Direct and Indirect Effects of Visual Impairment on Mortality Risk in Older Persons

The Blue Mountains Eye Study

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Objective: To investigate pathways from visual impairment to increased all-cause mortality in older persons.

Methods: The Blue Mountains Eye Study examined 3654 persons 49 years and older (82.4% response) during 1992-1994 and after 5 and 10 years. Australian National Death Index data confirmed deaths until 2005. Visual impairment was defined as presenting, correctable, and noncorrectable, using better-eye visual acuity. Associations between visual impairment and mortality risk were estimated using Cox regression and structural equation modeling.

Results: After 13 years, 1273 participants had died. Adjusting for mortality risk markers, higher mortality was associated with noncorrectable visual impairment (hazard ratio [HR], 1.35; 95% confidence interval [CI], 1.04-1.75). This association was stronger for ages younger than 75 years (HR, 2.58; 95% CI, 1.42-4.69). Structural equation modeling revealed greater effects of noncorrectable visual impairment on mortality risk (HR, 5.25; 95% CI, 1.97-14.01 for baseline ages <75 years), with both direct (HR, 2.16; 95% CI, 1.11-4.23) and indirect (HR, 2.43; 95% CI, 1.17-5.03) effects. Of mortality risk markers examined, only disability in walking demonstrated a significant indirect pathway for the link between visual impairment and mortality.

Conclusions: Visual impairment predicted mortality by both direct and indirect pathways, particularly for persons younger than 75 years with noncorrectable visual impairment. Disability in walking, which can substantially influence general health, represented a major indirect pathway.

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VISUAL IMPAIRMENT HAS CONsistently been associated with a higher risk of dying.[1-8] Visual impairment is also reportedly associated with many factors also linked to increased mortality. These include unintentional injury,[9,10] reduced walking speed,[9,11] depression,[2,11,12] lower body mass index (BMI),[13,14] increased risk of falls,[9,15] self-rated health,[16] self-reported difficulty in physical activity,[11,17] systemic inflammation,[14,18] cardiovascular disease,[11,14] dementia,[17] and cancer.[19,20] Correction for these "confounders" has been found to attenuate the association between visual impairment and mortality, but the mechanisms behind the association between visual impairment and mortality remain to be determined.

Because of the complex interactions of other mortality risk factors with visual impairment, correcting for these covariates using traditional regression techniques could underestimate the total effect of visual impairment on mortality.[21] For example, persons with visual impairment may be more likely to use walking aids because of an increased risk or fear of falling. If true, then adjustment for the use of walking aids, an independent marker of mortality, would underestimate the effect of visual impairment. This covariate is an intermediate variable, a variable that lies on the causal pathway between visual impairment and mortality[22] so that simple adjustment for such variables in a traditional statistical model is not appropriate.

Structural equation modeling (SEM) is a modern statistical method that permits modeling of complex relationships that are difficult to estimate using traditional regression techniques.[23] Structural equation modeling facilitates the examination and quantification of direct pathways and indirect pathways via intermediate variables. Estimates for such variables can be summated to determine the total indirect effect of the variable of interest on the outcome. Add-

ing the indirect and direct effects then estimates the total effect of the variable of interest on the outcome. To our knowledge, only 1 study has used SEM to examine the associations between visual impairment and mortality.[24] This large population survey relied on self-reporting or proxy reporting of visual impairment and comorbidities. The authors reported that in addition to a direct effect on mortality, visual impairment increased mortality risk indirectly through intermediate variables self-rated health and disability.[24] To confirm the findings by Christ et al,[24] we aimed, in an older Australian population-based cohort, to examine associations between visual impairment, mortality risk markers, and the 13-year risk of mortality using a SEM approach.

METHODS

STUDY POPULATION

The Blue Mountains Eye Study (BMES) is a population-based cohort study of vision and common eye diseases in a suburban Australian population 49 years and older at baseline. The study was approved by the Human Research Ethics Committee of the University of Sydney and was conducted adhering to the tenets of the Declaration of Helsinki. Signed informed consent was obtained from all the participants at each examination.

DATA COLLECTION

Survey methods and procedures have been described previously.[25] Briefly, baseline examinations of 3654 residents older than 49 years were conducted during 1992-1994 (BMES 1, 82.4% participation rate). Of the baseline participants, 2335 (75.1% of survivors) returned for 5-year follow-up examinations during 1997-1999 (BMES 2), and 1952 participants (53.4% of the original cohort, or 76.6% of survivors) returned for 10-year follow-up examinations during 2002-2004 (BMES 3). Medical and smoking histories were determined by interviewer-administered questionnaire at baseline. A history of angina, myocardial infarction, diabetes mellitus, hypertension, stroke, or cancer was determined by responses to questions starting with "Has a doctor advised you that you have . . . ?" History of smoking was defined as never, past, or current smoking. Current smokers included those who had stopped smoking within the past year. Weight in kilograms, height in meters, and systolic and diastolic blood pressures were also recorded at baseline.

To identify and confirm persons who died after the baseline examination, demographic information, including surname, first and second names, sex, and date of birth of the 3654 participants, was cross-matched with Australian National Death Index data for deaths to the end of 2005.[26] A probabilistic record linkage package was used, adopting a multiple-pass procedure in which both data sets were grouped based on different characteristics (eg, date of birth, name, sex) each time. Matches were divided into exact and nonexact. All nonexact matched records were examined manually and accepted if there was only 1 nonexact matched characteristic that was not critical. Information provided by family members during follow-up was also included if the participant was reported to have died on or before December 2005.

DEFINITIONS

Classification of hypertension was based on the 2003 World Health Organization/International Society of Hypertension guidelines.[27] Participants were classified as having hypertension stage 1 if systolic blood pressure was 140 to 159 mm Hg or if diastolic blood pressure was 90 to 99 mm Hg. Participants were classified as having hypertension stage 2 if they were previously diagnosed with hypertension and were using antihypertensive medications, if systolic blood pressure was 160 mm Hg or greater, or if diastolic blood pressure was 100 mm Hg or greater at examination. Body mass index was calculated as weight in kilograms divided by height in meters squared, with less than 20 defined as low. Disability in walking at baseline was assessed as present if the participant was observed by a trained examiner to have walking difficulties or used walking aids or a wheelchair.

Visual acuity (VA) was assessed using a logMAR chart. Visual acuity was initially assessed with patients wearing their current eyeglasses. If initial VA was less than 54 letters read correctly (<20/20 Snellen equivalent), refraction was performed. Visual impairment was categorized as presenting visual impairment (PVI), VA less than 20/40 Snellen equivalent (<39 letters read correctly) in the better eye using current glasses; correctable visual impairment (CVI), PVI correctable to 20/40 Snellen equivalent or better by subjective refraction; and noncorrectable visual impairment (NCVI), PVI correctable to worse than 20/40 Snellen equivalent in the better eye after subjective refraction.

STATISTICAL ANALYSIS

Statistical analyses were performed using SAS software version 9.13 (SAS Institute, Cary, North Carolina) and Mplus.[28] Simple statistics included *t* tests for comparing means and χ^2 tests for comparing proportions. Cox regression models were used to estimate hazard ratios (HRs) and 95% confidence intervals (CIs). Multivariable-adjusted models included variables found significantly associated with mortality after age adjustment. These were history of acute myocardial infarction, stroke, angina and hypertension, current smoking, low BMI, cancer, diabetes, walking disability, home ownership, tertiary education, and self-rated health. Additional stratified analyses were conducted by age group (<75 years vs ≥75 years) to assess whether the impact from visual impairment was stronger on premature mortality of the relatively younger age group at baseline (<75 years). A *P* value of less than .05 was considered statistically significant.

Structural equation modeling pathway analysis[23] was used to model the relationship between visual impairment, survival, and covariables found significantly associated with mortality by Cox regression. The SEM was fit using the Mplus[28] statistical package with maximum likelihood and Monte Carlo integration methods. Standard errors were calculated using the delta method and hazard rates obtained from the coefficients by exponentiation. The covariables used in the model were history of acute myocardial infarction, stroke, angina and hypertension, current smoking, low BMI, cancer, diabetes, walking disability, home ownership, tertiary education, and self-rated health. The multiple potential pathways to mortality are shown in **Figure 1**. Each variable was adjusted for age and sex. The indirect effect of visual impairment was then calculated for each covariable by multiplying the effects of that covariable on mortality and visual impairment on the covariable. Models were simplified by removing indirect pathways for individual covariables that were not significant at the *P* value level of .10. The total indirect effect of visual impairment could then be calculated by summating the coefficients of the estimated indirect effects of each mediating variable and then converting to HRs. The total estimated effect of visual impairment on mortality was calculated by summating the coefficients of the indirect and direct effects and then converting to HRs.

RESULTS

STUDY POPULATION

As of December 31, 2005, 1273 BMES participants had died. **Table 1** shows the distribution of known mortality risk markers in persons with and without visual impairment. Compared with those with normal vision, participants with NCVI at baseline were more likely to be female, older (age ≥75 years), and underweight. Persons with CVI were more likely to be older (age ≥75 years), but there was no difference in the proportions of women or persons with low BMI. They were more likely to have a self-reported history of angina, myocardial infarction, stroke, cancer, low self-rated health, and an observed difficulty in walking or use of walking aids. They were less likely to have tertiary education or to own their home. There were no significant differences in the proportions of current smokers or history of hypertension or diabetes between the groups with and without visual impairment.

ASSOCIATION BETWEEN VISUAL IMPAIRMENT AND MORTALITY

Table 2 shows all-cause mortality rates and mortality risk after age and sex adjustment, which were higher in persons with visual impairment compared with those with normal vision. This difference was greater in persons younger than 75 years compared with those 75 years and older at baseline. Persons younger than 75 years with visual impairment were at greater risk of PVI, CVI, and NCVI (PVI: HR, 1.69; 95% CI, 1.32-2.17; CVI: HR, 1.60; 95% CI, 1.23-2.09; NCVI: HR, 2.58; 95% CI, 1.42-4.69). The associations for all ages combined remained either significant or marginally significant after multivariable adjustment (Table 2), although they were substantially attenuated in magnitude (PVI: HR, 1.29; 95% CI, 1.09-1.52; CVI: HR, 1.26; 95% CI, 1.04-1.53; NCVI: HR, 1.35; 95% CI, 1.04-1.75). In persons younger than 75 years, only PVI and NCVI were statistically associated with mortality, while for those 75 years and older, only PVI was significantly associated with mortality, after multivariable adjustment.

Structural equation modeling pathway analysis confirmed that visual impairment influenced mortality by both direct and indirect pathways. **Table 3** shows the HRs and 95% CIs using this model. The pattern was similar to the Cox regression models, except that the HRs were higher when estimated using SEM.

Of the risk markers investigated by SEM, only disability in walking represented a significant indirect pathway from visual impairment to mortality. **Table 4** lists the HRs and 95% CIs for the indirect effects of disability in walking on mortality. **Figures 1**, **2**, and **3** illustrate the detailed pathways that could explain the associations found between visual impairment and mortality. There was a significant indirect pathway from visual impairment to mortality via disability in walking, through poorer self-rated health, to mortality (Table 4) (Figures 1, 2, and 3). An indirect pathway through lower BMI bordered on significance for NCVI in all age groups (HR, 1.21; 95% CI, 0.99-1.48; $P = .06$) but was not significant for other forms of visual impairment or after age stratification (data not shown). There was no indirect pathway through any other mortality risk markers (eg, history of angina, acute myocardial infarction, stroke, hypertension, diabetes, cancer, or smoking). There were also no indirect pathways from visual impairment to mortality through lower home ownership or education levels. There was no indirect pathway from visual impairment to mortality through poorer self-rated health that was independent of disability in walking.

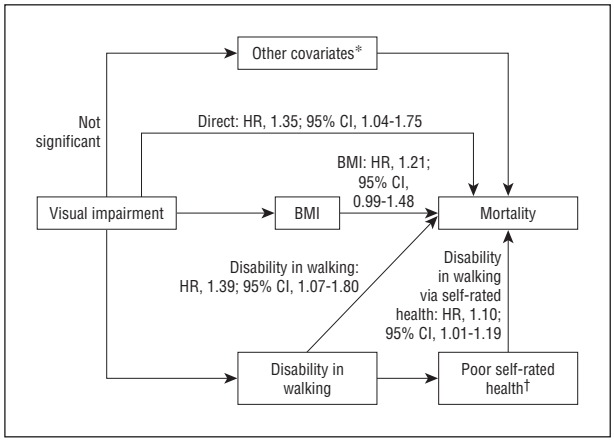

Figure 1. Structural equation modeling path for the relationship between noncorrectable visual impairment, risk markers, and all-cause mortality in all ages, showing hazard ratios (HRs) and 95% confidence intervals (CIs) (total indirect: HR, 1.68; 95% CI, 1.21-2.33). Covariates are corrected for age and sex. BMI indicates body mass index (calculated as weight in kilograms divided by height in meters squared). *Other covariates include the mortality risk markers angina, myocardial infarction, stroke, cancer, hypertension, smoking, diabetes mellitus, home ownership, tertiary education, and self-rated health. †There was no significant relationship between visual impairment and self-rated health independent of walking disability.

COMMENT

In agreement with previous reports,[1-8] we observed that the presence of visual impairment predicted mortality in older persons. Using Cox regression models, PVI predicted mortality independent of age, sex, and the presence of known mortality risk markers. Using SEM analysis, we confirmed that visual impairment increased mortality via both direct and indirect pathways. The relationship between visual impairment and mortality was strongest for NCVI among persons with baseline ages younger than 75 years.

Compared with estimates from SEM, Cox regression appears to underestimate the effect of visual impairment on mortality by overcorrecting for intermediate variables that were associated with both visual impairment and mortality. To determine which indirect effects were important in predicting mortality for visually impaired persons, we modeled each covariate as a pathway to mortality (Table 4). Of the mortality risk markers we assessed, only disability in walking represented a significant indirect pathway. For this association, 2 possible pathways were identified; 1 pathway involved only disability in walking, and the second also involved an effect through low self-rated health (Table 4) (Figure 1). Because of reduced power through fewer events, we were unable to differentiate indirect effects via age. The age-related trend for mortality, however, suggests that in persons younger than 75 years

Table 1. Prevalence of Mortality Risk Markers in Participants of the Blue Mountains Eye Study 10-Year Follow-up Examination by Visual Impairment

Characteristic	Visual Impairment, No. (%)			*P* Value
	None (n=3224)	Correctable (n=269)	Noncorrectable (n=130)	
Sex				.004
M	1412 (43.8)	119 (44.2)	38 (29.2)	
F	1812 (56.2)	150 (55.8)	92 (70.8)	
Age, y				<.001
<75	2743 (85.1)	155 (57.6)	27 (20.8)	
≥75	481 (14.9)	114 (42.4)	103 (79.2)	
Smoking[a]				.13
Never	1492 (48.4)	128 (49.6)	67 (59.8)	
Past	1122 (36.4)	88 (31.3)	35 (34.1)	
Current	471 (15.3)	42 (16.3)	10 (8.9)	
BMI[b]				<.001
Underweight	168 (5.3)	18 (6.9)	19 (17.9)	
Normal	1183 (37.6)	110 (42.3)	45 (42.5)	
Overweight	1250 (39.7)	97 (37.3)	24 (22.6)	
Obese	549 (17.4)	35 (13.5)	18 (17.0)	
Hypertension[a,b]				.41
None	926 (28.9)	69 (25.7)	30 (24.4)	
Stage 1	843 (26.3)	65 (24.2)	34 (27.6)	
Stage 2	1437 (44.8)	135 (50.2)	59 (48.0)	
Diabetes mellitus[a]	244 (7.6)	23 (8.6)	13 (10.0)	.52
Stroke[a]	150 (4.7)	23 (8.6)	16 (12.7)	<.001
Angina[a]	366 (11.4)	54 (20.1)	25 (20.0)	<.001
Myocardial infarction[a]	275 (8.6)	34 (12.7)	21 (16.8)	<.001
Cancer[a]	260 (8.1)	27 (10.0)	19 (14.6)	.02
Walking disability[b]	173 (5.4)	41 (15.2)	44 (33.8)	<.001
Home ownership[a]	2807 (89.3)	219 (83.9)	103 (83.1)	.004
Higher education[a]	1810 (59.7)	116 (47.2)	48 (41.7)	<.001
Fair or poor self-rated health[a]	766 (24.1)	83 (31.4)	47 (38.8)	<.001

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).
[a] Self-reported.
[b] Examiner assessed.

Table 2. Association of VI and All-Cause Mortality Assessed Using Cox Regression by VI Category[a]

Age, y	Mortality Rate, No. of Deaths/No. at Risk		Age- and Sex-Adjusted		Multivariable Adjusted[b]	
	No VI	VI	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
			PVI			
All	995/3224	273/399	1.49 (1.29-1.73)	<.001	1.29 (1.09-1.52)	.003
<75	595/2680	72/170	1.69 (1.32-2.17)	<.001	1.42 (1.07-1.87)	.02
≥75	400/544	201/229	1.39 (1.17-1.67)	<.001	1.24 (1.01-1.53)	.04
			CVI			
All	995/3224	163/269	1.47 (1.24-1.74)	<.001	1.26 (1.04-1.53)	.02
<75	595/2680	61/147	1.60 (1.23-2.09)	<.001	1.33 (0.99-1.80)	.06
≥75	400/544	102/122	1.36 (1.09-1.70)	.006	1.20 (0.94-1.55)	.15
			NCVI			
All	995/3224	110/130	1.56 (1.25-1.94)	<.001	1.35 (1.04-1.75)	.02
<75	595/2680	11/23	2.58 (1.42-4.69)	.002	2.16 (1.11-4.23)	.02
≥75	400/544	99/107	1.45 (1.15-1.83)	.002	1.30 (0.97-1.73)	.08

Abbreviations: CI, confidence interval; CVI, correctable visual impairment; HR, hazard ratio; NCVI, noncorrectable visual impairment; PVI, presenting visual impairment; VI, visual impairment.
[a] Reference group is persons without any VI.
[b] Covariates include the mortality risk markers angina, myocardial infarction, stroke, cancer, hypertension, walking disability, low body mass index (calculated as weight in kilograms divided by height in meters squared), smoking, diabetes mellitus, home ownership, and tertiary education, corrected for age, sex, and VI.

at baseline, the pathway through self-rated health may be more important than the pathway directly from disability in walking to mortality (Table 4).

Weaker associations were consistently found in persons 75 years and older at baseline and are not unexpected. Many studies have reported no associations be-

Table 3. Association of VI and All-Cause Mortality Assessed Using Structural Equation Modeling by VI Category[a]

	Total		Direct		Indirect[b]	
Age, y	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
			PVI			
All	1.80 (1.38-2.35)	<.001	1.29 (1.09-1.52)	.003	1.40 (1.13-1.73)	.002
<75	2.14 (1.39-3.28)	<.001	1.42 (1.07-1.87)	.02	1.51 (1.07-2.12)	.02
≥75	1.46 (1.04-2.05)	.03	1.24 (1.01-1.53)	.04	1.18 (0.90-1.54)	.24
			CVI			
All	1.60 (1.18-2.17)	.002	1.26 (1.04-1.53)	.02	1.27 (1.00-1.61)	.05
<75	1.81 (1.15-2.85)	.01	1.33 (0.99-1.80)	.06	1.36 (0.95-1.93)	.09
≥75	1.34 (0.89-2.03)	.16	1.20 (0.94-1.55)	.15	1.12 (0.80-1.55)	.51
			NCVI			
All	2.27 (1.50-3.43)	<.001	1.35 (1.04-1.75)	.02	1.68 (1.21-2.33)	.002
<75	5.25 (1.97-14.01)	<.001	2.16 (1.11-4.23)	.02	2.43 (1.17-5.03)	.02
≥75	1.63 (1.03-2.59)	.04	1.30 (0.97-1.73)	.08	1.25 (0.87-1.81)	.22

Abbreviations: See Table 2.
[a] Reference group is persons without any VI.
[b] Covariates include walking disability and low body mass index (calculated as weight in kilograms divided by height in meters squared).

Table 4. Total Indirect Effects of VI to All-Cause Mortality Using Structural Equation Modeling Pathway Analysis Stratified by Pathway[a]

	Total Indirect Effect		Disability in Walking Pathway		Disability in Walking via Poor Self-rated Health Pathway	
Age, y	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
			PVI			
All	1.29 (1.09-1.53)	.004	1.20 (1.05-1.37)	.006	1.07 (1.01-1.14)	.01
<75	1.35 (1.01-1.80)	.04	1.22 (0.99-1.51)	.07	1.11 (0.99-1.24)	.07
≥75	1.18 (0.95-1.47)	.12	1.14 (0.96-1.34)	.14	1.04 (0.98-1.11)	.19
			CVI			
All	1.24 (1.03-1.51)	.03	1.17 (1.02-1.35)	.03	1.06 (1.00-1.13)	.04
<75	1.27 (0.94-1.71)	.11	1.08 (0.97-1.21)	.14	1.17 (0.95-1.44)	.14
≥75	1.19 (0.92-1.53)	.19	1.14 (0.94-1.38)	.20	1.04 (0.97-1.12)	.23
			NCVI			
All	1.39 (1.07-1.80)	.01	1.27 (1.04-1.54)	.02	1.10 (1.01-1.19)	.03
<75	1.82 (0.99-3.34)	.05	1.23 (0.98-1.54)	.08	1.48 (0.95-2.31)	.08
≥75	1.18 (0.88-1.57)	.26	1.13 (0.91-1.41)	.27	1.04 (0.97-1.12)	.29

Abbreviations: See Table 2.
[a] Reference group is persons without any VI.

tween visual impairment and mortality after correcting for covariates in older populations or in analyses that included all ages in 1 model.[1,10,13] Similar findings are reported for cardiovascular risk factors where risk factors lose their predictive power after ages of 80 years and older.[1,29-31] One explanation is a ceiling effect, where mortality risk is already high in persons 75 years and older because of multiple mortality risk factors so that there is a limit to the additional contribution from visual impairment to mortality. Another explanation is "selective survival," that is, persons genetically predisposed to die of causes related to visual impairment will do so at a relatively younger age, leaving those without this predisposition to survive into very old age.

We found that CVI also increased mortality risk via both direct and indirect pathways. Although the direct effect of CVI on mortality risk seems counterintuitive, the association may occur in both directions. The SEM provides information on the magnitude of the association but not its direction. There are several mechanisms that could explain the associations we found between visual impairment and mortality. Persons with various disabilities in walking may be less likely to see a doctor regularly or to have prescriptions for critical medications filled. They may be more socially isolated, have a poorer and relatively unvaried diet, and less able to seek urgent help when needed. They may also be less likely to exercise regularly, leading to lower cardiorespiratory reserve and greater risk of death during the stress of illness. Disabilities in walking are also associated with increasing risk of falls and fractures (eg, hip fractures),[32] which may lead to an increased risk of death.

For the direct pathway, there are probably many unidentified covariates that were not accounted for. One example is poor diet, which is associated with age-related macular degeneration,[33-35] cataract,[36,37] cancer,[38,39] diabe-

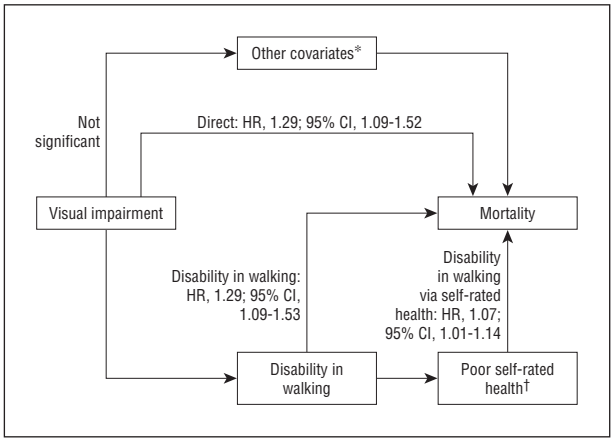

Figure 2. Structural equation modeling path for the relationship between presenting visual impairment, risk markers, and all-cause mortality in all ages, showing hazard ratios (HRs) and 95% confidence intervals (CIs) (total indirect: HR, 1.40; 95% CI, 1.13-1.73). Covariates are corrected for age and sex. *Other covariates include the mortality risk markers angina, myocardial infarction, stroke, cancer, hypertension, smoking, diabetes mellitus, home ownership, tertiary education, and self-rated health. †There was no significant relationship between visual impairment and self-rated health independent of walking disability.

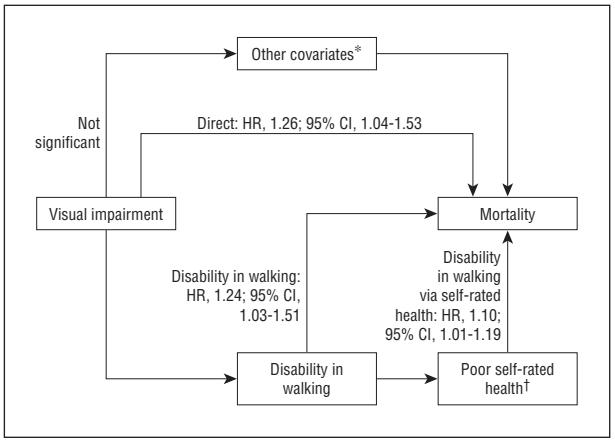

Figure 3. Structural equation modeling path for the relationship between correctable visual impairment, risk markers, and all-cause mortality in all ages, showing hazard ratios (HRs) and 95% confidence intervals (CIs) (total indirect: HR, 1.27; 95% CI, 1.00-1.61). Covariates are corrected for age and sex. *Other covariates include the mortality risk markers angina, myocardial infarction, stroke, cancer, hypertension, smoking, diabetes mellitus, home ownership, tertiary education, and self-rated health. †There was no significant relationship between visual impairment and self-rated health independent of walking disability.

tes,[40,41] and cardiovascular disease.[38,39,42] We found some evidence of an indirect association through lower BMI to mortality for NCVI, which may support this speculation. The direct pathway may also be explained by some systemic processes that are common to both visual impairment and mortality, such as chronic inflammation.

To our knowledge, only 1 other study has used SEM to examine the pathways from visual impairment to mortality. In agreement with their findings, our study reported a small but significant indirect effect through disability.[24] In contrast to our results, however, these authors reported that self-rated health was a significant indirect pathway that was independent of disability in walking. Other notable differences from this earlier study were that the indirect pathways had a lower magnitude than the direct pathway and the HRs were much lower in comparison with those estimated from our study sample. There were 2 main differences between this earlier study and ours that may explain this disagreement. First, while the earlier study was comparable with ours in many ways, there was no objective measure of VA. Visual function was assessed by self-reporting and proxy reporting of visual impairment by asking whether each person was blind or had difficulty seeing from one or both eyes. This could have introduced bias because persons with lower self-rated health and/or disability might have been more likely to overestimate visual impairment and vice versa. Second, the earlier study included persons 18 years and older in comparison with 49 years and older in our study.

The strengths of our study include its large population-based data set, with high participation and long follow-up period, standardized VA assessment, use of Australian National Death Index mortality and causes of death data, and detailed data on the health and functional status of participants. Limitations include the possibility that not all potential mortality markers were included in the model, such as exercise, diet, and nutrition variables. Also, the relatively low number of persons with visual impairment after age stratification limits our ability to detect weak associations that could be significant. Limitations of SEM include the assumption that relationships between variables in the model are linear and that the directions of the arrows in the path model are assumed but cannot be proven.

In conclusion, this study reaffirms that visual impairment is associated with an increased risk of all-cause mortality. Analysis using SEM suggests both direct and indirect pathways for this relationship. Disability in walking may represent an important indirect pathway to mortality for persons with visual impairment, and adjusting for this factor in statistical analysis may overadjust for the indirect effect of visual impairment on mortality risk. The impact of visual impairment on mortality may in fact be greater than that reported from previous studies that have used traditional statistical models.

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