CLINICAL SCIENCE

Utility values and myopia in teenage school students

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Aim: To ascertain the utility values of myopic teenage students in Singapore.
Methods: Children (n=699) aged 15–18 years with myopia (spherical equivalent (SE) at least –0.5 dioptres (D)) in two high schools in Singapore were recruited. Information on time trade-off (years of life willing to sacrifice for treatment of myopia) and standard gamble for blindness (risk of blindness from therapy willing to sacrifice for treatment of myopia) utility values, demographic, and socioeconomic status data were obtained.
Results: The time trade-off and standard gamble for blindness utility values were 0.93 (95% confidence interval (CI) 0.93 to 0.94) and 0.85 (95% CI 0.84 to 0.86), respectively. Children with presenting better eye logMAR visual acuity >0.3 had lower time trade-off utility values (mean 0.92 versus mean 0.94), after adjusting for race and sex. There were dose-response relations between standard gamble for blindness values and total family income, as well as both utility values and educational stream (all p values for trend <0.01), after controlling for the same factors.
Conclusion: The utility values in myopic students were higher for teenagers with better presenting visual acuity, children who wore spectacles or contact lenses, higher total family income, more "academic" schooling stream, and who were non-Muslims.

Myopia is a growing public health problem with visual, quality of life, and economic consequences. The prevalence rate and severity of myopia is increasing in different parts of the world, especially in several Asian cities including Singapore.[1-4] Blindness from myopia may be a significant problem in the near future, as high myopia (spherical equivalent (SE) at least –6.0 D) is associated with an increased lifelong risk of potentially blinding complications such as rhegmatogenous retinal detachment, glaucoma, and myopic macular degeneration.[5-7] The costs of regular optometry visits and spectacles, contact lenses or surgical correction amount to several billion US dollars a year in the United States.[8] Psychological and cosmetic factors posed by optical correction affect the quality of life of myopic individuals. A study of 112 myopic patients aged 18–65 years in the United Kingdom showed that patients with high myopia (refractive error at least –10.0 D) had significantly worse visual function (measured using the VF-14) and vision related quality of life (VCM1) scores.[9]

Patient preferences for medical therapies and diminution of quality of life associated with disease have been evaluated using utility values, a theory developed in the 1940s. Brown *et al* modified the utility values to address the health care of eye diseases and patient preferences for perfect vision. The time trade-off utility value measures the number of years the patient is willing to sacrifice for a new technology that restores perfect health; while the standard gamble utility value assesses the risks associated with the new technology the patient is willing to take to return to the perfect health state.[10-12] Utility values have been assessed in patients with diabetic retinopathy, age related macular degeneration, and blindness (Table 1).[10-12] To our knowledge, there is currently no report on the utility values of myopic individuals. We aim to evaluate the utility values and associated factors in myopic teenage students in Singapore.

MATERIALS AND METHODS

All students (n=983) in secondary three level (completed 8 years of formal education) and secondary four level (completed 9 years of formal education) of two high schools in Singapore were invited to participate in a cross sectional study on the risk factors for myopia. Students with serious medical conditions and non-refractive eye disorders were excluded (n=4). Refractive error measurements were obtained for 946 students (participation rate 96.6%). There were 699 myopic students (spherical equivalent (SE) at least –0.5 D) and 247 students without myopia (prevalence rate = 73.9% (95% CI 71.0 to 76.7)). The utility values of all 699 myopic students (373 boys and 326 girls; 15–19 years of age) were assessed. This study was conducted as part of the teaching curriculum of the medical school and approval for the study was obtained from the undergraduate committee, Department of Community, Occupational and Family Medicine, National University of Singapore. Verbal consent was obtained from the students after the nature of the study was explained. However, consent from the parents was not obtained. The conduct of the study followed the tenets of the Declaration of Helsinki.

During a week in January 2002, trained medical students examined the subject's eyes in the school premises. Presenting (defined as visual acuity wearing current correction, if any) and uncorrected distance visual acuity was measured using log minimum angle of resolution (logMAR) charts according to a standard protocol. Poorer visual acuity was defined as presenting right eye logMAR visual acuity >0.3: either myopia is not well corrected if the student is wearing corrective devices or undetected myopia may be present if the student is not wearing corrective devices. Three consecutive refractive error measurements were obtained using one of two autokeratorefractometers (model RK 5; Canon, Inc Ltd, Tochigiken, Japan). Cycloplegia was not used. Subjects were divided into three refractive error groups based on their refractions (SE): low myopes (–3.0 < SE = –0.5 D), moderate myopes (–6.0 < SE = –3.0 D), and high myopes (SE = –6.0 D). All refractive error measurements were obtained without previous knowledge of the results of the questionnaire.

Questionnaire

An in-person interview of the 699 myopic students using a standard questionnaire was conducted in English in January 2002. The English language is the first language of the students and 80% of classroom instruction is taught in

Table 1 Summary of previous studies on utility values in populations with other eye diseases

Author (year)	Study population	Mean utility (time trade-off) (95% CI)	Mean utility (gamble-death) (95% CI)
Brown et al (1999)[8]	100 patients (28–87 years; 95 white and 5 black) with diabetic retinopathy and best corrected visual acuity decreased to 20/40 or worse in at least one eye	0.77 (0.73 to 0.81)	0.88 (0.84 to 0.92)
Brown et al (2000)[9]	85 white patients (56–85 years) with unilateral or bilateral macular degeneration in one or both eyes, with visual loss of a minimum of at least 20/40 in 1 eye	0.72 (0.66 to 0.78)	0.81 (0.76 to 0.86)
Brown et al (2001)[10]	Adult patients from Wills Eye Hospital including 15 patients with complete absence of vision (NLP), 17 patients with light perception to counting fingers in the better eye (LP-CF), 33 patients with 20/200 to 20/400 in the better eye (20/200–20/400)	0.26 (0.19 to 0.33) for NLP 0.47 (0.33 to 0.61) for LP-CF 0.65 (0.58 to 0.72) for 20/200–20/400	0.32 (0.20 to 0.44) for NLP 0.60 (0.46 to 0.74) for LP-CF 0.80 (0.73 to 0.87) for 20/200–20/400

English. The questionnaire was piloted in 20 students of similar ages, and the questions were refined after the pilot. The questionnaire was administered in the classroom and an investigator explained each question. Conversations between participants were not allowed. Information on basic sociodemographic parameters such as race, religion, total family income per month, type of housing, and parental history of myopia were obtained. In addition, we asked about the schooling stream (express, normal academic, and normal technical). Students in Singapore are placed in different schooling streams based on the results of an examination at age 12 years. The most "academic" or "better" schooling stream is express, followed by normal academic and normal technical streams.

The time trade-off and standard gamble methods modified by Brown et al were used to assess the utility state.[10–12] A utility value of 1.0 implies a perfect health state and 0.0 signifies that the person would prefer death or blindness rather than the present disease state. The time trade-off was calculated by first dividing the number of years the teenager was willing to give up in return for a better quality of life (achieved by a hypothetical new technology to gain perfect vision) by the subject's estimated number of years of life remaining. This value is then subtracted from 1: (utility time trade-off = 1 − (time traded in years/estimated time of remaining life in years)).

The question for standard gamble for blindness was phrased as follows: "Suppose there was another technology that could remove your need to wear spectacles or contact lenses and return your eyesight to normal. This imaginary technology, however, doesn't always work. When it works, patients respond perfectly and have normal vision without spectacles or contact lenses in both eyes for the rest of their lives. When it doesn't work, however, the imaginary technology fails and patients become blind. Thus, it either restores perfect vision without spectacles or contact lenses in both eyes or causes blindness. What is the highest risk of blindness (in percentage terms), if any, would you be willing to accept before refusing to have the imaginary technology done on you to have perfect vision?" This value was calculated by subtracting the highest risk (%) of blindness, associated with a technology to restore perfect eyesight, that the teenager was willing to take from one (utility standard gamble = 1 − (risk of blindness associated with a new technology that a teenager is willing to take)). This is a modified version of the standard gamble in which the risk of blindness was assessed rather than risk of death. Blindness was chosen as a risk more relevant to any potential complications of myopia and more relevant to any therapies for myopia compared with the risk of death.

Data analysis

The means and 95% CI, as well as medians, of the utility time trade-off and utility standard gamble for all myopic students

were calculated. In addition, the mean utility values were compared across different sociodemographic groups using the χ^2 test for trend or Wilcoxon rank sum test. Race and sex adjusted means of the utility values for different presenting visual acuities and educational streams were evaluated using multivariate regression analysis models. All p values quoted are two sided and considered statistically significant when the values are below 0.05. All analysis was conducted using the commercially available software STATA version 7.0.[13]

RESULTS

The mean refractive error of the myopes was −2.83 D (range −0.5 to −8.75 D), and the mean of the better eye presenting logMAR visual acuity was −0.02 (range −0.2 to 0.52). There were 172 students (24.6%) who did not wear spectacles or contact lenses. Table 2 shows the mean utility values for time trade-off and standard gamble for students with different characteristics. The utility values for time trade-off (mean 0.93) and standard gamble for blindness (mean 0.85) were significantly different (p<0.001). For the time trade-off method, 173 students (24.8%) had perfect scores of 1.0 (that is, were unwilling to sacrifice any years of life for emmetropia), while 256 students (36.6%) had perfect scores of 1.0 for the standard gamble method (that is, were unwilling to undergo any risk of blindness for emmetropia). The mean time trade-off utility value was 0.92 for students with better eye presenting logMAR visual acuity of more than 0.3, in contrast with a mean of 0.94 for students with presenting logMAR visual acuity of 0.3 or less (p=0.03). There was no difference in the standard gamble for blindness utility value between subjects with logMAR values above and below 0.3 (p=0.10). The mean time trade-off utility values were higher for students who wore corrective devices (0.94: 95% CI 0.93 to 0.95) compared with students who did not (0.92: 95% CI 0.90 to 0.94) (p=0.027). There was no difference in the standard gamble for blindness utility value between subjects who wore spectacles or contact lenses and those who did not (p=0.20). Neither utility method varied with the severity of myopia (low versus moderate versus high) or uncorrected visual acuity.

The standard gamble utility value was higher in females than males (p=0.03) (Table 2). There was no difference in time trade-off utility value between non-Malays and Malays (p= 0.09), nor was there a difference between these groups in standard gamble (p=0.62). Muslim students had lower time trade-off utility scores (p=0.02). There were dose-response relations where both utility values were higher with higher total family income as well as "better" educational stream (all p values for trend <0.05). A large proportion of students with a total family income per month of Sin$5000 or more were in the express stream (80.2%), but only 14.8% in the normal academic and 5.0% in the normal technical stream (p<0.001). Both utility methods did not vary with type of housing or parental history of myopia.

Table 2 Utilities for all myopes by various sociodemographic factors

	No	Utility (time trade-off)		Utility (gamble-blindness)	
		Mean (95% CI) [median]	p Value	Mean (95% CI) [median]	p Value
All	699	0.93 (0.93 to 0.94) [0.97]		0.85 (0.84 to 0.86) [0.95]	
Severity of myopia					
Low myopes	274	0.94 (0.93 to 0.95) [0.97]	0.44	0.85 (0.83 to 0.87) [0.95]	0.41
Moderate myopes	372	0.93 (0.92 to 0.94) [0.97]		0.85 (0.83 to 0.87) [0.95]	
High myopes	53	0.94 (0.93 to 0.96) [0.96]		0.89 (0.84 to 0.93) [0.99]	
Right eye presenting logMAR visual acuity					
≤0.3	479	0.94 (0.93 to 0.95) [0.97]	0.03	0.86 (0.84 to 0.88) [0.95]	0.10
>0.3	220	0.92 (0.90 to 0.94) [0.97]		0.83 (0.81 to 0.86) [0.90]	
Wore corrective devices					
No	172	0.92 (0.90 to 0.94) [0.97]	0.027	0.83 (0.80 to 0.86) [0.95]	0.20
Yes	527	0.94 (0.93 to 0.95) [0.97]		0.86 (0.94 to 0.87) [0.95]	
Sex					
Male	373	0.93 (0.92 to 0.95) [0.97]	0.90	0.84 (0.82 to 0.86) [0.90]	0.03
Female	326	0.94 (0.92 to 0.95) [0.97]		0.87 (0.85 to 0.89) [0.95]	
Race					
Chinese	465	0.94 (0.94 to 0.95) [0.98]	0.03	0.85 (0.84 to 0.87) [0.95]	0.97
Malay	159	0.91 (0.88 to 0.93) [0.96]		0.84 (0.81 to 0.87) [0.90]	
Indian and others	75	0.93 (0.91 to 0.95) [0.97]		0.86 (0.82 to 0.90) [0.95]	
Religion					
Muslim	180	0.91 (0.88 to 0.93) [0.96]	0.02	0.84 (0.81 to 0.87) [0.92]	0.56
Non-Muslim	519	0.95 (0.94 to 0.95) [0.97]		0.86 (0.84 to 0.87) [0.95]	
Total family income (Sin$ per month)*					
<$2000	126	0.92 (0.90 to 0.94) [0.96]	0.033	0.81 (0.80 to 0.96) [0.90]	0.014
$2000–3999	361	0.93 (0.92 to 0.94) [0.97]		0.85 (0.83 to 0.87) [0.94]	
$4000–4999	111	0.95 (0.93 to 0.97) [0.98]		0.86 (0.82 to 0.89) [0.97]	
≥$5000	101	0.95 (0.93 to 0.97) [0.98]		0.88 (0.84 to 0.91) [0.99]	
Schooling stream					
Express	348	0.95 (0.94 to 0.96) [0.98]	<0.001	0.88 (0.86 to 0.90) [0.99]	<0.001
Normal academic	243	0.92 (0.91 to 0.94) [0.97]		0.83 (0.80 to 0.85) [0.90]	
Normal technical	108	0.91 (0.88 to 0.94) [0.95]		0.81 (0.77 to 0.84) [0.90]	

*1 US$ = 1.8 Sin$.

The race and sex adjusted mean time trade-off and standard gamble utility values are depicted in Table 3. Ten multiple linear regression models were constructed with the utility values (either time trade-off or standard gamble) as the response variables, and better eye presenting visual acuity, corrective devices, religion, income, or schooling stream as the main covariates, adjusting for race (a probable surrogate for religion) and sex. After controlling for race and sex, the mean time trade-off utility method for right eye presenting logMAR visual acuity greater than 0.3 was 0.02 lower, compared with students with presenting logMAR visual acuity of 0.3 or less (p=0.005). After adjusting for race and sex, there was no difference in the standard gamble for blindness utility value between subjects with logMAR values above and below 0.3 (p=0.11). After controlling for race and sex, the mean time trade-off utility method was lower (mean 0.92) for students without corrective devices, compared with students who wore spectacles or contact lenses (mean 0.94) (p=0.047). After adjusting for race and sex, there was no difference in standard gamble utility values between subjects who wore spectacles or contact lenses and those who did not (p=0.29). The time trade-off utility values were higher (mean 0.95: 95% CI 0.94 to

Table 3 Race and sex adjusted mean utilities for presenting visual acuity, income, and stream

	No	Utility (time trade-off)		Utility (gamble-blindness)	
		Race and sex adjusted mean (95% CI)	p Value	Race and sex adjusted mean (95% CI)	p Value
Right eye presenting logMAR visual acuity					
≤0.3	479	0.94 (0.93 to 0.95)	0.005	0.86 (0.84 to 0.88)	0.11
>0.3	220	0.92 (0.90 to 0.93)		0.83 (0.81 to 0.86)	
Wore corrective devices					
No	172	0.92 (0.90 to 0.94)	0.047	0.84 (0.81 to 0.87)	0.29
Yes	527	0.94 (0.93 to 0.95)		0.86 (0.84 to 0.87)	
Religion*					
Muslim	180	0.91 (0.89 to 0.92)	<0.001	0.84 (0.81 to 0.86)	0.20
Non-Muslim	519	0.95 (0.94 to 0.95)		0.86 (0.84 to 0.87)	
Total family income (Sin$ per month)†					
<$2000	126	0.92 (0.91 to 0.94)	0.07	0.82 (0.80 to 0.85)	0.008
$2000–3999	361	0.93 (0.92 to 0.94)		0.84 (0.83 to 0.86)	
$4000–4999	111	0.94 (0.93 to 0.95)		0.87 (0.85 to 0.88)	
≥$5000	101	0.95 (0.93 to 0.97)		0.89 (0.86 to 0.92)	
Schooling stream					
Express	348	0.95 (0.94 to 0.96)	<0.001	0.88 (0.86 to 0.90)	<0.001
Normal academic	243	0.93 (0.92 to 0.94)		0.84 (0.82 to 0.85)	
Normal technical	108	0.91 (0.89 to 0.92)		0.79 (0.77 to 0.82)	

*Means adjusted for sex only.
†1 US$ = 1.8 Sin$.

0.95) for non-Muslim students than for Muslim students (mean 0.91: 95% CI 0.89 to 0.92), after controlling for sex (p<0.001). The standard gamble values of students with a total family income per month of Sin$5000 or more were 0.07 higher than for families who earned less than Sin$2000 (p=0.008). After adjusting for race and sex, there was no significant difference in time trade-off (p=0.07) as a function of family income. Students in the express stream had time trade-off utility and standard gamble utility values that were 0.04 and 0.09 higher, respectively, than for students in the normal technical stream.

DISCUSSION

Utility values indicate the perceived quality of life of patients with specific health states, and the uncertainty of therapeutic modalities is quantified. The entirety of the degree of disability of the disease (economic, social, functional, and psychological) is reflected in the measures of utility as it is experienced and weighted by the patient.[14] As such it will be influenced by social factors such as religious belief, attitudes to risk and an individual's expectations about their future life. In summary, the time trade-off (mean 0.93) and standard gamble for blindness (mean 0.85) utility values of Singapore teenagers with myopia are relatively high. The time trade-off utility value was lower for myopic students with worse presenting visual acuity of the better eye, after controlling for race and sex (visual acuity >0.3). In multivariate analysis, both utility methods were higher for students with more "academic" schooling stream and standard gamble utility method was higher for students with higher total family income. Our study achieved a high participation rate (96.6%) and included information on several factors including total family income and presenting visual acuity.

Although myopia is a readily treatable disorder, it may significantly affect visual function and quality of life.[9] There may be practical difficulties associated with the wearing and maintenance of optical corrective devices, and limitations imposed on sport and career opportunities. The extent of disability may be greater if myopia is not optimally corrected with appropriate spectacles or contact lenses. The mean time trade-off was 0.93, indicating that the students were willing on average to sacrifice 7% of expected life years for perfect health associated with emmetropia. The mean standard gamble for blindness was 0.85; the teenagers were willing to accept a 15% risk of blindness associated with a treatment that cures myopia. We did not compare the utility value for standard gamble across studies as the risk of "blindness" was evaluated in our study, rather than the risk of "death." It has been purported that the standard gamble for death overestimates risk aversion as the idea of death evokes an emotional response. As myopia is an ocular disorder which is not associated with considerable morbidity or significant mortality, the risk of "blindness" was chosen as a more relevant complication of a hypothetical treatment for myopia. As expected, the time trade-off utility value (for blindness) for myopia (mean 0.93) was higher (denoting a better quality of life), compared with diabetic retinopathy (time trade-off utility value (for death), mean 0.77) and age related macular degeneration (time trade-off utility value (for death), mean 0.72).[10 11] Attempts at comparing utility values across studies may be limited by differences in the selection of the study population and interview methods used to assess utility values.

We note that teenagers, in contrast with adults, may place different values on the impact of eye disease and life expectancy because of their youth and good health. Teenagers may be less willing to take risks in return for perfect vision than adults. As cycloplegia was not used in our study, it is possible that excessive accommodation may lead to "pseudo-myopia" in otherwise normal teenagers. Thus, both true myopes and emmetropes with pseudo-myopes may be included in our study sample and the utility values may be higher than expected. However, a validation study of cycloplegic and non-cycloplegic refraction in 670 male Singapore military conscripts (mean age 19.5 years) showed an intraclass correlation coefficient of 0.99 for refractive error.[3]

The time trade-off utility value for myopia decreased (mean 0.92) for teenagers with presenting logMAR visual acuity worse than 0.3, compared with teenagers whose better eye presenting logMAR visual acuity was better than 0.3 (mean = 0.94), after controlling for race and sex (p=0.005). This difference in time trade-off utility value (0.02) appears small, but may be of clinical significance. For example, if a teenager reports that he or she expects to live to 80 years and the number of years willing to sacrifice for a new technology to restore emmetropia is 6.5 years, then the reported time trade-off utility value is 0.92; while another teenager who expects to live to 80 years but will sacrifice only 5 years of life will have a time trade-off utility value of 0.94. Non-optimal or no correction of myopia with spectacles or contact lenses may impair vision and diminish quality of life of myopic teenagers. Ophthalmologists, optometrists, and the general public should be educated about the need for regular annual eye checkups for all myopic individuals.

In previous studies of other eye diseases, the utility values were lower for patients with worse best corrected visual acuity (Table 1). In the United States, the time trade-off utility values of 80 white patients with age related macular degeneration and 100 patients with diabetic retinopathy were lower concomitantly as the corresponding best corrected visual acuity in the better eye decreased.[10 11] In our present study, the utility values do not vary with the degree of myopia, suggesting that poor presenting visual acuity, rather than visual disability associated with the disease itself (myopia), is the main determinant affecting quality of life and patient's perception of the value of vision.

Higher utility values using *both* the time trade-off and standard gamble for blindness methods were found in students in "better" schooling streams; whereas the standard gamble utility values were higher for students with higher total family income. Students from families with lower socioeconomic status or who were in less "academic" streams tended to associate myopia with a larger detrimental effect on perceived quality of life, and may have a greater prejudice against myopia. This cannot be explained simply by a greater willingness to forego years of life, (perhaps because of different perceptions of their future quality of life), because the standard gamble is also lower. The reporting of information such as total family income among teenagers may be inaccurate or biased. However, it is likely that this misclassification bias is non-differential and the results tend towards the null. Similarly, the time trade-off utility values for age related macular degeneration patients were lower in adults with high school education or less (mean 0.70), than in adults with greater than high school education (mean 0.74).[11] In contrast, in a study of diabetic retinopathy patients, the standard gamble utility value of adults with 12 years of education or less was higher (mean 0.91), than in adults with more than 12 years of education (mean 0.82)[10]; which could perhaps reflect differing attitudes and perceptions of risks in these populations.

We explored the differences in utility values associated with the same eye condition across different ethnic or religious groups. Previous studies on the utility values of patients with diabetic retinopathy, age related macular degeneration, and blindness were conducted in primarily white populations.[10–12] Patients' perceptions towards the degree of disability associated with myopia may be influenced by social or cultural beliefs of the subject. In our multiethnic Asian study, Muslim students reported lower utility values.

In summary, the mean time trade-off and standard gamble for blindness utility values of Singapore myopic teenage students were 0.93 and 0.85, respectively. The utility values

were higher in students with better presenting visual acuity, students who wore appropriate optical corrective devices, students with higher total family income, more "academic" schooling streams, and those who were non-Muslims.

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