Visual Acuity and Mortality in a Chinese Population

The Tanjong Pagar Study

Athena W. P. Foong, BSc,[1,2] Chee Weng Fong, MSc(Stats),[3] Tien Y. Wong, PhD, FRANZCO,[1,2,4] Seang-Mei Saw, PhD,[1,2,5] Derrick Heng, MPhil,[3] Paul J. Foster, PhD, FRCSEd[6]

Objective: To examine the relationship between visual acuity and mortality in a Chinese population.

Design: Population-based cohort study.

Participants: Chinese persons in Singapore ages 40 to 79 years at baseline examination.

Methods: The Tanjong Pagar Study in Singapore examined 1232 persons (response rate, 71.8%) at the baseline examination in 1997 and 1998. Participants had measurements of presenting and best-corrected visual acuity (VA) using standardized protocols. Mortality data were obtained from the National Death Registry, which linked subjects who had died since the baseline examination. Cause of death was determined from the International Classification of Diseases 9 codes. Analysis was performed on 1225 (99.4%) participants with VA data.

Main Outcome Measure: All-cause mortality.

Results: By December 31, 2004 (median follow-up, 6.8 years), 126 persons had died. Participants with presenting VA in the better eye worse than 20/40 (logarithm of the minimum angle of resolution [logMAR] score, 0.3) had a significantly higher mortality rate (hazard ratio [HR], 2.9; 95% confidence interval [CI], 1.4–6.3, adjusting for age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income) as compared with participants with VA of 20/20 (logMAR, 0.0). Associations were similar for best-corrected VA in the better eye (HR, 2.7; 95% CI, 1.4–5.5). Among clinic participants with logMAR VA measurements, each 1-line difference in presenting VA (logMAR gain, 0.10) was associated with a 4-fold increased risk of mortality (HR, 4.4; 95% CI, 1.9–10.2).

Conclusions: In this Chinese population in Singapore, visual impairment was associated independently with an increased risk of mortality. *Ophthalmology 2008;115:802–807 © 2008 by the American Academy of Ophthalmology.*

Visual impairment is a significant public health problem and is associated with ocular morbidity and poorer quality of life. Emerging evidence suggests that visual impairment also is an independent marker for mortality. Population-based studies, largely among white persons, have shown that poorer visual acuity (VA) significantly increases the risk of death.[1–9] In the 14-year follow-up of the Beaver Dam Eye Study in Wisconsin, best-corrected VA of 20/40 (logarithm of the minimum angle of resolution [logMAR] score, 0.3) or worse was associated with increased mortality (hazard ratio [HR], 1.24; 95% confidence interval [CI], 1.04–1.48) while controlling for demographic, lifestyle, and various systemic risk factors for mortality.[9]

To the best of our knowledge, no data show an association between VA and mortality in Asian populations. In this study, we examined the relationship between VA and mortality in a population-based cohort of urban Chinese adults aged 40 to 79 years at baseline residing in Singapore.

Originally received: October 10, 2006.
Final revision: April 30, 2007.
Accepted: April 30, 2007.
Available online: August 31, 2007. Manuscript no. 2006-1149.

[1] Singapore Eye Research Institute, Singapore.

[2] Department of Ophthalmology, Yong Loo Lin School of Medicine, National University of Singapore, Singapore.

[3] Epidemiology & Disease Control Division, Ministry of Health, Singapore.

[4] Centre for Eye Research Australia, University of Melbourne, Melbourne, Australia.

[5] Department of Community, Occupational, and Family Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore.

[6] Institute of Ophthalmology, University College London, London, United Kingdom.

Supported by the National Medical Research Council, Singapore, and British Council for the Prevention of Blindness, London, United Kingdom.

The authors have no proprietary interests related to the article.

Correspondence to Tien Yin Wong, PhD, FRANZCO, Centre for Eye Research Australia, University of Melbourne, 32 Gisborne Street, Victoria 3002, Australia. E-mail: twong@unimelb.edu.au.

Patients and Methods

Study Population and Procedures

The Tanjong Pagar Study was a population-based survey of eye diseases among Chinese adults living in Singapore conducted

ISSN 0161-6420/08/$–see front matter
doi:10.1016/j.ophtha.2007.04.066

between October, 1997, and August, 1998.[10,11] The study was approved by the ethics committee of the Singapore National Eye Center and was carried out in accordance with the tenets of the World Medical Association's Declaration of Helsinki. Written informed consent was obtained from all participants. Detailed population selection and methodology were described previously.[10–16] Briefly, the names of 2000 Chinese persons aged 40 to 79 years residing in the Tanjong Pagar district was selected from the 1996 electoral register (13% of 15 082 names) using a disproportionate (with more weights given to the older age groups), stratified, clustered, random sampling procedure. Of the 1717 persons considered eligible to participate, 1090 underwent a comprehensive eye examination at the research clinic and a further 142 were examined at their homes, bringing the total number of participants to 1232 (response rate, 71.8%).

This study included participants from both the clinic and home examinations with VA measurements (n = 1225; 99.4% of 1232). We also conducted a subanalysis among the 1088 participants (99.8% of 1090) who attended the research clinic examination, where VA was measured using logMAR charts at 4 m.

Visual Acuity Measurement and Definitions

Visual acuity was measured using standardized procedures previously described. For all examinations conducted at the clinic, presenting VA was measured using logMAR charts at 4 m with distance correction, if any.[11] Refractive error was assessed using an autorefractor, and best-corrected VA was obtained after subjective refraction.[10] LogMAR scores for each eye for both presenting and best-corrected VA were recorded as the last line where 3 letters or more were read correctly, in increments of 0.10.[14] For home examinations, presenting VA was assessed using a Snellen chart at 3 m with distance correction, if any. If the reading was less than 20/40, VA was remeasured using a pinhole to ascertain best-corrected VA. Refractive error was measured using a handheld autorefractor; subjective refraction was not assessed in home examinations.

In our main analyses (n = 1225), Snellen readings from home examinations were converted to equivalent logMAR scores and were combined with logMAR scores obtained from the clinic examination. Visual acuity then was categorized into none, mild, moderate, and severe reduction, corresponding to logMAR (Snellen) cutoffs of 0.00 (20/20), 0.18 (20/30), 0.30 (20/40), and more than 0.30 (more than 20/40). In our subanalysis of clinic participants (n = 1088), VA also was analyzed as a continuous variable (per 0.10 difference in the logMAR score).

Complete examinations of the anterior segment, fundus, and optic disc were conducted at the slit lamp using standardized protocols. Ocular biometry, intraocular pressure, lens opacity scores using the modified Lens Opacity Classification System III, as well as blood pressure, height, and weight were recorded.[11–13] Information on medical history, smoking status, and socioeconomic indicators were obtained using interviewer-administered standard questionnaires.[10–16]

Hypertension was defined as systolic blood pressure of 140 mmHg or more, diastolic blood pressure of 90 mmHg or more, use of antihypertensive medication, or a combination thereof.[15] Diabetes was defined as use of diet, oral diabetic medications, insulin injections, or a combination thereof.[16] Cigarette smoking was defined as either current or past/never. Heart attack and stroke were defined from self-report (yes or no). Income was defined as individual monthly income (no income/retired, Singapore $1–$1000, $1001–$1500, $1501–$2000, or more than $2000).

Definitions of various ocular condition examined in the Tanjong Pagar Study, including presence of cataract (nuclear, cortical, posterior subcapsular), glaucoma, refractive errors (myopia, hypermetropia, astigmatism, anisometropia), undercorrected refractive error, and pterygium, were described previously.[10–14]

Mortality Data

The unique national registration identity card numbers, together with date of birth and gender, of the 1232 members of the original cohort were matched with mortality records maintained by the National Registry of Births and Deaths. Vital status as of December 31, 2004, was determined for 100% of the participants. Information on the date of death and primary cause of death (given on the death certificate) for the participants were extracted. The underlying cause of death was reported using the International Classification of Diseases 9 codes. Cancer mortality was defined according to codes 140.0 to 208.9, ischemic heart disease was defined according to codes 410.0 to 414.9, cerebrovascular disease was defined according to mortality codes 430.0 to 438.9, and pneumonia, influenza, bronchitis, asthma were defined according to codes 480.0 to 493.9. Previous studies using this system of identifying deaths and using International Classification of Diseases 9 codes have been reported in Singapore.[17]

Statistical Analysis

Person-days were calculated for each participant from the date of individual examinations where VA was measured through December 31, 2004. We used presenting and best-corrected VA data from the better eye for this study. Analyses using data from the right or left eye produced largely similar results (data not shown).

To determine the association of VA and mortality, we estimated HRs and 95% CIs for all-cause mortality using Cox's proportional hazards regression for stratified presenting VA and best-corrected VA groups (VA≤0.00, 0.00<VA≤0.18, 0.18<VA≤0.30, and VA>0.30). The proportional hazard assumption was checked by plotting the log-minus-log plot of the estimated survival functions against log time. Plots of survival curves stratified by group were generated by the Kaplan-Meier method, and the log-rank test was used for comparing different groups with respect to their survival distributions. We constructed 3 models: crude; adjusted for age and gender; and adjusted for age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income (multivariable model). All analyses were performed using SPSS software version 13.0 (SPSS, Inc., Chicago, IL).

Results

Table 1 shows the baseline characteristics of participants according to their better-eye presenting VA status. Persons with poorer presenting VA tended to be females, to have cataract or to have undergone cataract surgery, and to have undercorrected refractive error, regardless of age.

By December 31, 2004 (median follow-up, 6.8 years), 126 persons from the baseline cohort had died. After adjusting for age and gender, systemic correlates of mortality include hypertension (HR, 1.7; 95% CI, 1.0–3.0), diabetes (HR, 2.5; 95% CI, 1.6–4.0), smoking (HR, 1.9; 95% CI, 1.2–3.0), heart attack (HR, 1.7; 95% CI, 0.9–3.0), stroke (HR, 2.2; 95% CI, 1.0–4.7), and income (HR, 2.0; 95% CI, 1.2–3.2, comparing retired/no income with income of Singapore $1–$1000; other income categories were not statistically significant [data not shown]).

Table 2 shows mortality by better-eye presenting VA. In crude analysis, poorer presenting VA categories were associated strongly with mortality. Figure 1 shows the age- and gender-adjusted survival curve for presenting VA categories. Persons with mild,

Table 1. Baseline Characteristics of Study Participants by Presenting Visual Acuity Categories in the Better Eye in The Tanjong Pagar Study

Characteristics	Presenting Visual Acuity, Logarithm of the Minimum Angle of Resolution Scores (Snellen Equivalent)				
	Visual Acuity≤0.00 (Visual Acuity≤20/20), n = 456	*0.00<Visual Acuity≤0.18 (20/20<Visual Acuity≤20/30), n = 265*	*0.18<Visual Acuity≤0.30 (20/30<Visual Acuity≤20/40), n = 291*	*Visual Acuity>0.30 (Visual Acuity>20/40), n = 213*	P *Value (Trend)**
Mean age, yrs (standard deviation)	53.6 (9.6)	59.6 (9.8)	64.5 (9.8)	67.9 (10.0)	
Male gender, %	49.1	42.6	47.1	37.1	0.00
Hypertension, %	51.3	61.4	74.2	77.5	0.11
Diabetes, %	7.2	10.6	13.9	17.1	0.27
Smoking, %	17.5	18.1	22.3	15.7	0.74
Any cataract or cataract surgery, %	35.6	55.2	73.6	83.4	0.03
Any undercorrected refractive error, %	0.0	0.0	50.0	70.2	<0.001
Any glaucoma, %	1.4	2.1	4.3	5.7	0.31

*Adjusted for age.

moderate, and severe reduction in presenting VA (presenting VA, worse than 20/20) had poorer survival compared with persons with normal vision (presenting VA, 20/20 or better; $P<0.001$, log-rank test). The association between presenting VA and mortality was weakened but remained significant after controlling for age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income. In the final multivariable model, participants with presenting VA in the better eye worse than logMAR 0.3 had an HR of 2.9 (95% CI, 1.4–6.3) as compared with participants with logMAR VA of 0.0. Associations were largely similar in the subanalysis of clinic participants, with a corresponding multivariate-adjusted HR of 2.6 (95% CI, 1.2–5.7) comparing logMAR 0.3 versus logMAR 0.0.

Table 3 shows results for better-eye best-corrected VA, and Figure 2 shows the age- and gender-adjusted survival curve for best-corrected VA categories ($P<0.001$, log-rank test). In the final multivariable model, as compared with participants with best-corrected logMAR VA of 0.0, participants with VA worse than logMAR 0.3 had an HR of 2.7 and 2.4, respectively, for all participants and clinic participants.

Among clinic participants, a 1-line difference in presenting VA (logMAR increase, 0.10) was associated with a 4-fold increased risk in mortality (HR, 4.4; 95% CI, 1.9–10.2), after adjustment for independent predictors of mortality, including age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income. The increase in mortality risk was more pronounced for every 1-line difference in best-corrected VA (HR, 6.8; 95% CI, 1.8–25.9) after adjustment for the variables (data not shown).

The underlying causes of death varied by presenting VA categories. Persons with VA of 20/20 or better were more likely to die of cancer, whereas persons with VA worse than 20/40 were more likely to die of other causes that included diabetes, renal failure, and injury. However, the number of deaths was too small to detect any significant pattern in the causes of death by increasing severity of visual impairment.

Table 2. Proportional Hazards Models of All-Cause Mortality by Better-Eye Presenting Visual Acuity in All Participants and Clinic Participants

Presenting Visual Acuity, Logarithm of the Minimum Angle of Resolution Scores (Snellen Equivalent)	No.	All-Cause Mortality Hazard Ratio (95% Confidence Interval)			
		No. (%)	*Crude*	*Age- and Gender-Adjusted**	*Multivariable Adjusted†*
All participants (n = 1225)					
VA≤0.00 (Snellen≤20/20)	456	12 (2.6)	1.0	1.0	1.0
0.00<VA≤0.18 (20/20<Snellen≤20/30)	265	25 (9.4)	3.8 (1.9–7.5)‡	2.5 (1.2–5.0)§	2.2 (1.0–4.6)§
0.18<VA≤0.30 (20/30<Snellen≤20/40)	291	43 (14.8)	6.1 (3.2–11.5)‡	2.8 (1.5–5.5)§	3.0 (1.5–6.2)§
VA>0.30 (Snellen>20/40)	213	46 (21.6)	9.4 (5.0–17.7)‡	3.7 (1.9–7.4)§	2.9 (1.4–6.3)§
P value (trend)			<0.001	<0.001	0.01
Clinic participants only (n = 1088)					
VA≤0.00 (Snellen≤20/20)	438	11 (2.5)	1.0	1.0	1.0
0.00<VA≤0.18 (20/20<Snellen≤20/30)	237	22 (9.3)	3.8 (1.9–7.9)‡	2.5 (1.2–5.2)§	2.3 (1.1–4.9)§
0.18<VA≤0.30 (20/30<Snellen≤20/40)	256	37 (14.5)	6.2 (3.1–12.1)‡	2.9 (1.4–5.8)§	2.8 (1.4–5.8)§
VA>0.30 (Snellen>20/40)	157	25 (15.9)	6.8 (3.3–13.8)‡	2.6 (1.2–5.5)§	2.6 (1.2–5.7)§
P value (trend)			<0.001	0.02	0.02

VA = visual acuity.
*Adjusted for age and gender.
†Adjusted for age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income.
‡$P<0.001$.
§$P<0.05$.

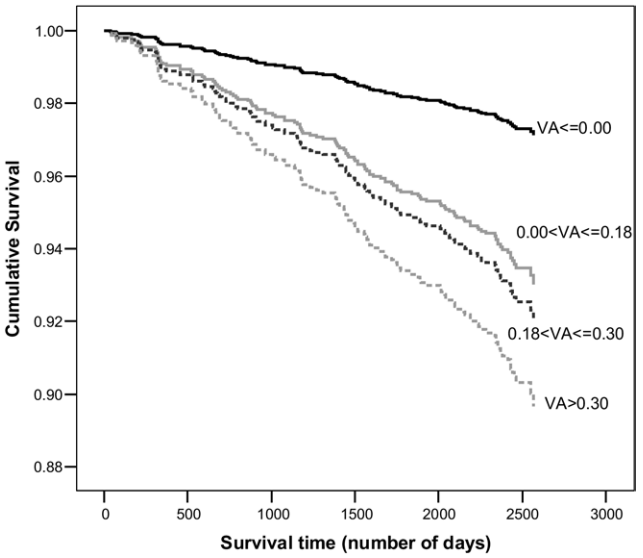

Figure 1. Graph showing age- and gender-adjusted survival curves according to better-eye presenting visual acuity (VA) categories.

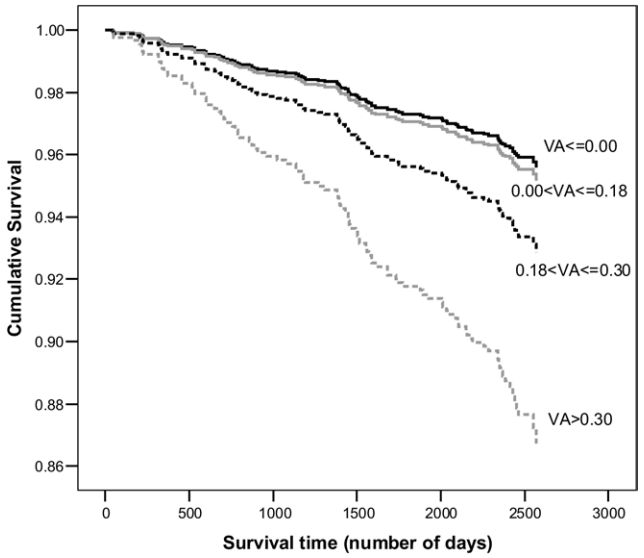

Figure 2. Graph showing age- and gender-adjusted survival curves according to better-eye best-corrected visual acuity (VA) categories.

In addition to VA, we examined the association of cataract (nuclear, cortical, posterior subcapsular, cataract surgery), glaucoma, intraocular pressure, refractive errors (myopia, hypermetropia, astigmatism, anisometropia), undercorrected refractive error, pterygium, and ocular biometry parameters (axial length and vitreous chamber depth) with mortality. We did not find significant associations for any of these conditions (data not shown).

Discussion

Our study demonstrates the relationship of presenting and best-corrected VA with mortality in an urban Chinese population in Singapore. We showed that persons with presenting VA worse than 20/20 (logMAR, 0.0) had a 3-fold higher risk of death as compared with persons with normal vision (VA, 20/20 or better), independent of other predictors of mortality. The risk of death increased 4-fold for every 1-line decrease of presenting VA. After best correction, persons with VA worse than 20/40 (logMAR, 0.3) also had a higher risk of death after multivariate adjustments.

These results are consistent with findings from other population-based studies in Western countries that have documented the relationship of VA and mortality (Table 4).

Table 3. Proportional Hazards Models of All-Cause Mortality by Better Eye Best-Corrected Visual Acuity in All Participants and Clinic Participants

Best-Corrected Visual Acuity, Logarithm of the Minimum Angle of Resolution Scores (Snellen Equivalent)	No.	All-Cause Mortality Hazard Ratio (95% Confidence Interval)			
		No. (%)	*Crude*	*Age- and Gender-Adjusted**	*Multivariable Adjusted†*
All participants (n = 1102)‡					
VA≤0.00 (Snellen≤20/20)	708	34 (4.8)	1.0	1.0	1.0
0.00<VA≤0.18 (20/20<Snellen≤20/30)	186	19 (10.2)	2.2 (1.3–3.8)§	1.1 (0.6–2.0)	1.0 (0.5–1.8)
0.18<VA≤0.30 (20/30<Snellen≤20/40)	139	27 (19.4)	4.5 (2.7–7.4)§	1.6 (0.9–2.9)	1.6 (0.9–2.9)
VA>0.30 (Snellen>20/40)	69	20 (29.0)	7.3 (4.2–12.8)§	3.2 (1.7–5.9)§	2.7 (1.4–5.5)‖
P value (trend)			<0.001	0.00	0.02
Clinic participants only (n = 1061)§					
VA≤0.00 (Snellen≤20/20)	708	34 (4.8)	1.0	1.0	1.0
0.00<VA≤0.18 (20/20<Snellen≤20/30)	183	19 (10.4)	2.2 (1.3–3.9)‖	1.1 (0.6–2.0)	1.0 (0.5–1.8)
0.18<VA≤0.30 (20/30<Snellen≤20/40)	125	24 (19.2)	4.3 (2.6–7.3)§	1.5 (0.8–2.8)	1.5 (0.8–2.9)
VA>0.30 (Snellen>20/40)	45	12 (26.7)	6.3 (3.3–12.2)§	2.8 (1.3–5.7)‖	2.4 (1.2–5.1)‖
P value (trend)			<0.001	0.01	0.04

VA = visual acuity.
*Adjusted for age and gender.
†Adjusted for age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income.
‡Difference in numbers between presenting VA (Table 2) and best-corrected VA (Table 3) because of the lack of best-corrected VA data among home examination participants who had a presenting VA of 20/40 or better (logarithm of the minimum angle of resolution, 0.3 or better) and inability to perform subjective refraction on clinic participants.
§$P<0.001$.
‖$P<0.05$.

Table 4. Studies of Visual Acuity as a Predictor for Mortality in Population-Based Surveys

Year	Study Name, Location	Population	Sample Size (No. Persons)	Follow-up (yrs)	Significant Association with Mortality	Hazard Ratio (95% Confidence Interval)	Multivariate Controls
1989	Melton Mowbray, United Kingdom[1]	White persons more than 75 yrs of age	469	5	Best-corrected VA worse than 20/20 and better than 20/200	2.10 (1.19–3.68)	Age and gender
2001	Visual Impairment Project, Australia[3]	White persons more than 40 yrs of age	3271	5	Best-corrected VA worse than 20/40	2.34 (1.03–5.32)	Age, gender, smoking, systemic, and ocular conditions
2001	Blue Mountains Eye Study, Australia[4]	White persons more than 49 yrs of age	3654	5	Best-corrected VA 20/40 or worse	1.7 (1.2–2.3)	Age, gender, socioeconomic status, smoking, alcohol intake, and systemic conditions
2002	National Health Interview Survey, United States[5]	Multiracial	116 796	11	Self-reported severe bilateral visual impairment for women	2.21 (1.61–3.02)	Survey design, age, race, socioeconomic status, health status, and ocular conditions
2004	Age-Related Eye Disease Study, United States[6]	Multiracial	4757	6.5	Best-corrected VA worse than 20/40	1.36 (1.12–1.65)	Age, gender, race, education, smoking, and systemic conditions
2005	Medical Research Council Study, United Kingdom[7]	White persons	13 569	6	Presenting VA worse than 20/60	1.17 (1.07–1.27)	Age, gender, lifestyle, smoking, alcohol intake, socioeconomic status, and systemic conditions
2005	Salisbury Eye Evaluation, Maryland[8]	White and black persons	1991	8	Presenting VA, per 1 line decrease, at baseline	1.05 (1.01–1.09)	Age, gender, race, body mass index, smoking, and systemic conditions
2006	Beaver Dam Eye Study, United States[9]	White persons	4926	14	Best-corrected VA 20/40 or worse	1.24 (1.04–1.48)	Age, gender, body mass index, smoking, socioeconomic status, and systemic conditions
2006	Tanjong Pagar Study, Singapore	Chinese persons	1225	7	(1) Presenting VA worse than 20/40 (2) Best-corrected VA worse than 20/40	(1) 2.9 (1.4–6.3) (2) 2.7 (1.4–5.5)	Age, gender, hypertension, diabetes, smoking, heart attack, stroke, and income

VA = visual acuity.

Most of these studies defined visual impairment by best-corrected VA measurements.[1–4,6,9] We found that the predictive value of presenting VA for mortality was somewhat stronger than for best-corrected VA. It is possible that presenting VA reflects a person's daily level of visual comfort and may affect mortality through intervening factors such as falls,[18] accidents,[19] depression,[8] and general quality of life.[20] In this respect, we found that the causes of death were different between VA categories, with cancer being the leading cause of death in people with normal vision, and all others being the leading cause of death in people with poorer vision. We had limited numbers to examine specific causes further.

We had small numbers of participants with VA poorer than 20/40. In a subsidiary analysis, we did not find an association of bilateral low vision (defined as best-corrected VA in the better eye of 20/60–20/400) or blindness (worse than 20/400)[13] with mortality (data not shown). Thompson et al[1] found similar patterns in their study of the association between visual impairment and mortality, in which visual impairment was associated with increased mortality in persons with moderately poor VA but not in those with VA worse than 20/200. The authors suggest that this pattern may reflect that persons with extremely poor vision or blindness generally were better cared for by society than those with moderate visual impairment.

Some, but not all, population-based studies have shown that increased mortality risk is associated with cataract,[4,6,21–25] glaucoma,[26] diabetic retinopathy,[9,27] and age-related macular degeneration.[6,28] We did not find a relationship between mortality and other ocular conditions measured in the Tanjong Pagar study, including refractive errors, ocular biometry parameters (axial length and vitreous chamber depth), presence of cataract or cataract surgery, glaucoma, and pterygium.

Limitations in our study should be discussed. Our study did not have standardized diagnosis for diabetic retinopathy and age-related macular degeneration, and retinal photographs were not obtained. In addition, the sample size for this study was too small to permit potentially important subgroup analysis, such as mortality risk between men and women. A longer duration of follow-up for this population may provide more precise estimates of these associations.

Our study was not designed to address the underlying biologic rationale for the relationship between VA and mortality. Nonetheless, studies of cataract and mortality have postulated that lens changes may reflect cellular processes associated with aging and accelerated mortality,[9,23] whereas others have indicated that severity of retinopathy serves as a marker of microvascular diseases affecting systemic functions in diabetics.[24] However, we did not find an association between lens opacity and mortality. In conclusion, we found a strong association of poor presenting and best-corrected VA and mortality in an urban Chinese population in Singapore.

References

1. Thompson JR, Gibson JM, Jagger C. The association between visual impairment and mortality in elderly people. Age Ageing 1989;18:83–8.
2. Klein R, Klein BE, Moss SE. Age-related eye disease and survival: the Beaver Dam Eye Study. Arch Ophthalmol 1995; 113:333–9.
3. McCarty CA, Nanjan MB, Taylor HR. Vision impairment predicts 5 year mortality. Br J Ophthalmol 2001;85:322–6.
4. Wang JJ, Mitchell P, Simpson JM, et al. Visual impairment, age-related cataract, and mortality. Arch Ophthalmol 2001; 119:1186–90.
5. Lee DJ, Gomez-Marin O, Lam BL, Zheng DD. Visual acuity impairment and mortality in US adults. Arch Ophthalmol 2002;120:1544–50.
6. AREDS Research Group. Associations of mortality with ocular disorders and an intervention of high-dose antioxidants and zinc in the Age-Related Eye Disease Study: AREDS report no. 13. Arch Ophthalmol 2004;122:716–26.
7. Thiagarajan M, Evans JR, Smeeth L, et al. Cause-specific visual impairment and mortality: results from a population-based study of older people in the united kingdom. Arch Ophthalmol 2005;123:1397–403.
8. Freeman EE, Egleston BL, West SK, et al. Visual acuity change and mortality in older adults. Invest Ophthalmol Vis Sci 2005;46:4040–5.
9. Knudtson MD, Klein BE, Klein R. Age-related eye disease, visual impairment, and survival: the Beaver Dam Eye Study. Arch Ophthalmol 2006;124:243–9.
10. Wong TY, Foster PJ, Hee J, et al. Prevalence and risk factors for refractive errors in adult Chinese in Singapore. Invest Ophthalmol Vis Sci 2000;41:2486–94.
11. Foster PJ, Oen FT, Machin D, et al. The prevalence of glaucoma in Chinese residents of Singapore: a cross-sectional population survey of the Tanjong Pagar district. Arch Ophthalmol 2000;118:1105–11.
12. Wong TY, Foster PJ, Ng TP, et al. Variations in ocular biometry in an adult Chinese population in Singapore. Invest Ophthalmol Vis Sci 2001;42:73–80.
13. Seah SK, Wong TY, Foster PJ, et al. Prevalence of lens opacity in Chinese residents of Singapore: the Tanjong Pagar Survey. Ophthalmology 2002;109:2058–64.
14. Saw SM, Foster PJ, Gazzard G, Seah S. Causes of blindness, low vision, and questionnaire-assessed poor visual function in Singaporean Chinese adults. The Tanjong Pagar Survey. Ophthalmology 2004;111:1161–8.
15. Foong AW, Wong TY, Saw SM, Foster PJ. Hypermetropia, axial length, and hypertension: the Tanjong Pagar Survey. Am J Ophthalmol 2006;141:1142–4.
16. Wong TY, Foster PJ, Johnson GJ, Seah SK. Refractive errors, axial ocular dimensions, and age-related cataracts: the Tanjong Pagar Survey. Invest Ophthalmol Vis Sci 2003; 44:1479–85.
17. Venketasubramanian N. Trends in cerebrovascular disease mortality in Singapore: 1970–1994. Int J Epidemiol 1998;27: 15–9.
18. Ivers RQ, Cumming RG, Mitchell P, Attebo K. Visual impairment and falls in older adults: the Blue Mountain Eye Study. J Am Geriatr Soc 1998;46:58–64.
19. Ivers RQ, Mitchell P, Cumming RG. Sensory impairment and driving: the Blue Mountain Eye Study. Am J Public Health 1999;89:85–7.
20. Carabellese C, Appollonio I, Rozzini R, et al. Sensory impairment and quality of life in a community elderly population. J Am Geriatr Soc 1993;41:401–7.
21. Minassian DC, Mehra V, Johnson GJ. Mortality and cataract: findings from a population-based longitudinal study. Bull World Health Organ 1992;70:219–23.
22. Reidy A, Minassian DC, Desai P, et al. Increased mortality in women with cataract: a population based follow up of the North London Eye Study. Br J Ophthalmol 2002;86:424–8.
23. Podgor MJ, Cassel GH, Kannel WB. Lens changes and survival in a population-based study. N Engl J Med 1985;313: 1438–44.
24. Hennis A, Wu SY, Li X, et al. Lens opacities and mortality: the Barbados Eye Studies. Ophthalmology 2001;108:498–504.
25. West SK, Munoz B, Istre J, et al. Mixed lens opacities and subsequent mortality. Arch Ophthalmol 2000;118:393–7.
26. Grodum K, Heijl A, Bengtsson B. Glaucoma and mortality. Graefes Arch Clin Exp Ophthalmol 2004;242:397–401.
27. Klein R, Klein BE, Moss SE, Cruickshanks KJ. Association of ocular disease and mortality in a diabetic population. Arch Ophthalmol 1999;117:1487–95.
28. Buch H, Vinding T, la Cour M, et al. Age-related maculopathy: a risk indicator for poorer survival in women. The Copenhagen City Eye Study. Ophthalmology 2005; 112:305–12.