Utility and Uncorrected Refractive Error

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Purpose: To investigate utility (a preference-based quality of life [QoL] measure) associated with uncorrected refractive error (URE).

Design: Cross-sectional study.

Participants: A cohort of 341 consecutive patients 40 to 65 years of age with refractive error and no ocular disease impairing vision worse than 20/25 (0.1 logarithm of the minimum angle of resolution [logMAR] units) in the better eye. Without vision correction, 30 had no vision impairment, 65 had only distance vision impairment (DVI), 97 had only near vision impairment (NVI), 112 had moderate amounts of both distance and near vision impairment (DNVI), and 37 had severe impairment (distance or near worse than 20/200 [$>$1.0 logMAR]) in the better eye.

Methods: All participants underwent a comprehensive eye examination with refraction, aided and unaided visual acuity (VA) at 6 m and 40 cm, and ocular health assessment. Utilities were elicited for a number of scenarios using a standardized, face-to-face time trade-off (TTO) interview method.

Main Outcome Measures: The main outcome measure was TTO utility for the participant's own uncorrected vision state. Utilities ranged from 0 to 1, where 0 = death and 1 = perfect vision, and were scaled to account for comorbidities so that 1 = perfect health (adjusted utility).

Results: Unaided VA was 0.50$\pm$0.24 logMAR at distance in the DVI group, 0.43$\pm$0.17 logMAR at near in the NVI group, and 0.72$\pm$0.36 and 0.56$\pm$0.29 at distance and near, respectively, in the DNVI group. Adjusted utilities for the 3 groups were 0.82$\pm$0.16 in the DVI group, 0.81$\pm$0.17 in the NVI group, and 0.68$\pm$0.25 in the DNVI group. The DVI and NVI group utilities (adjusted and unadjusted) did not differ significantly ($P = 0.73$ and $P = 0.77$, respectively). The DNVI utility was significantly worse than that of the DVI and NVI groups (adjusted and unadjusted, $P<0.01$).

Conclusions: The URE is associated with measurable reductions in utility (and therefore QoL). Reductions are similar regardless of whether near or distance vision is impaired, but worse when both are impaired. The results underscore the significance of the effect of URE on QoL, particularly with respect to uncorrected presbyopia, which has been a relatively neglected area in research and policy. The utility figures in this study can be used as inputs for cost-effectiveness studies relating to URE to assist resource allocation decisions.

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Uncorrected refractive error (URE) is the leading cause of vision impairment worldwide. It is estimated that 123 million people are affected by distance URE[1] and 517 million are affected by near URE.[2] Even in developed countries such as Australia, URE accounts for a high proportion of vision impairment,[3] with socially, economically, and geographically disadvantaged communities at greatest risk.[4,5]

Historically, there has been greater emphasis on the societal burden of vision impairment from eye disease than from URE.[6,7] A decade ago, URE was not even included in global estimates of vision impairment.[6] Reference to the International Statistical Classification of Diseases, Injuries and Causes of Death,[8] where blindness and vision impairment were defined according to best-corrected distance visual acuity (VA), was a factor in this oversight.

Recognition of URE has been mounting since 2006, when the World Health Organization incorporated presenting VA in their vision impairment definition and updated estimates of the global number of people with visual impairment to include URE.[7] However, estimates were, and are still,[1,9] otherwise based on the International Statistical Classification of Diseases, Injuries and Causes of Death definition, where VA is measured on a distance chart. Therefore, those affected by refractive error that impairs only near vision, that is, presbyopia, have not been included. Reference to this definition in research quantifying the extent and impact of URE unfortunately is not peculiar to this one article, but rather one that is more typical in the literature. Vision impairment definitions and guidelines that researchers often refer to during the study design process currently do not include uncorrected near vision in their vision impairment category.[8,9]

Because uncorrected presbyopia now is recognized as the most common vision problem globally,[1,2] it is unclear why it has been represented so poorly with respect to research or policy. Perhaps there is a perception that it impacts a person's quality of life (QoL) less significantly than other eye conditions. However, clear evidence supporting this claim has yet to be observed in the literature.

Utility is a measure or rating of QoL that is derived by assessing people's preferences for living in a particular health state. The higher the utility, the better the state of a person's QoL. Utilities typically range from 0 to 1, where 0 represents death and 1 represents perfect health.[10] The advantage of

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utilities over other QoL measures is their usefulness in health economic evaluations (cost-effectiveness studies). These evaluations assist governmental resource allocation decisions. In such evaluations, utility is multiplied by the number of years a person lives in a health state, or improved health state, to calculate quality-adjusted life years (QALYs) or QALYs gained.[10,11] One QALY can be considered a unit of QoL that governments or decision makers are seeking to purchase (through health intervention) at the most competitive price.

Utility has been investigated extensively in the ophthalmic field.[12–14] For example, complete blindness has been associated with a utility of 0.26,[15] whereas corrected presbyopia has a utility of approximately 0.98.[16] The derivation of these values has facilitated a number of subsequent economic evaluations justifying the cost effectiveness of interventions.[12] However, there seems to be no published research reporting the utility associated with URE. The aims of this project were to quantify and compare utility associated with various forms of URE (including presbyopia) and to compare these with literature findings for other ocular conditions.

Methods

Study Design and Participant Recruitment

This was a cross-sectional study involving participants with refractive error undergoing an eye examination at a university-based eye research clinic and the School of Optometry teaching clinic at the University of New South Wales, Sydney, Australia. Data collection took place from July 2010 through January 2012. Recruitment efforts were assisted by local community advertisements offering free eye examinations to those who fit study criteria. The study was approved by the University of New South Wales Human Research Ethics Committee. Formal written consent was obtained from all participants.

Participants satisfied the inclusion criteria if they were between 40 and 65 years of age and wore refractive error correction, that is, spectacles or contact lenses for myopia, hyperopia, astigmatism, or presbyopia. Participants were excluded if there was poor study comprehension (e.g., because of poor English), were unwilling or unable to answer the questions asked, or had nonrefractive visual impairment where distance VA was worse than 20/25 (0.1 logarithm of the minimum angle of resolution [logMAR]) in the better eye.

The first 34 participants willing to return for a second visit repeated utility assessment approximately 1 week after the first visit for evaluation of test–retest reliability. Data were combined with test–retest pilot study data using the same methods with an independent sample of participants (n = 33) 18 to 40 years of age who otherwise met study criteria.

Data Collection and Scaling of Utility

All participants completed a demographic and lifestyle questionnaire including data on age, sex, language spoken at home, education level, employment status, and length of time using vision correction. The lifestyle questionnaire (described and evaluated elsewhere[17,18]) required estimates of the number of hours spent on various distance, near, and intermediate vision tasks or activities. Scores for this questionnaire were ranked on a 4-point scale, where not at all = 1, less than 1 hour = 2, 1 to 2 hours = 3, and 3 hours or more = 4. Participants also could describe a task or activity unlisted under "other," and estimated hours spent on this were recoded at the investigator's discretion into distance, near, intermediate, or none, and these were assigned a rank on the same basis as the other activities. Four questions were listed for near, 2 questions were listed for distance, and 7 questions were listed for intermediate. Data range checks were made to assess extreme scores against a 24-hour clock. This resulted in 6 exclusions.

All participants underwent a comprehensive eye examination including ocular and medical history, presenting VA, best-corrected distance VA and unaided VA, subjective refraction, and a full ocular health assessment with biomicroscopy, tonometry, and ophthalmoscopy. All VA measures were obtained under standardized lighting conditions at 6 m and at 40 cm using high-contrast Bailey-Lovie logMAR charts.

Face-to-face interviews were used to elicit utility using a time trade-off (TTO) method that has been described commonly in the ophthalmic literature.[19] A single investigator (N.T.) conducted all interviews. The TTO interview first required participants to estimate their remaining life expectancy. Participants then were presented with 3 vision state scenarios: (1) the participants own best-corrected vision state, (2) the participants own uncorrected vision state, and (3) a hypothetical state of complete blindness (no light perception). For each of the above scenarios, participants were required to choose between the 2 alternatives, that is, the rest of their life in the state outlined versus a shorter amount of remaining life in a state of perfect vision where vision correction is not required. Choice of the perfect vision state required the participant to trade a number of their remaining life years to obtain that state. The maximum number of years that the participant was willing to trade (x_1) was recorded by the interviewer. Utility (where 1 = perfect vision) was calculated as $1-(x_1$/participant's own estimated remaining life expectancy in years).

In addition, participants responded to a fourth scenario where they considered their current health state in the absence of any eye or vision problems and provided a similar response (x_2) for a state of perfect health. The comorbidity score was calculated in the same way, that is, as $1-(x_2$/participant's own estimated remaining life expectancy in years). The comorbidity-adjusted utility (where utility is scaled so that 1 = perfect health) is the product of the utility and comorbidity score.[20,21]

Response validity was questioned if participants were willing to trade more years for less severe vision scenarios than for complete blindness. Exclusion because of questionable response validity was at the discretion of the interviewer because there were 2 participants who were not excluded, despite their willingness to trade more years for URE versus blindness. These 2 participants adamantly believed life would be better if they were completely blind rather than uncorrected. Reasons included their perception that they would receive more assistance and understanding from others and better access to services.

Defining and Categorizing According to Unaided Visual Acuity

Participants were stratified according to their unaided distance VA (in the better eye) and unaided near VA (binocular measurement), rather than their refractive error type. This is because of the relative complexity of the various combinations of refractive error possibilities (depending on the presence and degree of astigmatism and presbyopia) and how this ultimately affects uncorrected vision. Stratification according to VA rather than refractive error also facilitated comparability with ocular disease studies. Stratification was as follows: (1) near-only impairment if unaided VA was worse than 20/25 (>0.1 logMAR) at 40 cm and better than 20/25 (<0.1 logMAR) at 6 m; (2) distance-only impairment if unaided VA was worse than 20/25 at 6 m and better than 20/25 at 40 cm; (3) both distance and near impairment was considered to be moderate if distance and near VA ranged from 20/25 to 20/200 (0.1 to 1.0 logMAR), severe if distance or near VA was worse than 20/200, and no impairment if VA was better than 20/25 at both 6 m and 40 cm (note, all participants used vision correction). Segregation of those with both distance and near vision impairment into 2 groups was such that the degree of unaided VA (the average of distance and near unaided VA) in the moderate group would be similar to the level of distance unaided VA in the distance impaired group and near unaided VA in the near impaired group.

To investigate the relationship of utility with unaided VA for the group as a whole, an impaired unaided VA variable was created. Here, if the participant had only distance impairment, the unaided VA measurement at 6 m was used. If the participant had only near vision impairment, the unaided VA measurement at 40 cm was used, and if the participant had both distance and near vision impairment, then an average of distance and near unaided VA was used. The worst of distance and near unaided VA was considered as an alternative, but there was no significant improvement in the overall correlation with utility.

Data Analysis

A sample size calculation based on previous published and unpublished utility data estimated that 64 participants would be required in each independent group for a 2-sided α of 0.05 to have an 80% power to detect a 10% difference in mean utility. Univariate and multivariate analysis using a generalized linear model was used to explore the relationship between utility, unaided VA, age, sex, language spoken at home, education, employment, and time spent on near, intermediate, and distance tasks. Univariate methods included Pearson and Spearman rank order correlations, unequal variance independent *t* tests, and 1-way analysis of variance. For multivariate analysis, a backward elimination followed by forward entry method was used after assessing intercorrelation between covariates to ensure multicollinearity was not introduced. Evaluation of Cook's distance and standardized residuals confirmed that there were no significant outliers influencing the model. To ensure comparability with previous literature,[19,22] unadjusted utility was the dependent variable in multivariate analysis.

When utility data were divided into vision impairment categories for comparison, the homogeneity of variance assumption was not satisfied. Attempts at data transformation failed to remove this problem, and the discrepancy in sample size between the groups differed to a degree that rendered analysis of variance inappropriate.[23,24] Therefore, nonparametric statistical analysis was conducted and reported for this section. All statistical analysis were conducted using PASW Statistics version 18 (SPSS, Inc., Chicago, IL).

Results

Study Population

A total of 361 participants were screened and 347 fulfilled the study inclusion criteria. Six of those participants were excluded because of their inability to comprehend or respond appropriately to the TTO scenarios. Therefore, analysis was based on a cohort of 341 participants. Table 1 provides sociodemographic and lifestyle details, Table 2 provides vision and refractive details, and Table 3 provides mean utility for each of the scenarios presented.

Reproducibility

Test−retest reliability was found to be good to excellent for all scenarios presented. Intraclass correlation coefficients were as follows: corrected refractive error, 0.76; URE, 0.86; blindness, 0.76; and health, 0.60 (all $P<0.001$). The difference between test and retest responses was plotted against mean utility for the URE scenario and the scatter of data appeared randomly scattered along the utility scale (Pearson $r = -0.02$; $P = 0.86$).

The standard deviation of the difference in responses from one occasion to the next was multiplied by 1.96 to determine the 95% probable maximum difference in responses from one occasion to the next (coefficient of repeatability).[25,26] The coefficient of repeatability for each of the states was as follows: corrected refractive error, 0.002; URE, 0.021; blindness, 0.105; and health, 0.005.

Unaided Visual Acuity and Utility

Univariate analysis revealed a significant correlation between URE utility and unaided distance VA (Pearson $r = -0.37$; $P<0.01$), unaided near VA (Pearson $r = -0.36$; $P<0.01$), and with the impaired unaided VA variable (Pearson $r = -0.43$; $P<0.01$). The impaired unaided VA variable subsequently was used in multivariate analysis.

Other Variables and Utility

The only variables that were found to be significantly associated with utility (URE) using both univariate and multivariate analysis were sex and unaided VA (Table 4). The interaction between unaided VA and sex was not found to be significant ($P>0.05$). Length of time in vision correction was correlated significantly with utility in univariate analysis (Pearson $r = -0.19$; $P<0.01$) but lost its significance in the multivariate model because of multicollinearity with impaired unaided VA (Pearson $r = 0.38$; $P<0.01$). Although the association with sex was statistically significant, it accounted for only 1% of the variability in the multivariate model. Therefore, impaired unaided VA alone accounted for the greatest amount of explained variability (19%). The resulting bivariate model is presented in Table 4.

Because the amount of explained variability around sex was found to be very small (and to aid comparability with previous literature findings for ocular disease), an alternative univariate equation for the calculation of utilities using only impaired unaided VA is offered: URE utility = unaided VA (logMAR units)$\times -0.310+0.960$ ($R^2 = 0.187$; $F = 77.72$; $P<0.01$). The regression line reported in the literature for ocular disease data is in decimal notation.[22] Therefore, for display purposes, our VA data was converted from logMAR to decimal units, and the resulting regression line was plotted together with that reported for ocular disease in Figure 1.

Age and Utility

Univariate and multivariate analysis revealed that age did not correlate significantly with URE utility ($P>0.05$). However, a significant correlation was observed for health state utility (i.e., the comorbidity score; $r = -0.13$; $P = 0.02$), and it followed that comorbidity-adjusted utility for URE was correlated significantly with age ($r = -0.12$; $P = 0.03$).

Group Comparisons

Utility associated with URE was compared between vision impairment groups (Fig 2). Using the Kruskal-Wallis test, a statistically significant difference was observed between the 5 groups (chi-square [4, n = 341] = 65.73; $P<0.001$). Post hoc comparisons with Bonferroni correction were made using Mann−Whitney *U* tests (with 4 comparisons; α level was set at

Table 1. Participant Demographics

Sociodemographic Characteristics	Type of Uncorrected Refractive Error Vision Impairment					
	All Participants	No Impairment*	Only Distance Impairment	Only Near Impairment	Both Distance and Near Impairment	
					Moderate	Severe
No.	341	30	65	97	112	37
Age (yrs)						
Range	40–65	40–59	40–64	41–65	40–65	40–65
Mean ± SD	52±7	46±5	48±6	54±6	53±7	51±7
Female (%)	58.1	63.3	38.5	60.8	59.8	75.7
Language other than English spoken at home (%)	30	30	29.2	23.7	33.9	35.1
Education level (%)						
Year 12 or less	16.1	10.0	9.2	21.6	16.1	18.9
Certificate or diploma	24.0	26.7	21.5	24.7	22.3	29.7
Bachelor's degree	22.9	23.3	16.9	21.6	27.7	21.6
Postgraduate certificate/degree	37.0	40.0	52.3	32.0	33.9	29.7
Full-time employment (%)	59.5	63.3	72.3	57.7	51.8	62.2
Length of time in vision correction (yrs)						
Range	1–55	1–43	6–50	1–50	1–52	10–55
Mean ± SD	23±14	15±13	27±10	12±12	29±12	35±10
Time spent on tasks (mean rank ± SD)						
Near	9.7±1.5	10.2±1.9	9.9±1.5	9.6±1.4	9.8±1.5	9.6±1.8
Distance	5.5±1.3	5.3±1.3	5.8±1.6	5.5±1.2	5.4±1.1	5.3±1.1
Intermediate	14.7±2.4	14.7±2.7	14.2±2.1	14.9±2.4	14.6±2.5	14.8±2.1

SD = standard deviation.
*Unaided visual acuity better than 20/25 (<0.1 logarithm of the minimum angle of resolution units) at distance (6 m) and near (40 cm).

0.05/4 = 0.01). The only 2 groups that did not have significantly different average utilities were the distance vision impaired group compared with the near vision impaired group ($U = 3067$; $z = -0.29$; $P = 0.770$).

Findings were similar when comorbidity-adjusted utilities associated with URE were compared between refractive groups. Using the Kruskal-Wallis test, a statistically significant difference was observed between the 5 groups (chi-square [4, n = 340] = 60.30; $P<0.001$). The only 2 groups that did not have significantly different average utilities when compared using post hoc comparisons were the distance vision impaired compared with the near vision impaired ($U = 3050$; $z = -0.35$; $P = 0.726$).

Utility for URE was subtracted from that found for corrected refractive error (to investigate the difference that obtaining vision correction has on utility), and the difference also was compared between groups. Using the Kruskal-Wallis test, a statistically significant difference was observed between the 5 groups (chi-square [4, n = 344] = 50.69; $P<0.001$). Again, the only 2 groups that did not have significantly different average utilities when compared using post hoc comparisons were the distance vision impaired group versus the near vision impaired group ($U = 3070$; $z = -0.28$; $P = 0.777$).

The correlation between URE utility and impaired unaided VA was investigated for the vision impairment groups individually (Fig 3). The explained variability was higher for the near impaired group ($R^2 = 0.241$) compared with the distance impaired group ($R^2 = 0.049$) and the group with moderate amounts of distance and near impairment ($R^2 = 0.072$). There was also a more rapid decline in utility with decreasing unaided VA levels for the near impaired group (as observed in the relative steepness of the regression line) compared with the distance impaired group.

A separate regression line for the group with both distance and near vision impairment (total group including moderate and severe) also is plotted (after conversion to decimal notation) alongside the regression equation found for the total group and the one reported previously for ocular disease[22] in Figure 1. When the strength of the correlation with utility for distance unaided VA and near unaided VA was investigated separately for the group with both distance and near vision impairment (n = 149), the strength of the correlation is similar and significant for both distance and near unaided VA (Pearson $r = -0.21$ and $P<0.01$, and Pearson $r = -0.23$ and $P<0.01$, respectively).

Discussion

The utilities presented in this study allow comparison of the QoL decrement resulting from URE with that resulting from other ocular and medical conditions and also the relative impact of near vision impairment compared with distance vision impairment. The utility figures reported can be used as an input for cost-effectiveness evaluations of programs relating to URE, which in turn can assist resource allocation decisions.

Utility and Visual Acuity

The regression line we observed for utility and VA for URE (total group) runs virtually parallel to that reported previously for ocular disease (with similar levels of explained variability around the dependent variable).[19,22] On average, there is approximately 0.14 higher utility for the URE group as a whole compared with the ocular disease group. A difference is to be expected given that both distance and near vision were not impaired for

Table 2. Vision and Refractive Status

Vision and Refractive Status	Type of Uncorrected Refractive Error Vision Impairment											
									Both Distance and Near			
	Total Group		None*		Only Distance		Only Near		Moderate		Severe	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Presenting VA†	−0.03	0.09	−0.06	0.07	−0.07	0.09	−0.05	0.06	−0.01	0.10	0.02	0.10
Best-corrected VA (logMAR)†	−0.08	0.07	−0.09	0.05	−0.10	0.06	−0.09	0.06	−0.07	0.08	−0.04	0.07
Unaided Distance VA (logMAR)†	0.41	0.44	−0.04	0.08	0.50	0.24	−0.02	0.08	0.60	0.30	1.17	0.17
Unaided near VA (logMAR)‡	0.36	0.32	−0.02	0.08	−0.02	0.07	0.42	0.18	0.47	0.25	0.82	0.25
Impaired§ unaided VA												
LogMAR	0.49	0.29	−0.03	0.06	0.50	0.24	0.42	0.18	0.54	0.19	0.99	0.17
Decimal	0.4	0.27	1.07	0.14	0.36	0.19	0.41	0.16	0.32	0.14	0.11	0.04
Best-corrected sphere (DS)†	−1.18	2.46	0.05	0.48	−1.63	0.71	0.44	0.56	−1.59	2.77	−4.43	3.40
Best-corrected cylinder (DC)†	−0.51	0.54	−0.32	0.37	−0.50	0.47	−0.33	0.33	−0.63	0.68	−0.80	0.58
Mean sphere (DS)†	−1.33	2.50	−0.11	0.47	−1.88	0.64	0.28	0.55	−1.90	2.76	−4.83	3.51
Near addition‡	1.59	0.75	1.06	0.64	1.26	0.80	1.96	0.40	1.66	0.76	1.44	0.89

DC = diopters of cylinder; DS = diopters of sphere; logMAR = logarithm of the minimum angle of resolution; VA = visual acuity.
*Unaided VA better than 20/25 (<0.1 logMAR) units at distance (6 m) and near (40 cm).
†Better eye at 6 m.
‡Binocular at 40 cm.
§Measured at 6 m if only distance vision impairment, at 40 cm if only near vision impairment, and an average of distance and near if both.

everyone in the URE cohort. It would be logical to assume that uncorrected myopia, which affects only distance vision and not near, and uncorrected presbyopia, which affects only near vision and not distance, would have less impact on QoL than an ocular disease that typically would impair vision at both distances. Ocular disease additionally can affect other vision variables such as contrast, color, and fields, which may explain why the group with both near and distance vision impairment resulting from URE was still found to have a higher utility than those with ocular disease.

It is also possible the overall difference between the URE group and the ocular disease group may be explained by something other than vision because the ocular disease groups are, on average, willing to trade an extra year of every 10 years even when distance VA is 20/20 (1 decimal unit or 0 logMAR) in the better eye. For the ocular disease population, it has been postulated by Brown et al[27] that the decrement in utility for those with good vision in one eye may be psychosomatic, that is, there is apprehension or fear that the disease eventually will affect both eyes, rather than it actually impacting QoL at the time.

Table 3. Utility (Adjusted and Unadjusted) for Each Scenario

Utility	Type of Uncorrected Refractive Error Vision Impairment											
									Both Distance and Near			
	All		None*		Only Distance		Only Near		Moderate		Severe	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Utility (unadjusted)												
Corrected refractive error	0.96	0.09	0.99	0.02	0.96	0.07	0.97	0.07	0.95	0.10	0.90	0.15
URE	0.81	0.21	0.97	0.06	0.84	0.16	0.85	0.15	0.74	0.25	0.67	0.25
Blindness (NLP)	0.49	0.28	0.61	0.21	0.50	0.28	0.48	0.29	0.49	0.29	0.44	0.25
Health	0.95	0.09	0.98	0.05	0.97	0.07	0.94	0.09	0.94	0.10	0.92	0.13
Comorbidity-adjusted utility												
Corrected refractive error	0.91	0.13	0.97	0.05	0.93	0.10	0.92	0.12	0.90	0.14	0.83	0.19
URE	0.77	0.22	0.95	0.09	0.82	0.16	0.81	0.17	0.70	0.25	0.62	0.25
Blindness (NLP)	0.47	0.28	0.60	0.22	0.49	0.28	0.45	0.28	0.46	0.29	0.41	0.24
Unwilling to trade if blind (%)	2.40		3.30		3.10		1.00		3.60		0.00	

NLP = no light perception; URE = uncorrected refractive error.
*Unaided visual acuity better than 20/25 (<0.1 logarithm of the minimum angle of resolution units) at distance (6 m) and near (40 cm).

Table 4. General Linear Model for Uncorrected Refractive Error Utility*

Variable	Coefficient	Standard Error	P Value	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Intercept	0.939	0.023	<0.01	0.895	0.983
Unaided VA (logMAR)†	−0.305	0.035	<0.01	−0.737	−0.236
Male	0.04	0.021	0.04	0.002	0.084

logMAR = logarithm of the minimum angle of resolution; VA = visual acuity.
*Utility unadjusted for comorbidities: $R^2 = 0.197$, $F = 41.33$, $P<0.01$.
†Measured at 6 m in better eye if only distance vision impairment, at 40 cm if only near impairment, and an average of distance and near if both.

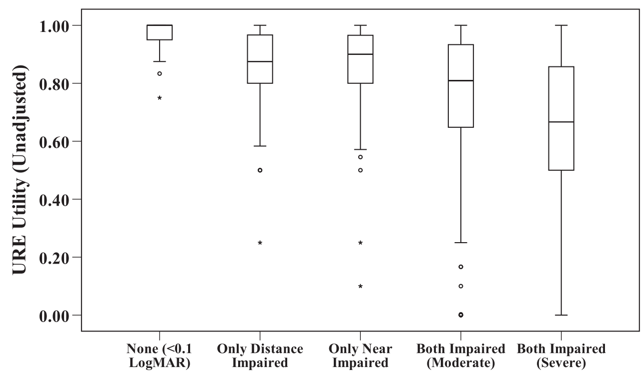

Figure 2. Box-and-whisker plot showing the utility by type of uncorrected refractive error (URE) vision impairment. LogMAR = logarithm of the minimum angle of resolution.

Generally, people's perception of an ocular disease state is likely to be much worse because there is awareness that it is much more difficult to overcome than URE. It is interesting to speculate how the difference in utility between ocular disease and URE would be affected if participants were not aware of the cause of their vision impairment.

Previous ocular disease research has shown that utility values are related to the degree of distance VA loss rather than the disease process itself. So if, for example, distance VA was reduced to 20/40 (0.5 decimal or 0.3 logMAR), utility would be 0.7 regardless of whether the cause was age-related macular degeneration or diabetic retinopathy.[19,22,28] As a result, economic evaluations for vision-impairing conditions without specific utility weight in theory could be based on the level of distance VA loss.

However, applying this to URE implies that presbyopic people with good distance VA would not experience a reduction in utility (or QoL), which, on the basis of conventional QoL research for uncorrected presbyopia alone, is incorrect.[29−31] In addition, it is counterintuitive that uncorrected myopia causing only poor distance vision would bring the same decrement in QoL as a condition affecting both distance and near vision. Therefore, a unique investigation for URE was warranted, particularly for an understanding of the relative distance and near effects.

Distance versus Near Impairment

When comparing the mean utility between the near and distance vision-impaired groups, the utility (or QoL) reductions seem to be similar. Because these were separate individuals, each with only one type of impairment, they were not able to make a direct internal comparison as to

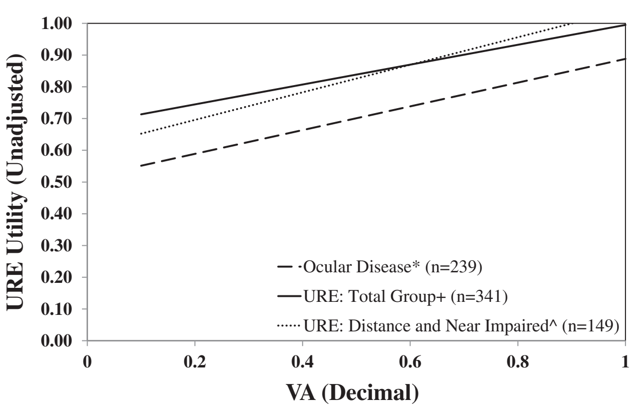

Figure 1. Graph showing the relationship between utility and visual acuity (VA) for uncorrected refractive error (URE) and ocular disease. *Utility = distance best-corrected VA (better eye, decimal)×0.374+0.514 ($R^2 = 0.173$; $F = 69.1$; $P<0.01$).[22] +Utility = unaided VA†×0.313+0.682 ($R^2 = 0.161$; $F = 64.88$; $P<0.01$). ^Utility = unaided VA†×0.434+0.609 ($R^2 = 0.072$; $F = 11.37$; $P<0.01$). †Decimal VA, measured at 6 m in better eye if only distance vision impairment, at 40 cm if only near impairment, and an average of distance and near if both.

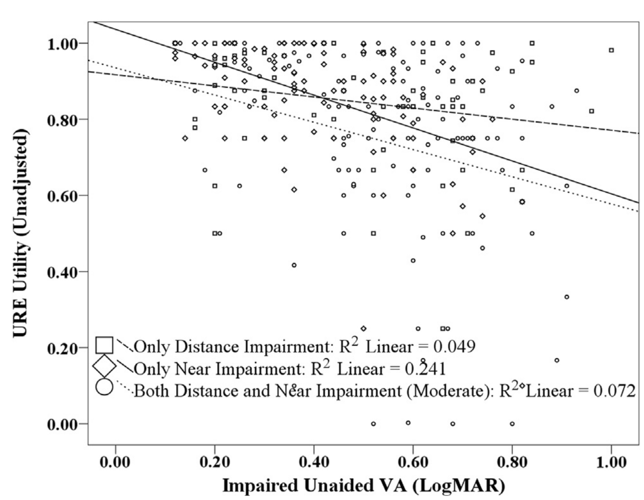

Figure 3. Scatterplot showing the relationship between utility and unaided visual acuity (VA)* for each uncorrected refractive error (URE) type. LogMAR = logarithm of the minimum angle of resolution. *Measured at 6 m in better eye if only distance vision impairment, at 40 cm if only near impairment, and an average of distance and near if both.

which might be worse. Interestingly, when we examined the group with both types of vision impairment, the correlation with utility was virtually the same for unaided distance VA as it was for unaided near VA. These 2 findings support the argument that near vision is at least as important to QoL as is distance vision.

The individual regression slopes show a more rapid decline in utility for the near vision impaired and a much stronger correlation than that found for the distance impaired. These variations could be explained by adaptation because the distance-impaired group has lived with refractive error a longer time, perhaps since adolescence, whereas those with near-vision impairment are likely to have enjoyed good vision all their life and suddenly are having to come to terms with increasing reliance of vision aids. In addition, there may be other psychosomatic explanations for this, such as the association of aging with the increasing reliance on reading glasses. It may be argued that literacy and therefore near demands may be higher in our Sydney population relative to a population in the developing world, where URE poses more of a problem. Although utility data for near vision impairment in developing nations currently are not available, conventional QoL research shows poor near vision remains a significant decrement to QoL in these population groups[29,30] and may even have greater impact than poor distance vision.[31] However, there is scope for more research in this area.

Scaling Utility to Account for Comorbidities

The TTO method is one of the most widely adopted preference-based measures for derivation of utility in the ophthalmic literature.[12,13] Direct elicitation of utility using this method has been found to be valid, reliable, and better correlated with distance VA than other measures.[12] There are some variations in the literature on the design and delivery of the TTO questions. These have included different approaches to anchoring of scores where 1 = perfect vision[15,16,19,28,32–35] versus 1 = perfect health,[36,37] use of computerized softwear[21,38] to deliver the questions versus face-to-face interviews,[15,16,19,39] and the use of a theoretical remaining lifespan of 10 years[36,37] as opposed to the participant's estimate of remaining life years.[15,16,19,32–35,39]

Because it is unclear how these variations affect responses, to aid comparisons with the literature, the TTO interview transcript was based on a version cited most commonly[15,16,19,32–35,39] in which prefect vision anchoring was used. However, it has been argued that perfect vision rather than perfect health anchoring would render results incomparable across health disciplines, and, therefore, for decision making in a policy setting.[13,14] In addition, disregarding the effect of comorbidities would result in an overestimation of utility loss (and therefore an overestimation of the benefits of intervention and treatment during cost-effectiveness evaluation).[20] To overcome these issues, a scaling method (using a health state scenario as described) was used in this study to adjust for comorbidities. The rational for this approach has been described elsewhere.[20,21,38]

Although the age range in this sample was limited to those 40 to 65 years of age, the lack of age association with unadjusted utility is in agreement with previous TTO research conducted in other settings with a broader range of participants where the perfect vision anchor was used.[16,19,22,28] As found in this study, those studies also showed utility to be relatively unaffected by sociodemographic factors such as sex, education level, and race. In addition, the time spent on near versus distance activities does not seem to be influential in this study. However, when questions are anchored in perfect health (comorbidity adjusted), it seems that age is influential on utility. This was a finding not only in this study, but also in previous vision-related[37] and health-related[40] utility research.

The inconsequential influence of sociodemographic and lifestyle factors on utility data anchored in perfect vision (unadjusted utility) suggests that these data could be generalized to any population and simply adjusted for the age or comorbidities (rescaled for the perfect health anchor) for the population of interest during economic evaluation. It must be kept in mind, however, that although the method used to adjust for comorbidities in this study has been used previously[21,38] and that the rationale justifying this approach has been well argued,[20] the need for verification of the validity of such an approach also has been argued.[14]

Cost Effectiveness (Cost Utility)

In Australia, an intervention can be considered cost effective if it costs less than $62 000 Australian dollars per QALY gained.[41] Cataract surgery has been described as one of the most cost-effective interventions worldwide.[42] In 2004, cost per QALY for cataract surgery was found to be highly cost effective in Australia at an estimated cost of 6566.00 Australian dollars per QALY gained.[43,44]

Although a comprehensive cost-effectiveness analysis for URE is beyond the scope of this study, a perspective on the relative value of intervention can be gleaned using the data from this article together with data from a recent article estimating the cost to correct URE globally. Using cost data specific to Australia (obtained from the authors of the aforementioned article[45]) and utility data from this study (using a discount rate of 1.9% for Australia[41]), the cost per QALY gained for the correction of URE over 5 years in Australia is estimated to be $140. A URE intervention therefore could be considered more than 40 times more cost effective than cataract surgery. Similar calculations using global cost figures (and a 3% discount rate) results in a cost per QALY of approximately $45 over 5 years. Globally, cost per QALY estimates for cataract surgery using a 5-year benefit period have been reported to range from $93 in India to $21 606 in the United States in 2004.[44]

Study Limitations

The participants in this study all had access to vision correction. Therefore, although participants were asked to respond to scenarios relating to their own refractive error if uncorrected, there is a level of uncertainty around the fact that this was not their habitual state. However, it could be argued that in fact it is better to interview people who have led a life in which they have had the opportunity to access correction because they are more likely aware of what their correction enables them to do and the difference having it makes to their life. A person who has never had access to correction would not be as aware of the opportunities they might have missed or the potential life they could have led, but instead would base their responses on a lifestyle to which they have adapted. For example, if it were found to be the case that near vision demands were lower in groups where access to vision correction was more limited, it may be difficult to determine whether this effect (particularly in relation to an older cohort) is the result of adaption or other reasons. In this study, the near vision-impaired group (which is habitually corrected) spent similar proportions of time on near tasks as our distance-impaired group. If these groups were uncorrected habitually, the data for time spent on various activities may be biased by the poor vision.

Another issue worthy of mention is the relatively small sample size for the severe vision-impaired group. This could explain the large spread of data for utility values observed for this group. However, the near-impaired, distance-impaired, and moderate groups with both distance and near vision impairment were our main groups of interest for comparison because the degree of vision impairment (according to impaired unaided VA levels) was similar between these groups. Here, the spread of data was not so severe, and sample size calculations rendered them adequate for comparative purposes.

Uncorrected refractive error, particularly uncorrected presbyopia, has been a poorly recognized, poorly researched, and a poorly prioritized area. We have demonstrated that near-vision impairment matters just as much to people's QoL as does distance-vision impairment. It is hoped this information will improve the recognition and positioning of uncorrected presbyopia on public health research and policy agendas.

Given that URE is the leading cause of vision impairment in the world in epidemiologic terms, the utility values reported herein will help assist and improve current vision and eye health care prioritization. These measures provide a basis to estimate more accurately the relative impact and economic consequences of this condition, to determine how this compares with other conditions (medical and ocular), and to determine the most cost-effective ways to alleviate the unnecessary blindness and impaired vision that result from avoidable causes.

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