VISION IMPAIRMENT PREDICTS FIVE-YEAR MORTALITY*

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ABSTRACT

Purpose: To describe predictors of mortality in the 5-year follow-up of the Melbourne Visual Impairment Project (VIP) cohort.

Methods: The Melbourne VIP was a population-based study of the distribution and determinants of age-related eye disease in a cluster random sample of Melbourne residents aged 40 years and older. Baseline examinations were conducted between 1992 and 1994. In 1997, 5-year follow-up examinations of the original cohort commenced. Causes of death were obtained from the National Death Index for all reported deaths.

Results: Of the original 3,271 participants, 231 (7.1%) were reported to have died in the intervening 5 years. Of the remaining 3,040 participants eligible to return for follow-up examinations, 2,594 (85% of eligible) did participate, 51 (2%) had moved interstate or overseas, 83 (3%) could not be traced, and 312 (10%) refused to participate. Best corrected visual acuity <6/12 and cortical cataract were associated with a significantly increased risk of mortality, as were increasing age, male sex, increased duration of cigarette smoking, increased duration of hypertension, and arthritis.

Conclusions: Even mild visual impairment increases the risk of death more than twofold.

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INTRODUCTION

A number of studies have shown an association between age-related eye conditions and increased mortality.[1-12] In particular, it has been suggested that cataract, especially nuclear cataract, or cataract surgery may be markers for aging. In the Beaver Dam Eye Study, people with visual acuity of <6/12 were 1.57 times as likely to die in the following 5 years than those with better vision.[9]

The Melbourne Visual Impairment Project (VIP) was a population-based study of the distribution and determinants of age-related eye disease in a representative sample of Melbourne residents aged 40 years and older. Baseline examinations were conducted between 1992 and 1994. We have shown previously that the 83% of eligible residents who chose to participate did not differ significantly in any factors that would likely lead to a bias in the estimate of prevalence estimates.[13] In 1997, 5-year follow-up examinations were commenced to determine the incidence of age-related eye conditions and risk factors associated with those eye diseases in the Melbourne VIP cohort.

The purpose of this study was to identify the predictors of 5-year mortality in our cohort of noninstitutionalized adults.

METHODS

Details of the methodology employed for the baseline Melbourne VIP examinations have been published previously.[14] Briefly, cluster random sampling was employed to identify 9 pairs of census collector districts in the Melbourne Statistical Division from which to recruit eligible residents. Eligible adults were defined as people aged 40 years and older who had been residents in their homes for at least 6 months. A household census was conducted to identify the eligible residents, collect basic demographic information, and invite the eligible residents to attend the local examination centers. The standardized examinations lasted approximately 90 minutes and included presenting and best corrected visual acuity, reading vision, Humphrey visual fields, intraocular pressure, personal health and health-related habits interview, clinical ophthalmic examination, and photography of the lens and

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fundus. The Wilmer lens grading scheme was used,[15] and cataract was defined as ≥4/16 cortical opacity, ≥ 2.0 nuclear standard, or ≥1 mm^2 posterior subcapsular opacity. Glaucoma diagnosis was determined by a consensus of glaucoma experts after review of intraocular pressure, visual fields, and optic discs.[16] Age-related maculopathy was graded from fundus photos according to the international classification system.[17] The protocol was approved by the Human Research and Ethics Committee at the Royal Victorian Eye and Ear Hospital.

Five-year follow-up examinations commenced in 1997. In 1996, letters were mailed to each of the 3,271 people who participated at baseline. These letters contained information about some of the baseline results and alerted participants to the fact that 5-year follow-up examinations would commence in 1997. Prior to the commencement of the 5-year follow-up examinations at each of the 9 test sites, information sessions were held to again inform the participants of the baseline results and to tell them what to expect from the follow-up examinations. Again, recruiters contacted each of the original participants to organize convenient appointment times for them, including nights and weekends when necessary. Information about contact people that was provided by the participants at baseline was used to locate people who had moved and to identify those people who had died in the intervening 5 years. If necessary, people were examined in their homes or nursing homes. Interpreters were provided if needed.

Causes of death were obtained from the National Death Index, which is maintained by the Australian Institute for Health and Welfare in Canberra. This organization provides a list of causes of death for individuals who are matched by name, year of birth, and year of death. The matches are given a probability of being the same person.

Interview data were entered directly into a Paradox computer package with consistency checks built in. All other data were entered twice and verified. Statistical analyses were conducted with SAS version 6.0. Pearson chi-square analyses were used to identify univariate predictors of participation and mortality for categorical variables, and Mantel-Haenszel chi-square analyses were used for ordinal variables. Stepwise multivariate logistic regression analyses were used to identify independent predictors of participation and 5-year mortality. Survival analyses were conducted with the Wilcoxon test for statistical significance of the survival curves. A P value of less than 0.05 was considered to be statistically significant.

RESULTS

At baseline, the VIP cohort was 54% female and ranged in age from 40 to 98 years, with a mean of 59 years. Of the original 3,271 participants, 231 (7.1%) were reported to have died in the intervening 5 years (Fig 1). Forty-nine (21%) of the deaths could not be confirmed from the National Death Index. Country of birth was significantly related to confirmation of death by the death registry. The percent of deaths confirmed by the death registry varied by country of birth: 90% for Italy, 86% for Australia, 78% for Great Britain, 74% for others, and 29% for Greece ($\chi 2 = 4$; $df = 27.2$, $P = .001$). The people whose deaths were confirmed by the death registry were not significantly different from those who deaths were not confirmed by the death registry in terms of age, sex, cortical cataract, nuclear cataract, posterior subcapsular

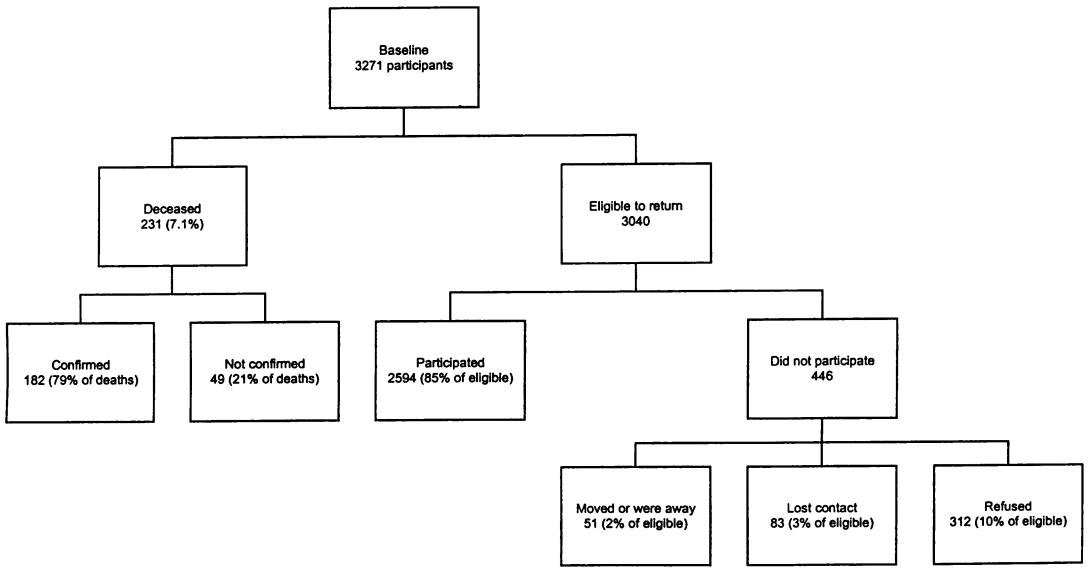

FIGURE 1
Status of Melbourne Visual Impairment Project participants at 5-year follow-up.

cataract, cataract surgery, age-related maculopathy, glaucoma, diabetes, high blood pressure, arthritis, gout, or cardiovascular disease (all $P > .10$, data not presented).

Of the remaining 3,040 participants eligible to return for follow-up examinations, 2,594 (85% of eligible) did participate, 51 (2%) had moved interstate or overseas, 83 (3%) could not be traced, and 312 (10%) refused to participate. The time between baseline and follow-up examinations ranged from 4 to 7 years (mean, 4.5 years, SD=0.64, median, 4 years). The mean age of the participants at follow-up was 62.5 years (SD=10.9, range, 44 to 101), and 1,421 (55%) were female.

Factors significantly related to participation at follow-up in the 3,040 eligible residents were identified (Table I). Male or female sex was not significantly related to participation, even at the univariate level (data not presented). The vision-related outcomes, such as cataract and glaucoma, were also not significantly related to participation. The only factors related to participation that remained in the multivariate model were age, country of birth, and language spoken at home. Non-English speakers and people born in Greece, Malta, or Cyprus were significantly less likely to participate. Age only just reached statistical significance in the multivariate model ($P=.04$), and all of the 10-year age-groups had participation rates of at least 83%.

Predictors of mortality were evaluated in the cohort (Table II). Increasing age, male sex, increased duration of cigarette smoking, increased duration of high blood pressure, arthritis, best corrected visual acuity of <6/12, and cortical cataract were all associated with a significantly increased risk of death.

Life table analyses were conducted to explore further the relationship between decreased visual acuity and mortality (Fig 2). Although not statistically significant over the time period because of the relatively small number of deaths at each time point, the probability of survival at each time point was less for people with best corrected visual acuity of <6/12 (c2=1.59, $P=.21$). These analyses were adjusted for age and sex.

The potential relationship between other levels of vision impairment (<6/6, <6/9, <6/18, <6/60) and mortality was investigated to determine if a linear trend was evident. Although all levels of visual acuity <6/6 were associated with an increased 5-year mortality, only the visual acuity category of <6/6 to ≥6/9 was statistically significant. The potential relationship between cataract and mortality was investigated further by using a more conservative and a more lenient definition of cortical and nuclear cataract. In none of the 4 additional multivariate analyses was cataract significantly related to mortality (data not presented).

TABLE I: PREDICTORS OF 5-YEAR FOLLOW-UP PARTICIPATION IN 3,040 ELIGIBLE RESIDENTS

FACTOR	% RESPONSE	CHI-SQUARE, *DF*, *P* VALUE	MULTIVARIATE OR (95% CL)
Age-group			
40-49, n=809	83%		
50-59, n=951	86%		
60-69, n=806	85%		
70-79, n=369	89%		
80-89, n=97	84%		
90+, n=8	88%	9.9, 5, 0.079	1.01 (1.000, 1.02)
Education level			
Did not complete secondary, n=1,516	83%		
Completed secondary, n=597	88%		
Trade certificate, n=189	84%		
Some tertiary study, n=268	88%		
Completed tertiary degree, n=434	88%	12.4, 4, 0.015	NS
Country of birth			
Australia/New Zealand, n=1,670	90%		Reference
British Isles, n=298	89%		0.93 (0.62, 1.38)
Greece/Cyprus/Malta/Macedonia, n=260	72%		0.43 (0.27, 0.70)
Italy, n=311	80%		0.73 (0.40, 1.34)
Other, n=500	78%	90.7, 4, 0.001	0.52 (0.38, 0.70)
Language spoken at home			
English, n=2,508	88%		Reference
Greek/Cyprian/Maltese/Macedonian, n=168	69%		0.59 (0.34, 0.99)
Italian, n=221	78%		0.52 (0.34, 0.99)
Other, n=140	69%	88.1, 3, 0.001	0.48 (0.31, 0.75)

TABLE II: PREDICTORS OF 5-YEAR MORTALITY IN THE MELBOURNE VISUAL IMPAIRMENT PROJECT COHORT

RISK FACTOR	5-YEAR MORTALITY (%)	CHI-SQUARE, *DF*, *P*-VALUE	MULTIVARIATE OR (95% CL)
Age			
40-49, n=823	1.7		
50-59, n=978	2.8		
60-69, n=863	6.6		
70-79, n=445	17.1		Age as continuous
80-89, n=145	33.1		variable:
90+, n=17	52.9	258.6, 5, 0.001	1.09 (1.07, 1.11)
Sex			
Female, n=1,760	5.7		1.00
Male, n=1,511	8.7	11.1, 1, 0.001	1.49 (1.06, 2.08)
Country of birth			
Australia/New Zealand, n=1,814	7.9		1.00
British Isles, n=325	8.3		0.95 (0.59, 1.54)
Greece/Cyprus/Malta, n=274	5.1		0.88 (0.48, 1.63)
Italy, n=338	8.0		1.07 (0.66, 1.73)
Other, n=519	3.7	14.1, 4, 0.007	0.57 (0.34, 0.96)
Pack-years smoking			
None, n=1,570	5.5		1.00
≤ 10, n=539	5.0		0.94 (0.57, 1.56)
11-30, n=562	8.5		1.85 (1.21, 2.84)
≥ 30, n=588	11.7	26.5, 1, 0.001	2.05 (1.37, 3.05)
Duration of high blood pressure			
None, n=2,368	5.7		1.00
_ 5 years, n=301	8.6		0.95 (0.58, 1.54)
6-10 years, n=198	7.6		0.74 (0.39, 1.41)
>10 years, n=394	14.0	33.6, 1, 0.001	1.48 (1.01, 2.17)
Arthritis			
No, n=2,521	5.4		
Yes, n=740	12.8	48.9, 1, 0.001	1.42 (1.03, 1.98)
Best corrected visual acuity			
≥ 6/12, n=3,225	6.6		
≤ 6/12, n=43	37.2	60.6, 1, 0.001	2.42 (1.07, 5.43)
Cortical cataract (excluding surgery)			
No, n=2,815	5.5		
Yes, n=363	17.4	71.4, 1, 0.001	1.45 (1.01, 2.10)
Nuclear cataract (excluding prior surgery)			
No, n=2,888	5.7		
Yes, n=289	18.3	66.2, 1, 0.001	NS
Prior cataract surgery			
No, n=3,123	6.5		
Yes, n=109	23.9	47.8, 1, 0.001	NS
Age-related maculopathy			
No, n=2,708	5.8		
Yes, n=501	13.8	41.6, 1, 0.001	NS
Glaucoma			
No, n=3,144	6.8		
Yes, n=120	14.2	9.5, 1, 0.002	NS
Diabetes			
No, n=3,092	6.7		
Yes, n=169	13.0	9.7, 1, 0.002	NS
Gout			
No, n=3,022	6.7		
Yes, n=239	12.1	10.2, 1, 0.001	NS
Cardiovascular disease			
No, n=2,903	6.0		
Yes, n=345	24.1	447.1, 1, 0.001	NS

NS, not significant.

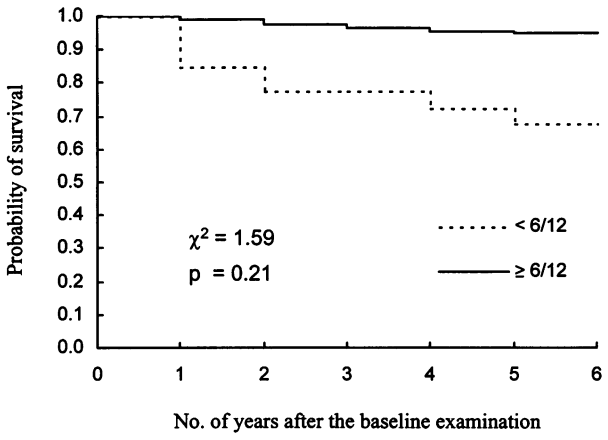

FIGURE 2

Age- and sex-adjusted survival curves by level of best corrected visual acuity.

TABLE III: RELATION OF BEST CORRECTED VISUAL ACUITY TO 5-YEAR MORTALITY IN THE MELBOURNE VISUAL IMPAIRMENT PROJECT*

VISUAL ACUITY LEVEL	OR (95%CL)
≥6/6	Reference
<6/6 to ≥ 6/9	1.55 (1.09, 2.20)
< 6/9 to ≥ 6/12	1.70 (0.53, 5.48)
<6/12 to ≥ 6/18	5.48 (1.78, 16.9)
<6/18 to ≥ 6/60	1.92 (0.49, 7.50)
<6/60	1.41 (0.13, 15.34)

* Adjusted for age, sex, country of birth, smoking, hypertension, and arthritis.

DISCUSSION

We found that decreased visual acuity was associated with increased 5-year mortality. This is consistent with the findings of a study reported in 1966[2] and with the univariate findings of the Beaver Dam Eye Study.[9] It is plausible that people with vision impairment have increased mortality rates for a number of reasons. Researchers have shown previously that people with vision impairment are significantly more likely to use healthcare services,[18,19] 3 times more likely to use regular support services provided by the municipality,[20] and 6 times more likely to be unable to go out alone.[20] Additionally, poorer visual function is associated with increased falls,[21] and decreased visual acuity is associated with an increased risk of car accidents.[22] All of these factors could lead to increased mortality rates in people with vision impairment.

Several studies have found a positive association between nuclear opacities and mortality,[8-10,13] particularly in people with diabetes.[5,10,13] These researchers have speculated that lens opacities are a biologic marker for aging. We did not find an association between nuclear cataract and mortality. However, we did find that people with cortical cataract as defined in our study were nearly 1.5 times more likely to die during the 5 years. The relationship may be artefactual, since we did not find an association between cortical cataract and mortality when we used a more lenient and a more conservative definition of cortical cataract.

A number of studies have also found increased mortality rates among people who have undergone cataract extraction.[4,6,7,10,11] Although we find an increased mortality rate in univariate analyses for people who had undergone cataract surgery, this finding was not statistically significant in our multivariate analyses.

A study reported in the 1960s showed an association between glaucoma and age-specific mortality.[2] No such association between glaucoma and mortality was seen in the more recently conducted Beaver Dam Eye Study.[9]More recently, high intraocular pressure and glaucoma treatment were found to predict decreased life expectancy in the Framingham Eye Study cohort.[12] We did not find a relationship between glaucoma or intraocular pressure and mortality in multivariate analyses.

In the over-65-year age cohort, there is evidence of a j-shaped curve for the relationship between alcohol consumption and mortality, with moderate levels of alcohol consumption protective for mortality and larger amounts of alcohol a risk for increased mortality. This j- or u-shaped curve for alcohol consumption and mortality risk has been demonstrated previously.[23]

Smoking is a well-known risk factor for mortality and has also been shown to be related to the prevalence and incidence of a number of ocular disorders, including age-related macular degeration[24] and nuclear cataract.[25] We found in our study that there was a linear trend between pack-years of smoking and mortality.

The strengths of the Melbourne VIP include the sampling strategy and the high response rate, which ensure that the study population is representative of Melbourne residents aged 40 years and older. The only factors found to be associated with nonparticipation by eligible residents in the 5-year follow-up examinations were country of birth and language spoken at home. Greeks were significantly less likely to participate, although their response rate is similar to what has been reported for the overall follow-up rate in a couple of other large epidemiologic studies of eye disease (the Chesapeake Bay Watermen Study and the Baltimore Eye Survey). Not only were the Greeks less likely to participate, but it was also less likely that their deaths could be confirmed on the death registry. It is possible that the Greek-born participants returned to Greece to die or that their relatives said that they were dead as an excuse for them not to participate.

SUMMARY

We have shown that decreased visual acuity is associated with the largest odds ratio for increased mortality in our cohort, even greater than age. Further research is needed to explore why people with decreased vision or cataract have a higher mortality rate.

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DISCUSSION

DR BARBARA E. K. KLEIN. It is an ancient observation that blindness is a harbinger of death. This is in large part because of the relationship of age to decreased visual function. In the Beaver Dam Eye Study, for example, severe visual impairment was found in 2.0% of those 75 years of age or older compared to 0.1% of those 43-54 years of age.[1] However, in the data reported by Taylor et al. from the Melbourne Visual Impairment Project (VIP), in the Beaver Dam Eye Study cohort and in other studies, visual impairment is a predictor of death even when comparing people of similar ages. The estimated risk differs between studies. This may reflect differences in populations, in techniques used to assess best corrected acuity, in participation rates, etc. The importance of the finding is not the differences between studies but the consistency of finding that visual function predicts survival.

Dr. Taylor suggests that increased falls and automobile accidents may lead to increased mortality in those with impaired vision. In Beaver Dam, we found significant associations between several performance-based measures of visual function and falls and fractures, as well as time to walk a measured course.[2] Table 1 indicates the relationships of falls and hip fractures to best corrected acuity, near acuity, and contrast sensitivity in those 60 years of age or older. For the 2 high contrast measures, the relationships are significant. For contrast sensitivity, the relationship is of borderline significance for falls. Also, time to walk a measured course (gait time) was correlated with the visual function measures (Table 2). These findings confirm the notion that visual function is associated with characteristics related to mobility. While it is not far fetched to interpret these findings as representing a causal relationship of decreased visual function to subsequent falls, auto accidents, fractures, slower gait, and even mortality, it is more likely that in most instances all these factors including poorer visual function are indicators of greater frailty, and hence of greater probability of death. In support of this, when considering visual impairment in the Beaver Dam data, if one controls not only for age and sex, but also considers presence of proteinuria,

TABLE I: HISTORY OF FALLS° AND HIP FRACTURES† IN THOSE 60 YEARS OF AGE OR OLDER BY VISUAL FUNCTION. BEAVER DAM EYE STUDY, 1993-95.

VISUAL FUNCTION	N	% WITH FALLS	*P*-VALUE‡	N	% WITH HIP GRACTURES	*P*-VALUE‡
Best Corrected Acuity, Better Eye						
20/20 or Better	1579	5.2	<0.001	1572	1.4	<0.001
20/25 or Worse	781	10.5		775	5.2	
Near Acuity						
20/16 or Better	1697	4.9	<0.001	1688	1.5	<0.001
20/20 or Worse	630	11.1		627	5.4	
Contrast Sensitivity§						
1.55 or Better	1403	5.5	0.07	1397	1.6	0.05
1.50 or Worse	839	7.4		833	2.8	

° History of falls within the past year.
† History of hip fractures after 40 years of age.
‡ *P*-value for chi-square test.
§ Pelli-Robson letter charts with characters of diminishing contrast on a white background; values reflect log contrast sensitivity scores.

TABLE II: CORRELATION BETWEEN GAIT TIME AND VISUAL FUNCTION FOR PERSONS 60 YEARS OF AGE AND OLDER. BEAVER DAM EYE STUDY, 1993-95.

		SPEARMAN CORRELATION	
VISUAL FUNCTION	N	COEFFICIENT	*P*-VALUE
Best Corrected Visual Acuity, Better Eye	2203	0.28	<0.001
Near Acuity	2204	0.27	<0.001
Contrast Sensitivity°	2194	0.29	<0.001

°Pelli-Robson letter charts with characters of diminishing contrast on a white background; values reflect log contrast sensitivity scores.

TABLE III: RELATIONSHIP OF OCULAR CHARACTERISTICS TO SURVIVAL.° BEAVER DAM EYE STUDY, 1993-95.

	HAZARD RATIO	
OCULAR CHARACTERISTIC	(95% CONFIDENCE INTERVAL)	*P*-VALUE†
Nuclear Sclerosis‡	1.14 (0.98-1.33)	0.08
Cortical Cataract	1.06 (0.84-1.35)	0.62
Posterior Subcapsular Cataract	1.10 (0.79-1.52)	0.58
Visual Impairment	1.08 (0.77-1.51)	0.65

° Controlling for age, sex, proteinuria, diuretic use, cancer history, diastolic blood pressure, ratio of total to HDL-cholesterol, smoking (never or former vs current), pulse, diabetes status, body mass index, cardiovascular disease history, sedentary lifestyle.
† Cox proportional hazards model.
‡ Nuclear sclerosis graded on a severity scale of 1 to 5, with 5 being most severe; hazard ratio is for a single step on the scale of 1 to 5.

diuretic use, history of cancer, diastolic blood pressure, ratio of total to HDL-cholesterol, smoking status, pulse rate, diabetes status, body mass index, history of cardiovascular disease, and lifestyle (sedentary), visual impairment is no longer a significant variable. This implies that other factors than visual function are related to death and that once these are considered, visual function status does not add to our statistical ability to predict death. It is interesting to note that in the Melbourne VIP and other studies,[3-12] the presence of lens opacities or cataract surgery were related to decreased survival. In Beaver Dam, after controlling for the myriad of factors I listed before, the severity of nuclear

sclerosis was associated with decreased survival, although the relationship was of borderline statistical significance (Table 3). It has been postulated that severity of nuclear sclerosis may be a good biologic marker of aging. In fact, when the age of non-human primates is not known, researchers may approximate it by examining the lens (PL Kaufman; Personal Communication). Cataracts may occur as part of systemic conditions of premature aging such as Werner's syndrome in humans[13,14] and in specific strains of some animal species. In population-based data where age-related cataracts are common, there is data to suggest that familial aggregation is significant.[15,16] Thus, while the time course of development of cataract may be the result of accumulated exposure to systemic and environmental factors associated with increasing age, a complementary hypothesis is that there are genetic determinants of physiologic aging as well, and cataract may be a more specific marker of this than visual acuity.

It has been said before that the eye is a window on the body, if not the soul. Indeed, examining the retina reveals important information about systemic vascular, infectious, congenital, and even trauma occurring at primary sites other than the visual system. However, we need an instrument finer than the Hermann von Helmhotz ophthalmoscope to fully reveal all the plethora of information about the very essence of survival that is manifest in the eye and visual function.

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DR GEORGE L. SPAETH. A comment: There is hardly a day that somebody doesn't say "well, the person is 90 years old. You are not going to treat the person for glaucoma, are you?" It is always given in terms of years, never in terms of life expectancy. The comment relates to that fascinating table that Dr Taylor showed us, about relationship between age and life expectancy. He chose the "half empty" aspect, saying "only 50% are going to live 5 years." He could equally choose the "half full" aspect, and say "Of all the patients who are 90 years old, 50% are going to live for more than 5 years." It is so important we remember always that we are treating individuals, not populations.

DR FREDRICK L. FERRIS. I think that Dr Taylor has done and excellent job of reminding us that visual function may be at least a marker for mortality, and this has been seen in multiple studies. However, observational studies, such as his, are not well equipped to identify cause and effect, and as Dr Klein has just mentioned, for example, lesions such as lens opacities which may be markers of physiologic age, may well lead to the results that were seen by Dr Taylor. I think that Dr Klein also mentioned the possibility of concurrent disease. For example, diabetes leads to vision loss. People with diabetes and vision loss have very increased rates of mortality.

Finally, there may be other markers. Even not seeking medical care for glasses might be a marker leading to increased mortality. Some of Dr Taylor's patients may well have had decreased vision, not because it could not be corrected, but because they did not seek the care necessary to correct it, and that they may well be a marker of other care that they should seek but do not. So perhaps the message is that fixing their vision may not keep them alive by itself, but it may be a marker of someone who is at increased risk and perhaps needs increased care.

DR RICHARD P. MILLS. My point is similiar to that of Dr Ferris, that particularly in this youngest cohort that Dr Taylor reported, in which there was the strongest association for visual acuity less than 20/40 and mortality,

were these people primarily Type I diabetics who, of course, are likeliest to die of cardiovascular disease, the commonest cause of death? Is the data rich enough to, for example to list diabetes as a tertiary cause of death, where you might be able to develop some cause-effect relationship?

Dr Malcolm R. Ing. Hugh I really enjoyed your paper. What was a little surprising was the lack of correlation between macular degeneration and the risk of mortality. Two recent articles in the Archives of Ophthalmology have brought out 2 very important and interesting findings. One was that high fat diet was associated with macular degeneration; the other was lack of fish, (or, inversely, more fish in the diet, less macular degeneration). I fully expected to hear that macular degeneration was associated with increased mortality.

So, let us jump 1 step forward and say is the cortical cataract, since that was one marker that did come out of your study, related to the other 2 entities; that is higher fat in a diet and lack of fish. Both of those have been associated with shorter longevity, as far as I know, in public health studies.

Dr Hugh Taylor. Thank you Dr Anderson, and I would like to thank Dr Barbara Klein and the other discussants for the very interesting and important points that they raised.

Dr Klein speculated on the possible mechanisms of death in people visually impaired and their data on falls and fractures I think is of great importance. But also there are increasing data coming to indicate that people who have visual impairment suffer from a number of other problems. Depression particularly is surprisingly common when one looks through the information coming from quality of life questionnaires, of which now there are quite a number. Depression always comes up much more frequently in people with visual impairment, and depression itself is a well recognised risk for decreased mortality.

There are also some indications that self-care practices are quite different in people who are visually impaired. As Dr Ferris suggested, not only are people who have visual impairment less likely to access medical services for their eyes on the one hand and for their general health on the other, but also people who have visual impairment have increased difficulty with medication, with monitoring their blood sugar if they happen to have diabetes, and also with managment of minor health problems, cuts and scratches, their podiatry will be less meticulous, and so on. But I think there are some very interesting questions that have not yet been addressed as to what mechanisms of death may be operating in these people. That relates also to the question brought up by Dr Mills. Are we seeing cause or effect here?

This is a population-based study. The ratio between Type I and Type II diabetes was about 5% for Type I and about 95% were Type II or adult onset diabetes. I cannot remember the number of people who had diabetes who died who were in the age group 40-59. If it were 1 or 2, then we just would not have the statistical power to ask the question raised by Dr Mills.

Clearly, we need to consider the dramatic changes that are occurring in our population structure, as alluded to by Dr Spaeth, and I am very happy to look at the glass being half full, as he said, rather than half empty. One hundred years ago, the life expectancy in America and in Australia was about 40 or 45 years. At the end of the Second World War, in 1950, the life expectancy had increased to about 60 years. Now, life expectancy is about 80 years, so that for every year that we have lived, we have gained about 4 months of life for free, as that increasing life expectancy has increased dramatically over the last century.

Now in the next 20 years, the population of the US will increase about 20%. But the number of people over the age of 65 will double. There will be a huge increase in this older people with greying of the population, With the doubling in the older population, there will be twice as many people requiring cataract surgery, twice as many people requiring glaucoma surgery. But only 20% more people requiring squint surgery! However, as for life expectancy in people who have reached the age of 40 now, two-thirds of them can expect to reach the age of 90. This is dramatically different from the figures that were operating 50 or 100 years ago. Let me repeat that two-thirds of people who have reached the age of 40 now can expect to reach the age of 90.

Finally, to answer Malcolm Ing's question on the role of fat diet and antioxidants. In our cross-sectional observational study, we do not have the ability to address those questions, other than to say that we did not find a relationship with macular degeneration and decreased longevity when we controlled for age and other factors. There are studies at the moment, such as AREDS study run by the National Eye Institute, and the VECAT study, a study we are conducting in Australia, looking at the specific effect of antioxidants on both cataract and macular degeneration, and I think that this is a very important area for further research and should answer the question raised by Dr Ing. Thank you.