use microdata areas (PUMAs), which we model as random effects. PUMAs have a minimum population of 100 000 and do not cross state lines.[16] In BRFSS, we examined 8 SDOH: (1) income, (2) currently working, (3) educational attainment, (4) has primary care physician, (5) health insurance coverage, (6) owning their home, (7) urban residence, and (8) marital status. BRFSS includes information on general health status, which we included as a covariate. In ACS, we examined 7 SDOH: (1) PIR, (2) currently working, (3) educational attainment, (4) health insurance, (5) owning their home, (6) high-speed internet access, and (7) marital status.

We conducted 2 sensitivity analyses using alternative vision measures available in NHANES: autorefractor-measured BCVA and self-reported vision status. First, we used a $\chi^2$ test to assess the association between evaluated vision impairment and self-reported vision status. We then dichotomously categorized self-reported vision as poor if respondents reported that their vision was fair, poor, or very poor.[17] We also conducted 1 sensitivity analysis using ACS in which we included a random effect for states rather than for PUMAs. All analyses incorporated survey design factors, eg, weights, including replicate weights for bivariate comparisons in ACS. We used Stata 15 (StataCorp) and SAS 9.4 (SAS Institute) for all analyses.

## Results

Among NHANES 2005 through 2008 participants 12 years and older, 10.3% (SE, 0.4) had presenting visual acuity of 20/40 or worse (**Table 3**). Most of this vision impairment was due to uncorrected refractive error; only 1.7% (SE, 0.1) of participants had visual acuity of 20/40 or worse when using BCVA. Among BRFSS 2019 participants 18 years and older, 5.2% (SE, 0.1) reported that they were blind or had serious difficulty seeing (hereafter, vision problems), even when wearing glasses. When answering the same question, 2.4% (SE, 0) of ACS 2019 respondents and their household members, infants and older, had respondent-reported vision problems.

In unadjusted analyses across surveys, almost all SDOH significantly differed between those with and without vision loss. In adjusted logistic (NHANES) and generalized linear mixed (BRFSS and ACS) models, most SDOH were significant predictors of vision loss and their effects were generally consistent across surveys (**Table 4**). Higher income was associated with lower odds of vision loss in all 3 surveys. Those who were employed and those with higher levels of education had significantly lower odds of vision loss. Owning a home, having an urban residence, and having high-speed internet access were associated with lower odds of vision loss. In BRFSS and ACS, those who were widowed, divorced, separated, or never married had higher odds of vision loss compared with those who were married. In NHANES, those who were widowed (though only at the 10% level) and those who were never married had higher odds of vision loss (Table 4).

The study team assessed several measures of health care access and quality. In BRFSS, having a primary care physician was associated with lower odds of vision loss. In ACS, those with Medicare, Medicaid, other government insurance, or no insurance had 22% to 155% higher odds of vision problems compared with those with private insurance (Table 4).

Table 3. Descriptive Statistics for Social Determinants of Health and Vision Loss[a,b]

| Characteristic | Weighted, % (SE) | | |
|---|---|---|---|
| | NHANES 2005-2008 (n = 12 885) | BRFSS 2019 (n = 396 647) | ACS 2019 (n = 3 239 553) |
| Sex | | | |
| Male | 48.8 (0.3) | 48.8 (0.2)[c] | 49.2 (0)[c] |
| Female | 51.2 (0.3) | 51.2 (0.2) | 50.8 (0) |
| Age, y, mean (SE) [range][d] | 42.2 (0.5) [12 to ≥80][c] | 47.7 (0.1) [18 to ≥80][c] | 39.1 (0) [0 to 99][c] |
| Race and ethnicity | | | |
| Hispanic | 12.8 (1.2) | 16.6 (0.1) | 18.4 (0) |
| Non-Hispanic Black | 11.5 (1.3) | 11.7 (0.1) | 12.4 (0) |
| Non-Hispanic White | 70.1 (2.2)[c] | 63.2 (0.2)[c] | 60.0 (0)[c] |
| Non-Hispanic other[e]/multiracial | 5.5 (0.6) | 8.5 (0.1) | 9.2 (0) |
| PIR, mean (SE)[f] | 3.0 (0.1)[c] | NA | 3.2 (0)[c] |
| Household income, $ | | | |
| <15 000 | NA | 9.7 (0.1)[c] | NA |
| 15 000-24 999 | NA | 15.5 (0.1) | NA |
| 25 000-34 999 | NA | 9.8 (0.1) | NA |
| 35 000-49 999 | NA | 12.7 (0.1) | NA |
| ≥50 000 | NA | 52.3 (0.2) | NA |
| Currently working[g] | 65.1 (1.0)[c] | 57.7 (0.2)[c] | 62.4 (0)[c] |
| Household food security | | | |
| High | 81.4 (0.9)[c] | NA | NA |
| Marginal | 7.3 (0.4) | NA | NA |
| Low | 7.5 (0.5) | NA | NA |
| Very low | 3.8 (0.3) | NA | NA |
| Education[h] | | | |
| <High school | 18.6 (1.0)[c] | 12.5 (0.1)[c] | 11.0 (0)[c] |
| High school | 25.3 (0.8) | 27.6 (0.1) | 27.4 (0) |
| Some college | 30.6 (0.7) | 31.2 (0.2) | 30.4 (0) |
| ≥College graduate | 25.5 (1.5) | 28.6 (0.1) | 31.2 (0.1) |
| Health insurance type | | | |
| Private/Medigap | 56.4 (1.4)[c] | NA | 53.2 (0.1)[c] |
| Medicare | 12.0 (0.8) | NA | 12.9 (0) |
| Medicaid, SCHIP, other state | 8.7 (0.6) | NA | 19.4 (0.1) |
| Other government | 4.5 (0.5) | NA | 5.0 (0) |
| None | 18.5 (1.0) | NA | 9.4 (0) |
| Has health insurance | NA | 87.3 (0.1)[c] | NA |
| Has routine place for health care | 85.7 (0.7) | NA | NA |
| Has PCP | NA | 76.9 (0.1) | NA |
| Urban residence | NA | 93.4 (0.1)[c] | NA |
| High-speed internet access | NA | NA | 76.5 (0.1)[c] |
| Owns home[i] | 71.7 (1.3)[c] | 66.9 (0.1)[c] | 67.8 (0.1)[c] |
| Marital status[j] | | | |
| Married | 55.6 (1.1)[c] | 50.6 (0.2)[c] | 38.8 (0.1)[c] |
| Widowed | 5.1 (0.3) | 6.8 (0.1) | 4.7 (0.0) |
| Divorced | 10.0 (0.4) | 10.6 (0.1) | 8.9 (0.0) |
| Separated | 2.4 (0.3) | 2.5 (0.1) | 1.5 (0.0) |
| Never married | 19.7 (0.9) | 24.5 (0.1) | 46.1 (0.0) |
| Living with/has partner | 7.2 (0.5) | 5.0 (0.1) | NA |
| Has diabetes | 6.9 (0.4)[c] | 11.1 (0.1)[c] | NA |
| General health status | | | |
| Excellent | 12.0 (0.6)[c] | 17.3 (0.1)[c] | NA |
| Very good | 35.0 (1.0) | 31.8 (0.1) | NA |
| Good | 37.8 (0.8) | 32.2 (0.2) | NA |
| Fair | 12.9 (0.5) | 13.9 (0.1) | NA |
| Poor | 2.3 (0.2) | 4.7 (0.1) | NA |

(continued)

Table 3. Descriptive Statistics for Social Determinants of Health and Vision Loss[a,b] (continued)

| Characteristic | Weighted, % (SE) | | |
|---|---|---|---|
| | NHANES 2005-2008 (n = 12 885) | BRFSS 2019 (n = 396 647) | ACS 2019 (n = 3 239 553) |
| Presenting vision | | | |
| Better than 20/40 | 89.7 (0.4) | NA | NA |
| 20/40 or Worse | 10.3 (0.4) | NA | NA |
| Best-corrected visual acuity | | | |
| Better than 20/40 | 98.3 (0.1)[c] | NA | NA |
| 20/40 or Worse | 1.7 (0.1) | NA | NA |
| Self-reported difficulty seeing or blind[k] | NA | 5.2 (0.1) | 2.4 (0) |
| Self-reported fair/poor/very poor vision | 14.0 (0.5)[c] | NA | NA |

Abbreviations: ACS, American Community Survey; BRFSS, Behavioral Risk Factor Surveillance System; NA, not applicable; NHANES, National Health and Nutrition Examination Survey; PCP, primary care physician; PIR, poverty-income ratio; SCHIP, state children's health insurance program.

[a] All estimates are weighted and account for the complex survey design. Not all surveys had the same variables or categories within a variable.

[b] All variables across all 3 surveys—besides presenting vision and best-corrected visual acuity—are self- or respondent-reported.

[c] $P < .05$: within a given survey, the variable is significantly different ($\alpha = .05$) between those with and without vision loss.

[d] In NHANES and BRFSS, age was top-coded at 80 years. In ACS, age was top-coded at 99 years.

[e] Includes all other races and ethnicities besides White, Black, and Hispanic, eg, Asian, Native American, Hawaiian or Pacific Islander, or anyone reporting more than 1 race.

[f] PIR ranges from 0 to 5, with 5 indicating higher income. PIR is top-coded at 5.

[g] For the ACS, we report summary statistics on currently working adults older than 18 years.

[h] In NHANES, educational attainment refers to the respondents' own education if they were 20 years or older at the time of the screening and to the household reference person's education if the respondent was younger than 20 years. For the ACS, we report summary statistics on educational attainment for adults older than 18 years.

[i] For the ACS, we report summary statistics on owning a home for adults older than 18 years.

[j] In NHANES, marital status refers to the respondents' own marital status if they were 20 years or older and to the marital status of the household reference person if the respondent was younger than 20 years. In ACS, never married by default includes those who are 15 years or younger.

[k] In ACS, self-reported difficulty seeing or blind is more accurately respondent-reported difficulty seeing or blind because the head of the household responds for all members of the household.

The study team also examined sociodemographic factors and whether the respondent reported ever having been diagnosed with diabetes (in NHANES and BRFSS). Black, Hispanic, or other race/multiracial individuals had higher odds of vision loss than White individuals. Those with diabetes had higher odds of vision loss (Table 4).

State of residence explained 5.3% of variation in vision loss in BRFSS. In ACS, PUMAs explained 19.9% of variation. In the supplemental analysis of ACS in which we used state random effects, state of residence explained 3.4% of the variation in vision loss (data not shown). This result did not differ in BRFSS, demonstrating cross-survey consistency in the finding that state differences are weak predictors of vision loss. The estimated effects of SDOH and sociodemographic factors when using state random effects are consistent with those seen when we use PUMA random effects, although the exact point estimates differ.

For sensitivity analyses using NHANES, among those categorized as having presenting visual acuity of 20/40 or worse, 82.6% were able to obtain 20/30 or better as their BCVA. In fully adjusted models examining vision impairment based on BCVA, the associations with several indicators disappeared, including PIR and owning a home (eTable in Supplement 1). Education and diabetes remained significant and the estimated effect size for the latter was slightly larger when assessing BCVA.

Self-reported vision status was significantly associated with clinically evaluated vision impairment ($\chi^2_4 = 534.4559$; $P < .001$). When reporting the condition of their eyesight, 14.0% (SE, 0.5) of NHANES participants categorized their vision as fair, poor, or very poor. A validation study of survey responses found that using the fair, poor, or very poor self-responses resulted in the greatest predictive accuracy for measured BCVA.[17] Results of models assessing self-reported poor vision were comparable with results of models using examination-based presenting vision impairment, with a few differences in estimated associations with race and ethnicity, insurance type, and self-reported health status (eTable in Supplement 1). When assessing poor vision, those with low (OR, 1.39; 1.09-1.78) or very low (OR, 1.70; 1.40-2.07) food security had significantly higher odds of poor vision when compared to those with high food security (eTable in Supplement 1).

## Discussion

We found strong evidence in 3 nationally representative surveys that SDOH were associated with vision loss and that the direction of the associations was consistent whether vision loss was examination based or self-reported. Examination-based associations were generally stronger for presenting vision impairment as compared with BCVA loss. We further found that SDOH across multiple domains predicted poor vision.

Previous studies identified similar connections between SDOH and vision impairment or eye health. Su et al[3] found that lower educational attainment, food insecurity, and having Medicaid were associated with self-reported visual difficulty. Ko et al[4] found that poverty and having less than a high school education were associated with BCVA among adults and Adomfeh et al[5] found that race, ethnicity, and not being a US citizen were associated with presenting vision impairment among adolescents. Lower incomes and lower levels of

Table 4. Social Determinants of Health and Odds of Vision Loss[a]

| Characteristic | OR (95% CI) | | |
|---|---|---|---|
| | NHANES[b] | BRFSS[c] | ACS[d] |
| Age category, y | | | |
| 0-17 | NA | NA | 1 [Reference] |
| 12-17 | 1 [Reference] | NA | NA |
| 18-24 | 1.02 (0.71-1.48) | 1 [Reference] | 2.11 (2.09-2.13)[e] |
| 25-29 | 0.75 (0.44-1.28) | 1.28 (1.28-1.29)[e] | 2.63 (2.61-2.65)[e] |
| 30-34 | 1.18 (0.73-1.90) | 1.14 (1.14-1.15)[e] | 2.57 (2.55-2.59)[e] |
| 35-39 | 0.94 (0.53-1.69) | 0.86 (0.86-0.86)[e] | 2.93 (2.91-2.96)[e] |
| 40-44 | 0.82 (0.46-1.46) | 1.12 (1.11-1.12)[e] | 3.48 (3.46-3.51)[e] |
| 45-49 | 0.82 (0.50-1.37) | 1.75 (1.74-1.75)[e] | 5.06 (5.02-5.10)[e] |
| 50-54 | 0.80 (0.45-1.41) | 1.88 (1.87-1.88)[e] | 6.23 (6.18-6.28)[e] |
| 55-59 | 1.04 (0.59-1.84) | 1.88 (1.88-1.89)[e] | 6.60 (6.55-6.65)[e] |
| 60-64 | 0.99 (0.66-1.51) | 1.59 (1.59-1.60)[e] | 6.86 (6.81-6.92)[e] |
| 65-69 | 1.36 (0.77-2.40) | 1.45 (1.44-1.45)[e] | 5.37 (5.33-5.42)[e] |
| 70-74 | 1.51 (0.89-2.56) | 1.65 (1.64-1.66)[e] | 5.63 (5.59-5.68)[e] |
| 75-79 | 1.81 (1.07-3.05)[f] | 1.79 (1.78-1.80)[e] | 6.92 (6.86-6.97)[e] |
| 80+ | 4.06 (2.55-6.47)[e] | 2.18 (2.17-2.19)[e] | 12.67 (12.57-12.77)[e] |
| Sex (male [reference]) | 1.04 (0.86-1.25) | 0.90 (0.90-0.90)[e] | 1.10 (1.10-1.10)[e] |
| Race and ethnicity | | | |
| Hispanic | 1.35 (1.10-1.65)[e] | 1.23 (1.23-1.24) | 1.04 (1.04-1.04)[e] |
| Non-Hispanic Black | 1.32 (1.07-1.64)[f] | 1.30 (1.29-1.30)[e] | 1.09 (1.09-1.09)[e] |
| Non-Hispanic White | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Non-Hispanic other[g]/multiracial | 1.33 (0.90-1.97) | 1.18 (1.18-1.19)[e] | 1.05 (1.05-1.06)[e] |
| Diabetes | 1.53 (1.15-2.03)[e] | 1.28 (1.27-1.28)[e] | NA |
| PIR | 0.91 (0.85-0.98)[f] | NA | 0.93 (0.93-0.94)[e] |
| Income, $ | | | |
| <15 000 | NA | 1 [Reference] | NA |
| 15 000-24 999 | NA | 0.91 (0.91-0.91)[e] | NA |
| 25 000-34 999 | NA | 0.80 (0.80-0.80)[e] | NA |
| 35 000-49 999 | NA | 0.71 (0.71-0.72)[e] | NA |
| ≥50 000 | NA | 0.49 (0.49-0.49)[e] | NA |
| Currently working | 0.85 (0.70-1.04) | 0.66 (0.66-0.66)[e] | 0.55 (0.54-0.55)[e] |
| Household food security | | | |
| High | 1 [Reference] | NA | NA |
| Marginal | 0.86 (0.65-1.13) | NA | NA |
| Low | 1.17 (0.89-1.54) | NA | NA |
| Very low | 1.23 (0.86-1.77) | NA | NA |
| Education | | | |
| <High school | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| High school | 0.78 (0.64-0.96)[f] | 0.79 (0.79-0.79)[e] | 0.78 (0.77-0.78)[e] |
| Some college | 0.72 (0.57-0.90)[e] | 0.81 (0.81-0.81)[e] | 0.77 (0.77-0.77)[e] |
| ≥College graduate | 0.71 (0.54-0.93)[f] | 0.58 (0.58-0.58)[e] | 0.60 (0.60-0.60)[e] |
| Has a routine place for health care | 1.02 (0.82-1.27) | NA | NA |
| Has primary care physician | NA | 0.87 (0.87-0.87)[e] | NA |
| Health insurance type[h] | | | |
| Private | 1 [Reference] | NA | 1 [Reference] |
| Medicare | 1.00 (0.73-1.37) | NA | 1.77 (1.76-1.77)[e] |
| Medicaid[i] | 1.26 (0.97-1.62)[j] | NA | 2.55 (2.54-2.55)[e] |
| Other government | 1.34 (0.94-1.90) | NA | 2.08 (2.07-2.08)[e] |
| None | 1.24 (0.95-1.61) | NA | 1.22 (1.22-1.23)[e] |
| Has health insurance | NA | 0.98 (0.98-0.98)[e] | NA |

(continued)

Table 4. Social Determinants of Health and Odds of Vision Loss[a] (continued)

| Characteristic | OR (95% CI) NHANES[b] | BRFSS[c] | ACS[d] |
|---|---|---|---|
| Owns home | 0.85 (0.73-1.00)[f] | 0.82 (0.82-0.82)[e] | 0.79 (0.79-0.79)[e] |
| Urban residence | NA | 0.96 (0.95-0.96)[e] | NA |
| High-speed internet access[k] | NA | NA | 0.90 (0.90-0.91)[e] |
| Marital status | | | |
| Married | 1 [Reference] | 1 [Reference] | 1 [Reference] |
| Widowed | 1.34 (0.96-1.88)[j] | 1.19 (1.19-1.20)[e] | 1.46 (1.46-1.47)[e] |
| Divorced | 0.91 (0.68-1.21) | 1.19 (1.19-1.20)[e] | 1.33 (1.33-1.34)[e] |
| Separated | 1.29 (0.82-2.04) | 1.30 (1.29-1.30)[e] | 1.58 (1.57-1.59)[e] |
| Never married | 1.32 (1.04-1.68)[f] | 1.13 (1.13-1.14)[e] | 1.31 (1.31-1.32)[e] |
| Has partner | 0.78 (0.57-1.08) | 1.36 (1.36-1.37)[e] | NA |
| Health status | | | |
| Excellent | 1 [Reference] | 1 [Reference] | NA |
| Very good | 0.83 (0.57-1.20) | 1.07 (1.06-1.07)[e] | NA |
| Good | 0.90 (0.66-1.24) | 1.47 (1.46-1.47)[e] | NA |
| Fair | 1.17 (0.81-1.68) | 2.75 (2.75-2.76)[e] | NA |
| Poor | 1.24 (0.75-2.02) | 5.45 (5.43-5.47)[e] | NA |
| Observations[l] | 10 570 | 315 108 | 2 477 528 |
| Area random effects | No | Yes: state | Yes: PUMA |
| Variation due to area random effects, % | NA | 5.34 | 19.85 |

Abbreviations: ACS, American Community Survey; BRFSS, Behavioral Risk Factor Surveillance System; NHANES, National Health and Nutrition Examination Survey; OR, odds ratio; PIR, poverty to income ratio; PUMA, public use microdata area.

[a] All variables across all 3 surveys—with the exception of the vision outcome in the NHANES model—are self- or respondent-reported.

[b] Vision impairment in NHANES indicates that the study participant had presenting visual acuity of 20/40 or worse in the better-seeing eye. The vision impairment variable also includes those reporting blindness, that is, not being able to see light. Analyses include NHANES data from 2005 to 2008. Estimates are weighted ORs, with 4-year mobile examination center weights computed from the 2-year mobile examination center weight following the National Center for Health Statistics' guidelines. This model also includes an intercept (OR, 0.15; 95% CI, 0.09-0.25).

[c] Impaired vision in BRFSS indicates that the survey respondent reported being blind or having difficulty seeing, even when wearing glasses. Estimates are weighted ORs from a generalized linear mixed model with state random effects.

[d] Impaired vision in ACS indicates that the survey respondent reported being blind or having difficulty seeing even when wearing glasses. Estimates are weighted OR from a generalized linear mixed model with PUMA random effects.

[e] $P < .01$.

[f] $P < .05$.

[g] Includes all other races and ethnicities besides White, Black, and Hispanic, eg, Asian, Native American, Hawaiian or Pacific Islander, or anyone reporting more than 1 race.

[h] Although BRFSS has data on type of health insurance coverage, we did not include it in our main models because only 11 states used the health insurance module and collected this information in 2019. Instead, we included a binary variable that indicates whether a respondent has any health insurance coverage, which was available for all states.

[i] In NHANES, the Medicaid category also includes state children's health insurance program and other state insurance programs.

[j] $P < .10$.

[k] ACS does not include data on urban or rural residence. We use high-speed internet access as a proxy.

[l] We use listwise deletion. Therefore, the number of observations differs slightly between our univariate summary statistics (Table 2) and our multivariate models (Table 3).

education have also been associated with increased odds of diabetic retinopathy.[1,2]

Most NHANES respondents with presenting vision impairment (82.6%) were able to obtain visual acuity of 20/30 or better with proper refraction. Many of the associations we found between SDOH and presenting vision impairment disappeared when modeling BCVA loss. This is intuitive because many of the significant determinants (eg, PIR, owning a home) are associated with income and access to resources. Given enough resources, people who have the means to do so tend to seek eye care and proper refractive equipment.[14] For example, Zhang et al[1] found that individuals with lower incomes were significantly less likely than their higher-income counterparts to have had an eye care visit in the past year or to be able to afford eyeglasses.

A second key finding is that differences were not identified in the significance of associations between SDOH and vision loss and their direction when using either self-reported or examination-based measures. To our knowledge, Rein et al[8] is the only other study to compare self-reported and examination-based measures of vision loss. The study authors compared prevalence rates of self-reported vision loss and examination-based presenting vision impairment across 5 national surveys. They found that prevalence rates of self-reported vision loss varied widely across surveys; however, the central tendency of these measures across surveys was similar—albeit slightly higher—in self-reported measures compared with examination-based measures.

A third key finding is the difference in explanatory power of state vs PUMAs. State of residence explained 5.3% and 3.8%

of variation in self-reported vision problems in BRFSS and ACS, respectively, whereas PUMAs explained nearly 20% in the ACS. Most states include a mixture of diverse people, whereas smaller PUMAs capture local concentrations of SDOH that could affect vision outcomes. Given that PUMAs are subgeographies within states, states may be too aggregated to capture differences in vision loss. Another possible explanation is that smaller geographic areas do play a greater role in vision status. Evidence indicates that area characteristics are associated with impaired vision or diseases of the eye.[18,19] Even considering the potential influence of vision-related state policies, area characteristics may overshadow policy effects. Alternatively, PUMAs might measure differences in vision loss between urban and rural areas which we were unable to directly control for in ACS, although we used high-speed internet access as a proxy.

SDOH are "the conditions in which people are born, grow, live, work, and age."[20] We used the term SDOH to refer to personal factors like race and ethnicity, income, educational attainment, and food security, consistent with previous research.[2,3] We chose variables that aligned with the Healthy People 2030 SDOH framework and measures.[12] Even so, it is important to note that the factors we assessed are more accurately described as individual social risk factors.[21] Although the inclusion of PUMAs in the ACS analysis may begin to address broader environmental factors, ideally we would link to local factors such as the built environment.

### Policy and Practice Implications

Given their lower cost of collection, self-reported data are more frequently collected and collected among larger sample sizes than examination measures, supporting their use for tracking geographic differences and changes over time. We found that associations between SDOH and vision loss track together when using either examination-based vision outcomes or self-reported measures, supporting the continued use of self-reported data to monitor and study SDOH and vision. We also found that PUMAs explain approximately 4 times the amount of variation in vision loss compared with states, indicating that local area differences contribute more to variation in vision loss than broader state-level effects, such as school screening policy or public insurance programs. This finding highlights the importance of data collection with samples large enough to capture geographic variation.

### Limitations

This study is limited by at least the following factors. First, none of our 3 data sets are longitudinal, preventing us from drawing conclusions regarding casual links between SDOH and vision impairment. Several variables may be endogenous to our outcomes, eg, vision loss may drive enrollment in Medicaid and Medicare.[22-24] Similarly, vision impairment may cause someone to indicate that their health status is poor. Therefore, it is important to keep in mind that our estimates are associations only.

Second, although we used nationally representative data sets, there is still the possibility that some populations (eg, people with the lowest incomes, recent immigrants) are excluded.[21] We tried to mitigate this by using 3 distinct data sets. Third, we used NHANES data from 2005 to 2008, whereas the BRFSS and ACS data were collected in 2019. We used 2019 data to provide the most recent data available. However, because we used different years of data, it is unclear whether any differences between NHANES estimates and BRFSS or ACS estimates are due to time or cohort effects.

Fourth, age groups are different between surveys, which could account for some differences between ACS and BRFSS. However, we controlled for age group in all models; thus, age should not drive the differences we see across surveys. Fifth, ACS differs from BRFSS in that one person responded to the questionnaire for all members of the household, rather than one person answering for themself. Next, our multilevel model for ACS does not incorporate replicate weights (due to limitations of existing statistical packages), resulting in smaller SEs of effect sizes and narrower 95% CIs. However, the same differences between people with and without vision loss were observed in bivariate comparisons that used replicate weights. When using nonreplicate weights, the ACS model coefficients are all statistically significant at the $P < .01$ level and these results are strongly concordant with those obtained from BRFSS and NHANES. Given these findings and the large ACS sample size, it is unlikely that the associations found in the ACS multilevel model would be insignificant if replicate weights were implemented. Additionally, we controlled for diabetes status as a potential confounder. However, it is highly plausible that the same risk factors would make someone more likely to have both diabetes and vision impairment.

## Conclusions

We found that 5 domains of SDOH were significantly associated with vision loss. We did not identify differences when using either examination-based or self-reported vision measures. These findings support the use of self-reported vision data in a surveillance system to assess trends in SDOH and vision health outcomes at subnational geographies and over time. Additionally, our results can inform and support future studies that rely on self-reported vision data to evaluate other vision-related research questions.

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*Concept and design:* Alfaro Hudak, Wittenborn, Saaddine, Rein.
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