

Reported Visual Impairment and Risk of Suicide

The 1986-1996 National Health Interview Surveys

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Objective: To examine the relationship between reported visual impairment and suicide mortality.

Methods: From 1986 through 1996, annual cross-sectional multistage area probability surveys of the US civilian noninstitutionalized population living at addressed dwellings were conducted by the National Center for Health Statistics. We performed mortality linkage through 2002 with the National Death Index of 137 479 adults 18 years and older. The relationships between reported visual impairment and suicide were examined using structural equation modeling.

Results: The mean duration of follow-up was 11.0 years, and 200 suicide deaths were identified. After controlling for survey design, age, sex, race, marital status, number of nonocular health conditions, and self-rated

health, the direct effect of visual impairment on death from suicide was elevated but not significant (hazard ratio, 1.50; 95% confidence interval, 0.90-2.49). The approximate indirect effect of visual impairment on death from suicide via poorer self-rated health (1.05; 1.02-1.08) or number of nonocular health conditions (1.12; 1.01-1.24) was significant. The total effect of visual impairment on death from suicide was elevated but not significant (1.64; 0.99-2.72).

Conclusions: Visual impairment may be associated with an increased risk of suicide through its effect on poor health. This suggests that improved treatment of visual impairment and factors causing poor health may potentially reduce suicide risk.

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THE PSYCHOSOCIAL AND health consequences of ocular conditions that lead to visual impairment (VI) are broad and include impaired activities of daily living,^{1,2} social isolation,^{2,3} cognitive impairment,⁴ impaired functional status and functional decline,⁵⁻⁷ increased dependency on others,^{8,9} increased risk of motor vehicle crashes,^{10,11} falls and fractures,^{12,13} poor self-rated health,^{2,14} and depression.^{15,16} Increased mortality risks also have been noted in adults with VI and disabling eye disease.¹⁷⁻²⁷

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An association between VI and suicide has been suggested by case reports.²⁸⁻³⁰ In a case-control study performed in Sweden, Waern et al³¹ rated physical illness by interviewing the relatives of 46 men and 39 women older than 65 years who committed suicide and compared the results with interviews of 84 men and 69 women older

than 65 years who were living. Visual impairment (odds ratio, 7.0; 95% confidence interval [CI], 2.3-21.4), neurological disorders (3.8; 1.5-9.4), and malignant disease (3.4; 1.2-9.8) were independently associated with increased suicide risk.

The relationship between VI and suicide has not been examined in population-based studies because of the low incidence of suicide. Established suicide risk factors rarely occur in isolation and include age, male sex, disrupted marital status, mental and addictive disorders, depression, prior suicide attempt, family history of psychiatric disorder or suicide, having a firearm in the home, and a recent, severely stressful life event.³² Suicide and suicide attempts also have been associated with select chronic conditions, such as cancer.³³⁻³⁵ In addition, the number of health conditions increases the risk of suicide attempts in a dose-response fashion.³³ Visual impairment could affect suicide risk by direct and indirect pathways. For instance, previous studies have found a relationship between VI and self-rated health,^{14,34,35} which, in turn, has been shown to be a predictor of mortality.^{36,37}

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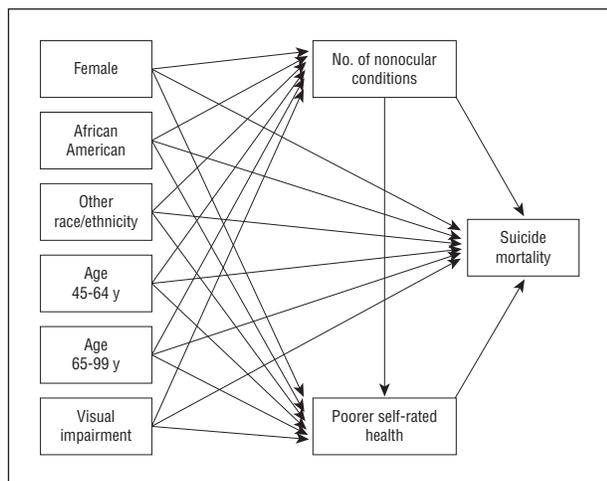


Figure 1. Tested structural equation model of suicide mortality with self-rated health and number of nonocular conditions as mediators.

The purpose of this study is to examine the relationship between VI and suicide in a population-based sample representative of the US adult population 18 years and older. In this study, structural equation modeling was used to assess direct and indirect effect of VI on suicide through self-rated health and nonocular health conditions while controlling for all covariates.

METHODS

STUDY POPULATION AND DESIGN

The National Health Interview Survey (NHIS) is conducted annually by the National Center for Health Statistics (NCHS).³⁸ The NHIS uses a complex sample survey design to obtain population-based samples that are representative of the US civilian noninstitutionalized population. Each year between 1986 and 1996 approximately 50 000 households were selected from 192 of the approximately 1900 primary sampling units (primarily counties or a small number of contiguous counties) that cover the 50 states and Washington, DC. Small clusters of households were drawn at random annually from these primary sampling units. The NCHS obtained informed consent before completing household interviews.

For the present analyses, complete data were available on 137 479 participants in the 1986-1996 NHIS who were 18 years or older at the time of the interview and who provided sufficient demographic information to undertake the mortality linkage.

VISUAL IMPAIRMENT

Information on VI was obtained annually in a random 1/6 sample of the households selected for the 1986-1996 NHIS. In most cases the participants themselves answered all the questions (61%-63% across survey years) and, for the remaining participants, responses were obtained from their relatives or other proxies. Participants were asked to indicate if they or any of their family members were blind in 1 or both eyes or had any other trouble seeing with 1 or both eyes even when wearing glasses.

The NCHS coders classified VI as follows: (1) blind in both eyes; (2) VI in both eyes; (3) blind in 1 eye and VI in the other eye; and (4) blind or VI in 1 eye only and the other eye with good vision or not mentioned.³⁹ For this study, participants were defined as having VI if they fell into any of the 4 categories.

DEFINITION OF COVARIATES

Participants were also asked if they had any other impairment-related health conditions (eg, hearing impairment or arthritis-related conditions). Any other health conditions the participants mentioned during the interview were also recorded. A series of standardized questions were used to obtain details on the name, characteristics, cause, onset, and effects of each reported condition and impairment. Trained medical coders used this information to generate an *International Classification of Diseases, Ninth Revision (ICD-9)* code for each condition. A condition count was generated for any acute condition, chronic condition, or impairment. In the present analysis, ICD-9 codes and impairment codes were used to exclude from these counts conditions associated with the visual systems (ICD-9 codes: 360-368, 370-379; impairment codes: X00-X04). A 3 category nonvision health condition variable was then created as follows: (1) no conditions; (2) 1 condition; and (3) 2 or more conditions.

Participants were asked to rate their own health as excellent, very good, good, fair, and poor. In this analysis, reported health status was classified as excellent, very good, good, or fair vs poor. Race was coded as: (1) African American; (2) white; and (3) all other races. Sex, marital status (married vs not married), and age (18-44 years, 45-64 years, and 65-99 years) were also controlled for in the analysis.

MORTALITY LINKAGE

The NHIS participants who were 18 years or older were included in the National Death Index mortality linkage completed through December 31, 2002. The weighted matching method used in linking the NHIS data files and the National Death Index permits the classification of potential death certificate matches into 1 of 5 mutually exclusive classes based on personal identifiers and the number of sociodemographic items matched (eg, name, Social Security number, birthday, state of birth, and state of residence).⁴⁰ It assigns a numerical value indicating the probability of a "true" match based on information recorded. All matches fulfilling class 1 criteria were considered true matches, while those in class 5 were false matches. The remaining 3 classes designated matches with varying degrees of probability. We used NCHS-recommended cutoff scores for classifying class 2 (>47), 3 (>45), and 4 (>40) matches as true or false (variable MORTSTAT).^{40,41} Using these cutoff scores, NCHS estimates survival status designations are correctly classified among 98.0%, 89.7%, and 98.6% of class 2, 3, and 4 cases, respectively.^{40,41}

ANALYSIS

Descriptive and model-based analyses were completed with SAS, version 9.1,⁴² and M-Plus, version 4.2.⁴³ statistical software packages, respectively. Structural equation modeling (SEM) using M-Plus software permitted the simultaneous estimation of logistic regression and Cox hazard modeling, with adjustments for the survey design. **Figure 1** depicts the full analytic structural equation model showing self-rated health, nonocular conditions, and suicide mortality are regressed on VI and the demographic covariates. **Figure 2** focuses just on the portion of the full model that involves the VI predictor.

We present the direct effect between VI and suicide risk, and we calculated the indirect effect of VI on suicide risk through its influence on self-rated health and number of nonocular conditions, with adjustments for all other factors in the model. These indirect pathways are considered important, given that VI is associated with poorer self-rated health^{14,34,35} and that poor self-rated health is associated with increased suicide risk.³⁶ In addition, VI can lead to reduced activities of daily living and functional decline, which can lead to an increased risk of chronic

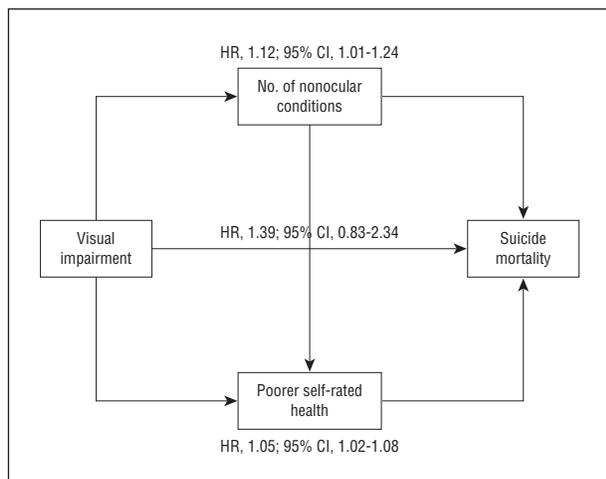


Figure 2. The visual impairment portion of the Cox proportional hazards model shown in Figure 1. The direct and indirect effects of visual impairment on suicide via number of nonocular conditions and self-rated health are shown (see Table 4 for details). HR indicates hazard ratio; CI, confidence interval.

disease.^{1,2,5-7} We also calculated the indirect effects on suicide risk for the covariates for comparison with the effects of VI.

Indirect effects and total effects (direct plus indirect effects) were estimated from a model that uses the ordinal self-rated health variable and the actual count of nonocular conditions variable and treats them as continuous. This is an approximation method for the model that uses the categorized mediators with logistic regression. Indirect effects were calculated using the product of coefficients method in which the effect of VI on self-rated health, for example, was multiplied by the estimate of self-rated health on suicide mortality. This indirect effect was subsequently exponentiated to obtain the hazard ratio. Using the uncollapsed mediator variables (eg, the actual number of nonocular conditions and the 5-point ordinal scale measure of self-rated health) and ordinary linear regression for the mediator equations gave the effect of VI on the actual units of the mediator rather than the logit units, allowing for a straight multiplication. The total effect of VI was calculated by summing both indirect effects with the direct effect, then exponentiating this value to obtain the hazard ratio (HR).

A comparison of our categorized mediation models with those that used the approximation method yielded similar, although not identical, parameter estimates. Therefore, we present results of the former for ease of interpretation (**Tables 1, 2, and 3**) but base our calculation of indirect model effects using the approximation method described above (**Table 4 and Table 5**). There were 579 observations with missing data on the self-rated health variable. Direct maximum likelihood methods for missing data were used to retain these observations.⁴⁴

RESULTS

Table 1 presents HRs from the Cox proportional hazard model and gives the direct effect of covariates on death from suicide. The HR for VI is elevated but not statistically significant (1.50; 95% CI, 0.90-2.49). Men, those with poorer self-rated health, and those with 2 or more nonocular health conditions had a higher risk of suicide. Compared with whites, African Americans had a lower risk of suicide. Married participants had a lower risk of suicide compared with those who were single, divorced, or widowed.

Table 2 represents the logistic regression portion of the model, examining the covariate associations with self-rated

Table 1. Cox Proportional Hazards Ratios of Suicide Death Using Structural Equation Modeling: The 1986-1996 National Health Interview Surveys (Mortality Linkage Through 2002)

Characteristic	No. of Suicides	Estimated Incidence Rate ^a	Hazard Ratio (95% CI)
Visual impairment			
No	182	13.3	1 [Reference]
Yes	18	28.3	1.50 (0.90-2.49)
Sex			
Female	50	6.6	1 [Reference]
Male	150	22.0	3.44 (2.35-5.03)
Age, y			
18-44	119	13.7	1 [Reference]
45-64	42	11.4	0.81 (0.56-1.18)
≥ 65	39	19.4	1.25 (0.86-1.81)
Race			
White	176	14.9	1 [Reference]
African American	12	6.2	0.39 (0.20-0.78)
Other ^b	12	13.1	0.90 (0.48-1.67)
Marital status			
Not married	86	16.9	1 [Reference]
Married	114	12.1	0.63 (0.46-0.86)
Self-rated health ^c			
Excellent, very good, good, or fair	186	13.2	1 [Reference]
Poor	13	35.6	2.09 (1.10-3.98)
Nonocular health conditions			
0	100	11.6	1 [Reference]
1	42	13.4	1.10 (0.76-1.61)
≥ 2	58	21.2	1.57 (1.08-2.30)

Abbreviation: CI, confidence interval.

^aPer 100 000 persons per year.

^bAsian/Pacific Islander, 49%; American Indian, 15%; multiple and other races, 36%.

^cOne suicide was missing self-rated health data.

Table 2. Logistic Regression of Self-Rated Health Using Structural Equation Modeling^a

Characteristic	Odds Ratio (95% CI)
Visual impairment	
No	1 [Reference]
Yes	2.13 (1.94-2.33)
Sex	
Female	1 [Reference]
Male	1.07 (1.00-1.14)
Age, y	
18-44	1 [Reference]
45-64	2.80 (2.56-3.07)
≥ 65	3.03 (2.74-3.36)
Race	
White	1 [Reference]
African American	2.35 (2.12-2.60)
Other ^b	1.69 (1.37-2.09)
Marital status	
Not married	1 [Reference]
Married	0.93 (0.87-1.00)
Nonocular health conditions	
0	1 [Reference]
1	9.76 (8.11-11.74)
≥ 2	47.68 (39.95-56.90)

Abbreviation: CI, confidence interval.

^aPoor vs excellent, very good, good, or fair.

^bAsian/Pacific Islander, 49%; American Indian, 15%; multiple and other races, 36%.

Table 3. Polytomous Logistic Regression of Number of Nonocular Conditions Using Structural Equation Modeling^a

Characteristic	Odds Ratio (95% CI)	
	1 Nonocular Condition	≥ 2 Nonocular Conditions
Visual impairment		
No	1 [Reference]	1 [Reference]
Yes	1.03 (0.96-1.11)	3.02 (2.82-3.24)
Sex		
Female	1 [Reference]	1 [Reference]
Male	1.03 (1.00-1.06)	0.95 (0.93-0.98)
Age, y		
18-44	1 [Reference]	1 [Reference]
45-64	1.09 (1.06-1.13)	2.70 (2.60-2.80)
≥ 65	1.16 (1.11-1.21)	5.74 (5.51-5.98)
Race		
White	1 [Reference]	1 [Reference]
African American	0.83 (0.80-0.87)	0.91 (0.86-0.96)
Other ^b	0.73 (0.68-0.78)	0.64 (0.59-0.70)
Marital status		
Not married	1 [Reference]	1 [Reference]
Married	1.08 (1.04-1.11)	0.77 (0.74-0.79)

Abbreviation: CI, confidence interval.

^aOne vs none and 2 or more vs none.

^bAsian/Pacific Islander, 49%; American Indian, 15%; multiple and other races, 36%.

Table 4. Approximate Direct, Indirect, and Total Effects of Reported Visual Impairment on Suicide Mortality Through Number of Nonocular Conditions and Self-Rated Health Using Structural Equation Modeling^a

Effect	Hazard Ratio (95% CI)
Direct	1.39 (0.83-2.34)
Indirect through nonocular conditions	1.12 (1.01-1.24)
Indirect through self-rated health	1.05 (1.02-1.08)
Indirect through both nonocular conditions and self-rated health	1.18 (1.07-1.29)
Total	1.64 (0.99-2.72)

Abbreviation: CI, confidence interval

^aActual number of nonocular conditions and ordered categories (1-5) of self-rated health.

health. The odds ratio for VI associated with poor self-rated health is 2.13 (95% CI, 1.94-2.33). Older participants, African Americans, those of other races, and those with nonocular health conditions had poorer self-rated health.

Table 3 presents the polytomous regression portion of the model for the effects of covariates on the number of nonocular conditions. Having VI increased the odds of reporting 2 or more nonocular conditions (odds ratio, 3.02; 95% CI, 2.82-3.24). Older participants and whites had increased odds of reporting nonocular conditions.

Table 4 shows the approximate indirect effect of VI on suicide through poorer self-rated health and number of nonocular conditions. These results are approximate for the model results previously reported because they are derived from the same structural model, with the 5-point health variable and the raw number of nonocular conditions, as quasicontinuous mediators. With this model, the direct effect of VI on death from suicide is com-

Table 5. Approximate Direct, Indirect, and Total Effects of Reported Visual Impairment on Suicide Mortality Through Number of Nonocular Conditions and Self-Rated Health Using Structural Equation Modeling^a

Characteristic	Hazard Ratio (95% CI)		
	Direct Effect	Combined Indirect Effect ^b	Total Effect
Sex			
Female	1 [Reference]	1 [Reference]	1 [Reference]
Male	3.53 (2.42-5.15)	0.97 (0.95-0.98)	3.42 (2.35-4.98)
Age, y			
18-44	1 [Reference]	1 [Reference]	1 [Reference]
45-64	0.75 (0.51-1.10)	1.13 (1.08-1.20)	0.85 (0.58-1.23)
≥ 65	1.09 (0.75-1.58)	1.29 (1.15-1.44)	1.40 (0.97-2.00)
Race			
White	1 [Reference]	1 [Reference]	1 [Reference]
African American	0.36 (0.18-0.72)	1.09 (1.03-1.15)	0.40 (0.20-0.79)
Other ^c	0.86 (0.46-1.60)	1.03 (0.98-1.08)	0.89 (0.48-1.66)
Marital status			
Not married	1 [Reference]	1 [Reference]	1 [Reference]
Married	0.63 (0.46-0.87)	0.98 (0.97-1.00)	0.62 (0.45-0.85)

Abbreviation: CI, confidence interval.

^aActual number of nonocular conditions and ordered categories (1-5) of self-rated health.

^bCombined indirect effect through nonocular conditions and self-rated health.

^cAsian/Pacific Islander, 49%; American Indian, 15%; multiple and other races, 36%.

parable with the direct effect reported in Table 1. The indirect effects of VI on death from suicide through nonocular conditions (HR, 1.12; 95% CI, 1.01-1.24) and self-rated health (1.05; 1.02-1.08) are significantly elevated. The combined indirect effects of VI through both mediators on suicide are significantly increased (HR, 1.18; 95% CI, 1.07-1.29). The total direct and indirect effect of VI on suicide mortality is substantive but not significant (HR, 1.64; 95% CI, 0.99-2.72).

Table 5 presents the direct, combined indirect, and total effects of study covariates on suicide risk. Only combined indirect effects through nonocular conditions and self-rated health are shown for ease of presentation. There are significant indirect effects for middle-aged adults (aged 45-64 years: HR, 1.13; 95% CI, 1.08-1.20) and older adults (older than 65 years: 1.29; 1.15-1.44) relative to young adults aged 18 to 44 years. Only small combined indirect effects are present for sex and marital status, with a small but significant indirect effect for African American relative to white participants (HR, 1.09; 95% CI, 1.03-1.15).

We repeated our models, adding a proxy response indicator to determine if estimates varied as a function of self vs proxy report of VI. There were some alterations to our model. For example, proxy reporters were more likely to report poor self-rated health than nonproxy reporters. However, the inclusion of the proxy indicator did not alter the direct effects on suicide risk. We also tested for moderation (interaction) of the relationship between VI and the outcome variables by the other covariates. We found a number of interactions between our covariates and mediators. For example, the effect of VI on poorer self-rated health was lower for men than for

women. However, there were no interaction effects for the direct effects on suicide mortality (results available from the corresponding author).

COMMENT

Our results indicate reported VI increased suicide risk directly and indirectly, although these associations were not always significant. Reported VI directly increased suicide risk by nearly 50% (Table 1) (HR, 1.50; 95% CI, 0.90-2.49), but this did not reach statistical significance. However, reported VI indirectly increased suicide risk significantly by 5% through poor self-rated health (Table 4) (HR, 1.05; 95% CI, 1.02-1.08) and by 12% through the number of nonocular conditions (1.12; 1.07-1.29). The combined indirect effects of reported VI operating jointly through poorer self-rated health and a higher number of reported nonocular conditions increased the risk of suicide significantly by 18% (HR, 1.18; 95% CI, 1.07-1.29). When we examined the combined indirect effects of the other covariates in the model, only older age produced stronger associations (Table 5), providing further support for the importance of the indirect effects of VI as a contributor to increased risk of suicide. In the traditional Cox regression analysis of suicide risk where only direct effect is examined, the relationship between VI and suicide would have been only partially studied. However, with SEM, direct and indirect effect of VI on suicide through multiple paths such as self-rated health could be examined while controlling for all covariates. The results suggest improved treatments of underlying ocular conditions responsible for VI and factors causing poor self-rated health and health conditions could reduce suicide risk.

Using SEM in our analysis offers several advantages over traditional analytic methods. First, SEM allows for the estimation of multiple equations simultaneously so that associations between multiple predictor and outcome variables can be assessed in the same model, even when the distribution of outcome measures vary from dichotomous (eg, VI) to continuous and time-dependent events (eg, mortality). In addition, SEM provides a powerful tool for the assessment of proposed model pathways, including indirect pathways such as self-rated health. Indirect effects are estimated and tested in a single step (as shown in Tables 4 and 5) with potentially more statistical power than traditional multistep methods.⁴⁵ However, this method has not been fully developed for limited mediator variables using generalized linear modeling, which led us to use an approximate method to calculate our indirect effects. The method of using standardized parameters does not provide interpretable estimates for survival data.⁴⁶ In addition, the method of approximate conversion of the mediator to original units using predicted probabilities is not accurate with mediators with very low probabilities, such as the self-rated health mediator in our model.⁴⁷ Software for SEM, such as M-Plus, can incorporate sample weights and complex sample survey design (ie, clustering and stratification) into the analysis. This advance permits the appropriate application of SEM to complex sample survey data, including the NHIS.

The relationship between VI and self-rated health has been previously reported.^{14,34,35} In the Blue Mountains Eye Study, decreased vision was found to have an independent effect on global health ranking by persons younger than 80 years.¹⁴ In this study, participants reporting VI were 2 times more likely to report poor self-rated health relative to participants not reporting VI (Table 2) (odds ratio, 2.13; 95% CI, 1.94-2.33). Self-rated health is considered a reflection of primarily physical health status. A person may also take into account their healthy or unhealthy lifestyles and activities in reporting self-rated health.³⁷

Previous studies have noted a strong association between self-rated health and increased mortality.^{36,37} Benjamins et al³⁶ analyzed data from the 1986-1994 NHIS with mortality linkage to 1997 and found a strong relationship between self-rated health and mortality, as well as a significant relationship between poor self-reported health and risk of suicide (HR, 2.45; 95% CI, 1.26-4.75). Similarly, our study of the 1986-1996 NHIS with mortality linkage to 2002 found that participants reporting poor self-rated health had a nearly 2-fold increased suicide risk (Table 1) (HR, 2.09; 95% CI, 1.10-3.98).

Up to two-thirds of people who commit suicide have some type of physician contact in their last month, and physician education is effective in reducing suicide rates.^{48,49} Our results suggest older adults and those with nonocular health conditions, poor self-rated health, and reported VI are at increased suicide risk. Eye care professionals should be aware of the potential increased risk of suicide for patients with VI, especially those in poor health, and provide appropriate referrals for these patients.

There are several advantages in using the NHIS to examine the relationship between reported VI and suicide. The NHIS is designed to be representative of the US population; only institutionalized and military groups have been omitted. Survey response rates (95%-98%) were excellent, and survival status was available for more than 96% of the participants. The ability to use 13 survey years with 137 479 adult participants with approximately 1.5 million person-years of follow-up allowed the identification of 200 suicide cases, making this analysis the largest study to date to examine the relationship between reported VI and suicide.

Limitations of this study include the fact that, during the study period, NHIS did not annually assess important risk factors associated with disabling eye conditions, such as smoking, a risk factor for cataract and age-related maculopathy. Assessment of some risk factors associated with suicide, such as depression, was not included. The NCHS has not published a study that validated reported chronic conditions against standardized, physician-confirmed diagnoses.

Due to the self- or proxy-reported nature of ascertainment of all ocular conditions in the NHIS, there is likely some misclassification of reported VI. In a study of 570 persons 50 years and older, questions related to visual acuity had a sensitivity of approximately 82% and a specificity from 87% to 89%.⁵⁰ However, visual acuity, contrast and glare sensitivity, stereoacuity, and visual fields are significant independent risk factors for self-reported visual disability, and visual acuity alone is not the only dimension of the association with subjective disability.⁵¹

Another potential limitation of this study is the accuracy of the National Death Index in ascertaining suicide death. Suicide death tends to be underreported, possibly moreso among African Americans and women.⁵²⁻⁵⁴ Unfortunately, the number of suicide deaths in this study is not large enough to perform meaningful race-specific analysis.

In summary, we observed that reported VI increased suicide risk, particularly indirectly via reported health status and health conditions. Our results suggest improved treatments of VI and factors causing poor health could potentially reduce suicide risk.

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