MONASH University
Business and Economics

Centre for Health Economics

Research Paper 2009 (45)

AQoL-7D (Vision) Instrument:

Overview, survey results and utility algorithms

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December 2009

Centre for Health Economics
ISSN 1833-1173
ISBN 1 921187 44 1

ACKNOWLEDGEMENTS

The research described in this paper is made possible through National Health and Medical Research Council (NHMRC) Project Grant ID: 491162 and Professorial Fellowship ID: 284363.

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ABSTRACT

The AQoL-7D (Vision) is the third of the Assessment of Quality of Life (AQoL) instruments for measuring health-related quality of life. The full suite, their use, algorithms and the relationship of different instruments to one another are described on the AQoL website (below).

The construction of the AQoL-7D descriptive system – questionnaire – and the underlying psychometric analysis are reported in Misajon et al 2005 and the theory behind the derivation of the utility weights in Peacock et al 2008. The present paper applies the theory to derive the utility algorithm for the instrument and, separately, for the 7 dimension weights. These may be accessed and used directly by downloading the algorithm from the AQoL website http://www.buseco.monash.edu.au/centres/che/aqol/

TABLE OF CONTENTS

List of Tables

List of Figures

AQoL-7D (Vision) Instrument:
Overview, survey results and utility algorithms

1 Introduction and Background

Around 19 percent of the world's population or 950 million people are aged 50 or over and in excess of 82 percent of those who are blind are in this age group. By 2050 the number aged over 60 will exceed 2 billion. The combined effect of an ageing population and the high correlation between age and vision impairment is an indication that visual impairment is set to increase over time AIHW (2007).

Vision impairment results in an increased risk of falls, hip fractures, depression, social isolation, need for community service and greater risk of admission to nursing home (West, Munoz et al. 1997; Taylor, McCarty et al. 2000; Wang , Mitchell et al. 2001; McCarty, Fu et al. 2002). The consequences of these for an individual's quality of life (QoL) need to be included in economic evaluations: their exclusion would result in a systematic bias against the funding of programs to prevent or cure visual impairment.

Presently economic evaluations attempt to take QoL into account using the Quality Adjusted Life Year (QALY) as a unique outcome in Cost Utility Analysis (CUA) which estimates and compares the costs per QALY from competing programs. However to obtain valid measures of QALYs requires the valid measurement of the QoL of the visually impaired using measurement units which are suitable for the construction of QALYs. This requires the measurement of QoL using people's preferences, or utilities, as the yardstick.

Two approaches can be adopted. With the holistic approach the relevant health states are described in a series of scenarios. These are then rated using a scaling instrument to obtain indices of 'utility' to calculate QALYs. The Time Trade-off (TTO) and standard gamble (SG) are the two most popular instruments. Generally, patients who have experienced a health state are interviewed for the construction of scenarios and randomly selected people from the general population are surveyed to obtain the utility weights.

With the 'decomposed' or multi attribute (MAU) approach a generic instrument is constructed to describe and pre-calibrate numerous health states. The instrument consists of the 'descriptive system' – a set of questions concerning the multi attributes which have been selected to describe or define the quality of life – and secondly, an algorithm or scoring system which can convert all possible combinations of item responses into an index of utility. The model can be derived using either econometric or decision analytic techniques to fit a simple additive model or a multiplicative model.

A number of generic utility instruments exist which, in principle, can measure disparate health states. These include the 15D, EQ5D, SF6D, HUI 1, 2, 3. One of these, the EQ5D, has been mandated for use in economic evaluations submitted to the UK National Institute of Clinical Excellence (NICE). All instruments, however are more or less sensitive in different domains of health and none of the generic instruments was constructed with the explicit objective of ensuring sensitivity and validity in the context of visual impairment. The EQ5D, for example, makes no reference to vision and impaired vision will impact upon this scale only indirectly via an effect upon mobility, personal care, usual activities or anxiety/depression. However, even these attributes have only three levels of 'problem' (no, moderate, extreme).

The objective of the AQoL program was to achieve a new generation of MAU instruments which could, if necessary, be supplemented in particular disease areas to achieve a greater sensitivity to the disease specific health states than would be achieved with the standard AQoL instrument but which nevertheless produced valid scores for the health states before and after the disease interventions. To date, supplementation has occurred in the areas of vision and mental health.

The creation of the vision specific dimension of the AQoL is described in Misajon et al. (2005) and the methods to be used for deriving the utility (weights) algorithm in Peacock et al. (2008). The present paper summarised these and presents results from the utility (weights) survey. It reports the final utility algorithm derived from the analysis of these results.

The paper unfolds as follows. Section 2 outlines the objectives and the derivation of the descriptive system. Section 3 summarises the theory behind utility modelling, the survey results and the derivation of the utility algorithm. Section 4 presents some results derived from the algorithms, namely population norms and the relationship between dimension scores and total AQoL-7D utilities.

2 The AQoL-7D descriptive instrument

The objective of the AQoL-7D project was to create an instrument for assessing vision related quality of life and which produced utility scores suitable for use in economic evaluation studies and specifically cost utility analysis.

This required a 'descriptive system' set of questions:

- With construct validity, ie a descriptive system based upon appropriate psychometric procedures;
- With increased sensitivity to overall quality of life but particularly those states affected by vision;
- With a descriptive system based on the concept of 'handicap', (ie problems arising in a social context) rather than one based on disability or impairment (ie a 'within the skin' description); and
- Which closely related to the AQoL-6D (Standard) instrument to permit a comparison of scores.

The first stage of this process – the construction of the descriptive system for the vision dimension – is described by Misajon et al. (2005). The AQoL-7D combines 26 items in 7 dimensions. The label 'VisQoL' was used to describe the vision dimension (6 items) reflecting the fact that a supplementary aim was to permit the use of VisQoL as a brief, stand alone (non utility) instrument for capturing the main effects of visual impairment.

The first step in this stage of the analysis was to create focus groups with people with impaired vision to determine their perceptions of quality of life. Focus group methodology is a well-established technique used to canvass a range of views about a topic and is also a useful aid in the design of questionnaires, including the development of terminology that is appropriate and understandable for a target population. Participants were recruited from existing self-help groups at the Vision Australia Foundation so that the sample was representative of the demographic profile of people with impaired vision. The moderator discussed the purpose of the study with each group prior to commencement. A semi-structured approach was used to conduct the groups.

Focus group topics were guided by the Impact of Vision Impairment (IVI)[2] questionnaire. However, group discussion flexibility allowed for exploration of any concepts raised by participants. The groups probed the effect of vision on self care, mobility in and out of the home, participation in work and leisure activities, interaction with other people, and their sense of self. There was also a question on which area of life had been most affected by visual impairment.

Grounded theory techniques were used to analyse transcripts and observer notes from the discussions. They were examined to identify distinct statements made, which were then coded into appropriate categories. Using the results from the focus groups and from previous research an item bank was created for the development of the various dimensions of the VisQoL. The next step was to determine the suitability and validity of the items in the item bank for inclusion in the instrument and to optimise the number of items. Participants in this second stage were required to fill in a questionnaire which contained all of the items which remained in the item bank after editing and initial triage to eliminate duplicate or obviously inadequate items. Two groups of participants were recruited:

1. People who were visually impaired, defined as having visual acuity (VA) <20/30 in the better eye; and
2. Non-visually impaired, defined as VA 20/20 or better in both eyes.

Recruitment: All participants were aged 18 years or over. Participants included people from the general public and people with vision impairment. People from the general population were recruited in metropolitan Melbourne and people with impaired vision were recruited from the Royal Victorian Eye and Ear Hospital (RVEEH). Eligible participants were given the option of completing the questionnaire in the waiting room or taking it home and returning it via reply-paid envelopes provided. This enabled participants to seek assistance from the research team or a family member/friend, if required, to complete the questionnaire. This was important as some participants had difficulty reading the questionnaire due to their vision impairment.

People examined and found to have normal vision from a population-based study, the Vision Impairment Project (VIP)[1], were sent an invitation letter, explanatory statement, the questionnaire, a participation consent form and a reply paid envelope via post. Participants who chose to participate were requested to return the completed questionnaire and signed consent form in the reply-paid envelope.

Ethics approval for the study was granted by the Human Research and Ethics committee of the RVEEH. Informed written consent was obtained from each participant.

Analysis: To reduce the item bank to the final structure, basic psychometric properties were examined. In addition, exploratory factor (EFA), reliability, item response theory (IRT), and structural equation modelling (SEM) analyses were conducted. The final step was to confirm the structural equation model obtained in the pilot study with a second sample group. This second group was recruited using the same methods as in the pilot study. That is, people with impaired vision were recruited from the RVEEH, while those with normal vision were recruited from the VIP study. SEM was used with this sample to confirm the construction sample model. Because there are known difficulties with SEM ADF (asymptotic distribution free) models constructed in AMOS[23], which may have provided misleading fit estimates, we pooled the two samples and ran a confirming analysis.

Results: Results indicated that it was possible to preserve AQoL-6D and achieve a psychometrically efficient instrument with the addition of one more dimension. The new vision dimension ('VisQoL') consisted of the following six questions:

1. Does my vision make it likely I will injure myself (ie when moving around the house, yard, neighbourhood or workplace)?
2. Does my vision make it difficult to cope with the demands in my life?
3. Does my vision affect my ability to have friendship?
4. Do I have difficulty organising any assistance I may need?
5. Does my vision make it difficult to fulfil the roles I would like to fulfil in my life (eg family roles, work roles, community roles)?
6. Does my vision affect my confidence to join in everyday activities?

The questions and response categories are reproduced in an appendix. This dimension was added to the AQoL-6D to create the AQoL-7D.

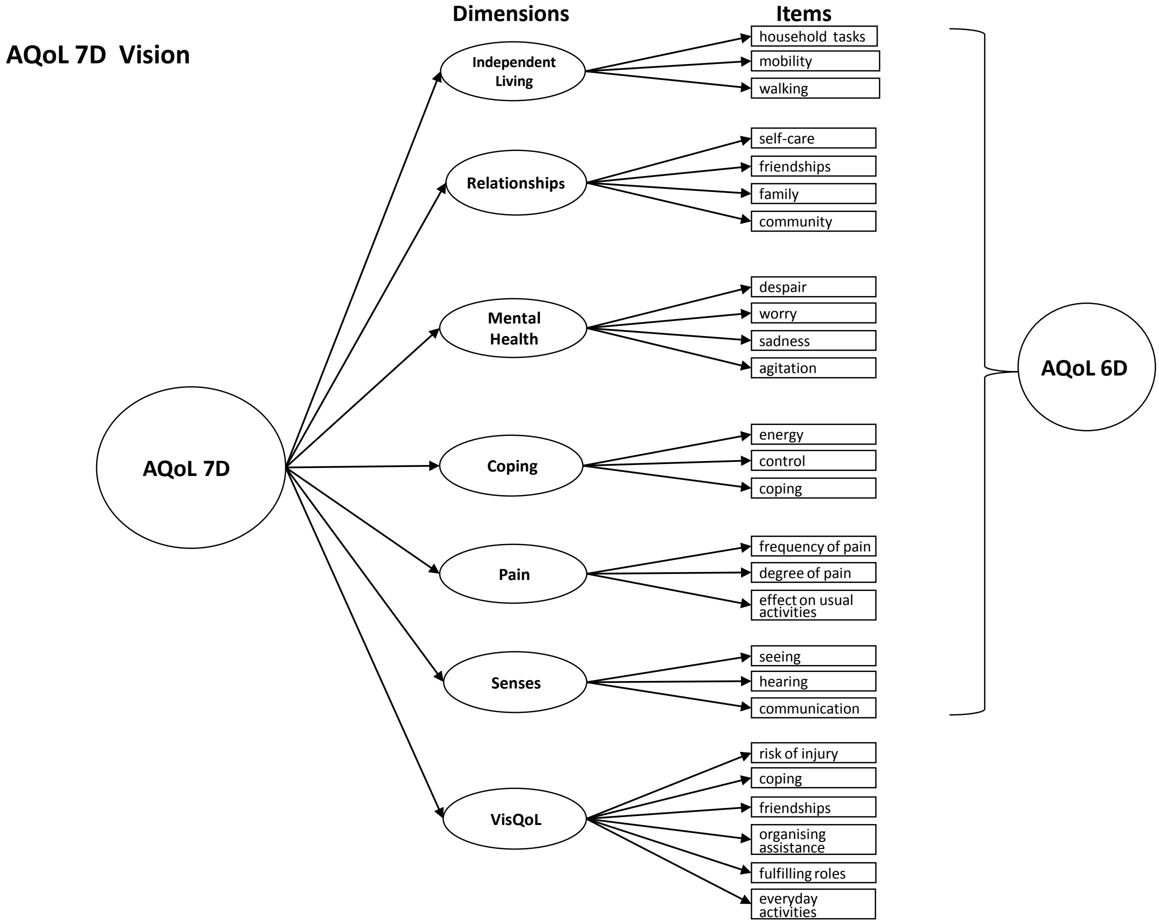
The full version of these instruments and the appendix VisQoL instrument (dimension 7, AQoL-7D) may be found on the website: http://www.buseco.monash.edu.au/centres/che/aqol/.

The dimensions of the AQoL-7D are as follows:

1. Independent living
2. Relationships
3. Mental health
4. Coping
5. Pain
6. Senses
7. VisQoL

The final hierarchical structure of the instrument is shown in Figure 1.

Figure 1. Structure of the AQoL-7D



3 Deriving the utility algorithm

The number of health states described by a multi attribute instrument is usually too large to derive utility weights for each state separately (AQoL-7D has in excess of 5^{26} combinations of item levels). Consequently values are estimated one of two ways. First, drawing upon decision analytic theory, some form of averaging of item scores is employed (for examples see 15D, Health Utility Index (HUI) 1, 2, 3, AQoL-4D). Secondly, econometric methods may be used to 'explain' a limited number of MAU states which are assessed holistically using the TTO or another scaling method and the econometric model with the greatest explanatory power is used to interpolate or extrapolate other values (for example EQ5D, SF6D). The former method has the advantage of comparative simplicity when there are a large number of items, but potentially introduces bias if there is structural or preference dependency, as these may cause 'double counting'. The second method mitigates this problem but is problematical when there are large numbers of items.

AQoL-7D followed AQoL-6D in using a combination of these approaches. Decision analytic (multiplicative) models were used to obtain dimension scores and an initial model for the overall score for the 7 dimensions combined. A second stage econometric analysis was then carried out to 'correct' the values obtained in the first stage: that is, to eliminate the effects of double counting of elements of a health state resulting from structural or preference dependency.

The multiplicative model used in the first step of the estimation procedure is shown in equations 1 and 2. The first equation, despite its apparent complexity is essentially the equation $U = U_1.U_2.U_3.U_4.U_5.U_6.U_7$ where U_i are the dimension scores and U the overall score. Equation 1 allows additional weights per dimension. Following decision analytic theory these weights are set equal to the disutility scores of the item worst health states where disutility, DU, is measured on a 0-1 scale and DU = 1-U. Equation 2 produces the scaling constant, k, which serves the same logical purpose as the requirement that weights add up to 1.00 in an additive model (a weighted average).

In stage 2, a variety of econometric models were used: double log, linear, quadratic and higher order. Two criteria were used to select the best fitting model; namely, the conventional R^2 coefficient and, secondly, that the final model should give an unbiased prediction of the observed multi attribute health states.

Since the AQoL-7D is the AQoL-6D plus an additional dimension, data were collected for the new vision dimension multiplicative model. This was added to the multiplicative equations for AQoL-6D and an overall multiplicative model for AQoL-7D created using AQoL-6D and VisQoL dimension weights. MA states were collected which spanned all dimensions.

Data

Population sampling: The sample was drawn from a computer readable phone directory, using a stratified, clustered two-stage design, similar to Hawthorne et al.'s (1999) procedures in the AQoL-4D validation study. Based on the Australian Bureau of Statistics Socio-Economic Index for Areas (SEIFA 2001) scores, postcodes were the primary sampling unit, with probability proportionate to population size (to reduce the effect of socio-economic confounding). From these postcode areas, telephone subscribers (18 years+) were randomly sampled (n=184). SEIFA provides various measures to rank areas based on relative social and economic wellbeing and was developed by the Australian Bureau of Statistics using data from the 2001 Census of Population and Housing. Subscribers were contacted by letter and subsequently by telephone. The use of post-codes as the primary sampling unit meant that informants would be fairly tightly clustered, minimizing the travel costs. These procedures were also employed in AQoL-4D.

Patient sampling: 182 participants with impaired vision were recruited from hospitals and rehabilitation agencies. Three levels of impairment were sampled: those with mild (<20/20-20/60); moderate (<20/60-20/200) and severe (<20/200) impairment. People with vision <20/30 were recruited from the Royal Victorian Eye and Ear Hospital (RVEEH), Vision Australia (VA) and Retina Australia. Prior to their next appointments eligible participants from the RVEEH special eye clinics were sent invitation letters to participate in the study. Peer workers and staff who were vision impaired from VA were recruited via mail-outs, while clients were recruited directly from VA day centres, training classes and support groups. Retina Australia included an invitation letter to their members with their newsletter.

Survey design and field procedure: Prior to their interview, participants were sent a confirmation letter with details of their interview, as well as a series of questionnaires. The questionnaires sent to the participants included:

- AQoL-4D (12 items) and AQoL-6D (20 items) questionnaires;
- VisQoL questionnaire (6 items); and
- Questions regarding demographics and health.

Utility weights were obtained using the TTO technique (as with AQoL-4D and 6D). Participants were also required to complete rating scales (VAS) for the item responses for the six VisQoL items and these were subsequently transformed into TTO equivalent scores using the transformation algorithm produced for AQoL-6D (Richardson et al. 2004).

Results

Table 1 reports the number of respondents by age and gender and Table 2 the distribution of their postcodes by SEIFA group. The age distribution of patients is heavily skewed towards the elderly reflecting increasing macular degeneration with age. Public respondents were also skewed towards the elderly but subsequent analysis found no significant response difference by age.

Table 1. Age and gender distribution

Age Group	Public			Patients			Grand total
	Male	Female	Total	Male	Female	Total	
18 to 34 Years	6	7	13	9	9	18	31
35 to 44 Years	8	10	18	3	6	9	27
45 to 54 years	13	21	34	12	9	21	55
55 to 65 Years	15	39	54	17	16	33	87
66 Years +	22	37	59	35	63	98	157
Total	64	114	178	76	103	179	357

Missing n = 9

Table 2. SEIFA groups by location

SEIFA Group	Public	Patients	Total
1	42	25	67
2	27	19	46
3	42	34	76
4	35	38	73
5	35	66	101
Total	181	182	363

Missing n = 3

Item response scores for each of the items of the vision dimension are reported in Table 3. Response categories for non-vision dimensions are reported in Richardson et al. (2004).

The VAS scale used to calibrate items set the best and worst item responses at 100 and 0.00 respectively and Table 3 reports the value of intermediate states relative to these endpoints. Patient and public respondents gave very similar responses. In half of the cases the difference was significant at the 5 percent level but the absolute differences were very small – the largest three differences being 8, 6 and 5 points on a 100 point scale.

Table 3. VAS scores for the 6 VisQoL items – on item best/worst scale (0-100)

	Mean VAS score		
	Public	Patient	Total
Q1: It is most unlikely I will injure myself because of my vision- rs1a	100.0	100.0	100.0
There is a small chance- rs1b	85.99	83.99	85.00
There is a good chance- rs1c	55.07	55.26	55.16
It is very likely -rs1d	29.70	30.26	29.98
Almost certainly my vision will cause me to injure myself- rs1e	.00	.00	.00
Q2: Has no affect on my ability to cope with the demands in my life- rs2a	100.0	100.0	100.0
Does not make it difficult at all to cope with the demands in my life -rs2b	96.25	96.46	96.35
Makes it a little difficult to cope- rs2c vis dim	79.89	77.29	78.59
Makes it moderately difficult to cope- rs2d	57.77	56.02	56.90
Makes it very difficult to cope- rs2e	26.26	23.05	24.67
Makes me unable to cope at all-rs2f	.00	.00	.00
Q3: My vision makes having friendships easier -rs3a	100.0	100.0	100.0
Has no effect on my friendships-rs3b	96.45	97.59	97.02
Makes friendships more difficult- rs3c	72.45	67.63	70.05
Makes friendships a lot more difficult-rs3d	46.83	42.69	44.77
Makes friendships extremely difficult- rs3e	26.08	20.82	23.46
Makes me unable to have friendships-rs3f	.00	.00	.00
Q4: I have no difficulty organising any assistance-rs4a	100.0	100.0	100.0
I have a little difficulty organising assistance- rs4b	87.24	83.03	85.14
I have moderate difficulty organising assistance-rs4c vis	65.91	60.21	63.08
I have a lot of difficulty organising assistance- rs4d	34.32	26.13	30.25
I unable to organising assistance at all- rs4e	.00	.00	.00
Q5: My vision has no effect on my ability to fulfil these roles- rs5a	100.0	100.0	100.0
Does not make it difficult to fulfil these roles-rs5b	96.66	98.21	97.43
Make it a little difficult to fulfil these roles- rs5c	79.53	77.54	78.54
Make it moderately difficult to fulfil these roles -rs5d	56.24	54.59	55.42
Make it very difficult to fulfil these roles-rs5e	28.85	23.28	26.08
My vision means I am unable to fulfil these roles-rs5f	.00	.00	.00
Q6: My vision makes me more confident to join in everyday activities- rs6a	100.0	100.0	100.0
Has no effect on my confidence to join in everyday activities-rs6b	96.82	98.64	97.72
Makes me feel a little less confident- rs6c	81.63	78.70	80.17
Makes me feel moderately less confident- rs6d	60.69	56.40	58.56
Makes me feel a lot less confident- rs6e	35.53	27.07	31.32
Makes me not confident at all- rs6f	.00	.00	.00

Item worst responses were valued on a scale with endpoints defined by the best and worst health states. Thus respondents were asked to consider a health state consisting of an item at its worst level with other items in the dimension at their best level. Evaluation was carried out using the TTO methodology with 10 years in the intermediate state compared with varying times in the best and worst states. (For details of the implementation of the TTO see Iezzi and Richardson (2009). Results are shown in Table 4.)

Table 4. Item worst TTO scores on a 10 point best health-death scale

VisQoL items	Mean TTO			SE			Sig
	Public (N=184)	Patients (N=182)	Total (N=366)	Public	Patients	Total	
1. Does my vision make it likely I will injure myself?	7.12	7.49	7.30	.17	.17	.12	.120
2. Does my vision make it difficult to cope with the demands in my life?	6.17	6.43	6.30	.20	.18	.14	.335
3. Does my vision affect my ability to have friendships?	6.84	7.00	6.92	.21	.17	.14	.552
4. Do I have difficulty organising any assistance I may need?	6.97	7.09	7.03	.19	.17	.13	.629
5. Does my vision make it difficult to fulfil the roles I would like to fulfil in life?	6.57	6.86	6.71	.20	.18	.13	.276
6. Does my vision affect my confidence to join in everyday activities?	7.18	7.20	7.19	.19	.17	.13	.946

As with item responses, patient and public scores are very similar, differing by an average of 0.2 and a maximum of 0.37 points on a 10 point scale. The result is perhaps unexpected as, according to the conventional wisdom, patients evaluate states they are familiar with more highly due to their experience with adaptation. Despite the statistical insignificance of individual differences, however, every patient's score is greater than the corresponding public score and together the 6 results allow a rejection of the null hypothesis that the two populations have identical scores. However the differences are small.

The item weights (w_{ij}) along with the scaling constant (k) in equation 3 results in the dimension algorithm shown in equation 2.

$$U = U_1 * U_2 * U_3 * \ldots * U_7 \quad (1)$$

$$DU = \frac{1}{k}\left[\prod_{i=1}^{n}\left[1 + k w_i DU_i\left(x_{ij}\right)\right] - 1\right] \quad (2)$$

where

$$k = \prod_{i=1}^{n}(1 + k w_i) - 1 \quad (3)$$

$$U = 1 - DU \quad (4)$$

This multiplicative model was applied at two levels; first to combine items into dimensions and second to combine dimensions into the overall AQoL-7D score.

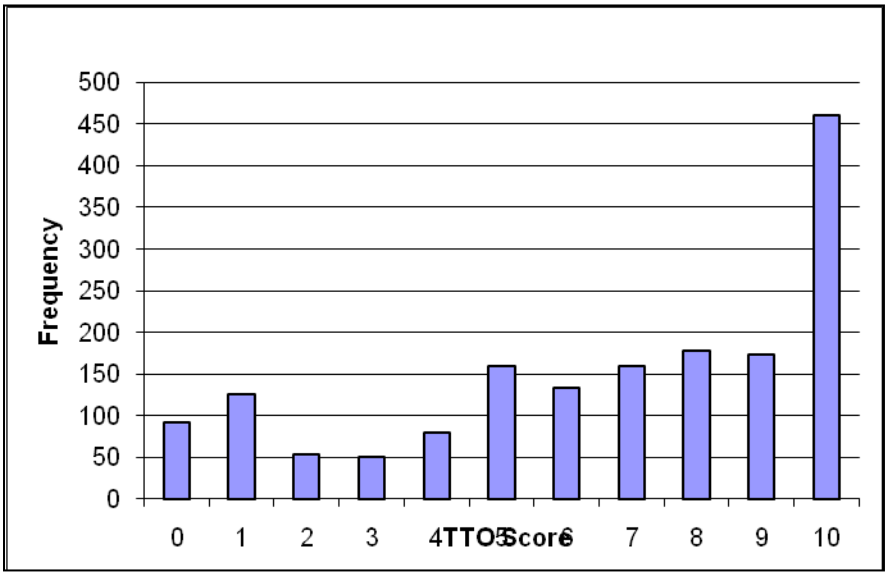
Second stage adjustment

Data: In the second stage 'correction' independently assessed MA health state utilities were explained econometrically using the first stage estimate and dimension scores as independent variables. In principle, MA states could be constructed using experimental design to achieve a statistically efficient coverage of dimensions. In practice this produces incoherent health states (bedridden, dead but independent and coping, fully satisfied). Consequently states were constructed logically using a criteria of (i) coherence; (ii) simplicity; (iii) multi dimensionality. Simplicity was included to minimise the cognitive load on respondents. States were generally constructed, therefore, in which several dimensions did not contribute to disutility. The states are defined in an appendix and were evaluated during the interview using the TTO technique.

Following a procedure developed for AQoL-6D a number of the most serious MA states were decomposed to create additional MA 'pseudo' states. For example, an MA state with dimension scores (1, a, b, 1, c, 1, 1, d) would be used to define two states (1, 1, b, 1, c, 1, 1, 1) and (1, a, 1, 1, 1, 1, 1, d). The overall MA utility derived from the TTO interview would be divided between the two new states.

Results: In total, 28 independent health states were employed and 1251 TTO 'observations' elicited, an average of 45 observations per health state. Figure 2 is the frequency distribution of individual TTO scores for the 28 states. An additional 37 pseudo health states were constructed, giving a total of 65 health states.

Figure 2. Frequency distribution of TTO scores (n = 1665)



Figures 3 and 4 are scatterplots of the mean (MA) TTO utilities for the derived 44 and total 72 health states against the multiplicative values predicted for them (Mult-AQoL). The OLS linear relationship between these strongly suggests what subsequent analysis revealed, that the best statistical fit of the data is linear. The simple plots also indicate the degree of 'double counting' of disutilities in the multiplicative model. If all items and dimensions were orthogonal – elements of poor health never correlated – then the slope of the linear relationship would be 45 degrees (TTO = 0.00 + 1.00 Mult-AQoL). Deviation from this indicates the high correlation between elements of health.

Figure 3. TTO Disutilities vs Mult-AQoL (Pseudo E-type)

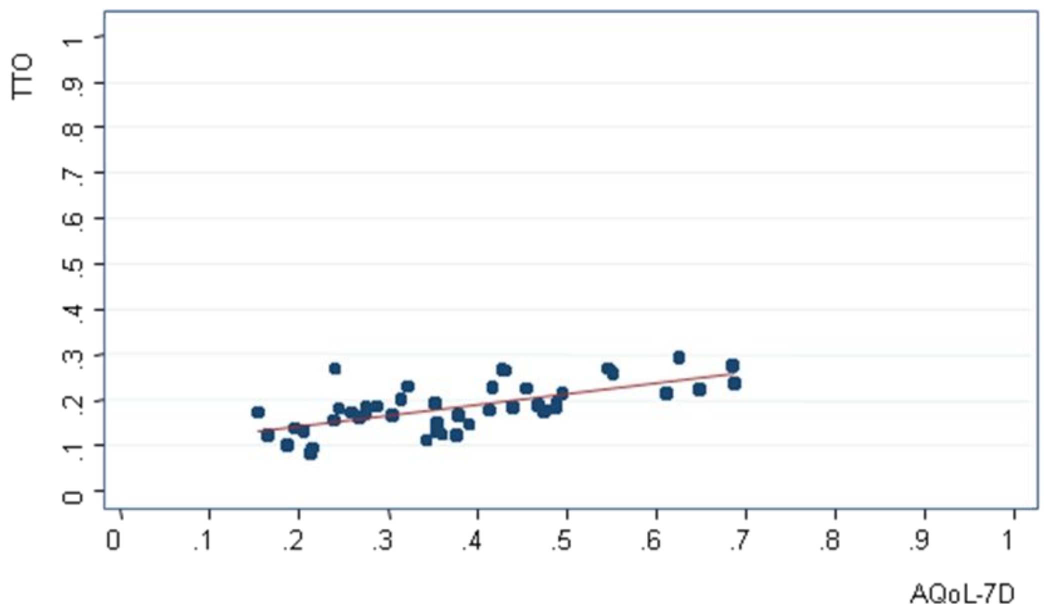
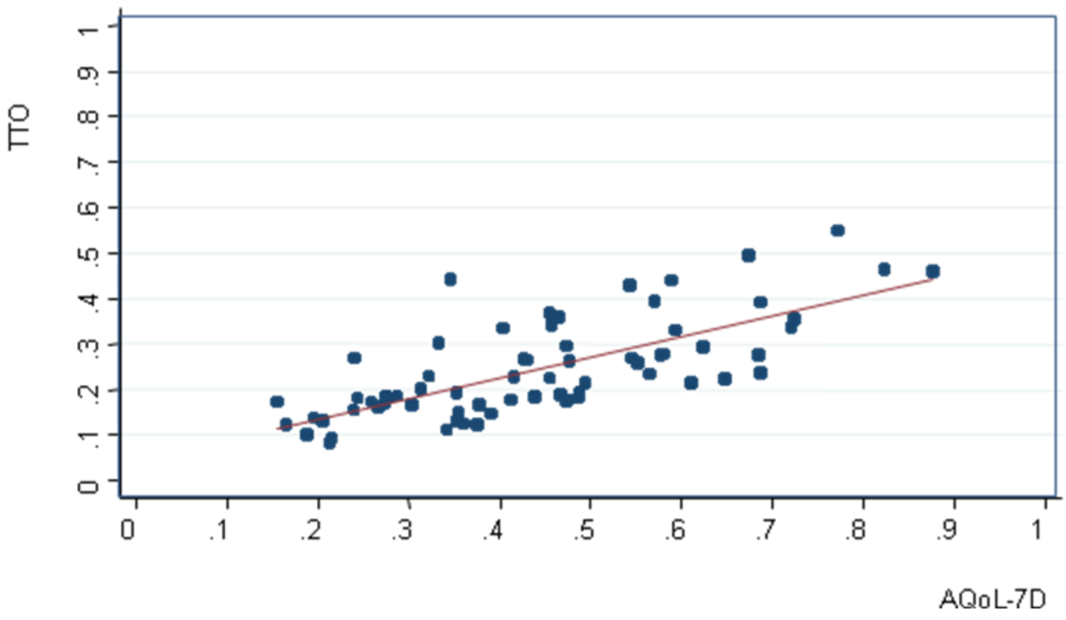


Figure 4. TTO Disutilities vs Mult-AQoL (all data)



The best fitting linear models are reported in Table 5 in which observed disutilities, DU, (measured by TTO) are explained by the multiplicative AQoL and its dimensions. Mean values of health states were used as observations to overcome the common problem of extreme non normality of the data and particularly the number of observations where respondents would not trade (see TTO score of 10 in Figure 2). As noted, each observation was therefore the result of an average of 45 individual responses. A logical requirement of models is that the regression line pass through (0.00, 0.00) – the AQoL all best health state must correspond with a predicted DU of 0. (One consequence of the suppression of the constant is an inflation of the R^2.)

Table 5. Regression of mean TTO on predicted (multiplicative) AQoL

Dependent mean TTO / Independent	Public		Patient		Total	
	b	**t**	**b**	**t**	**b**	**t**
AQoL (Mult)	0.68	(10.8)	.65	(11.9)	.71	(21.2)
Dim 1						
Dim 2	-0.16	(-3.07)	-0.08	(-1.5)	-0.11	(-4.4)
Dim 3						
Dim 4	-0.13	(-2.3)	-0.02	ns	-0.07	(-2.9)
Dim 5	-0.01	ns	-0.12	(-2.1)	-0.09	(-2.9)
Dim 6	-0.04	ns	-0.10	(-1.76)	-0.07	(-2.6)
Dim 7						
RMS	116				2.66	
R^2 (Pseudo)	0.95		0.93		0.95	
RMSE	0.06		0.05		0.06	
Dependent mean TTO / Independent						
n	30		35		65	
TTO Pred	1.00		1.00		0.78	(13.1)
Constant	0.00		0.00	3	0.05	(3.0)
R^2	0.73		0.64		0.73	
RMSE	0.06		0.07		0.05	
F	79		58		171	

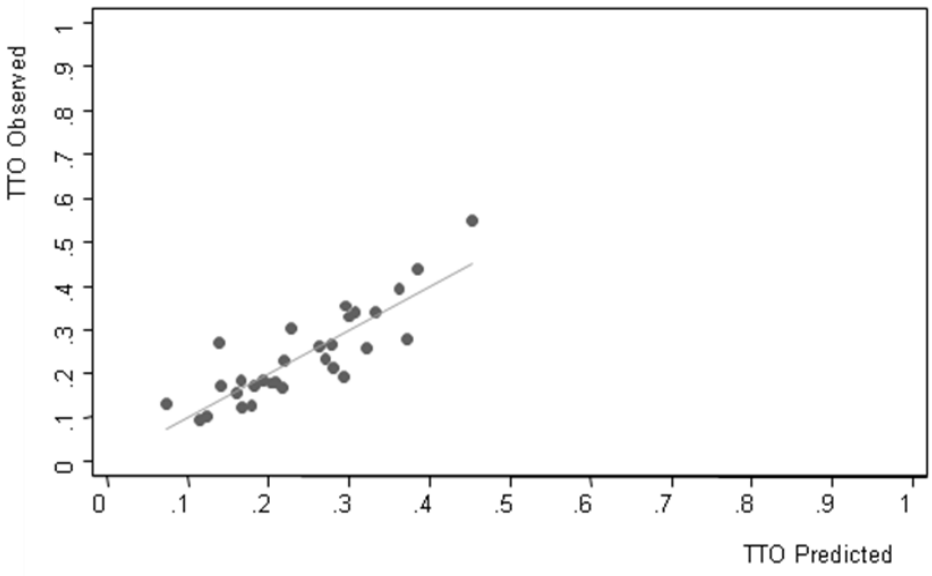
Non linear models did not fit the data, possibly because there are no observed health states with an average DU above 0.5. This means that extrapolating beyond this level of DU becomes increasingly unreliable. However, there are probably few health states which, in practice people would sacrifice half their remaining life to avoid.

Test of Bias

In the best fitting equations with the total population, total, dimension 2, 4, 5 and 6 were statistically significant. Consequently these were retained in the equations for the separate public and patient populations. Both of these were estimated from data obtained exclusively from public and patient respondents respectively.

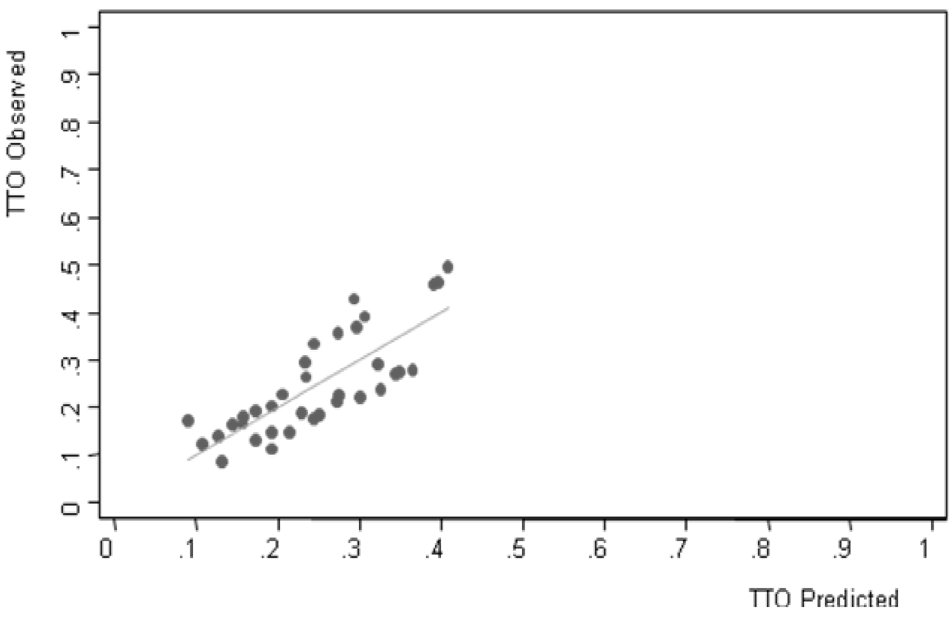
The second half of Table 5 reports a second regression for each of the initial regressions. In this TTO (pred) – the predicted value of the TTO – is itself used to predict the observed TTO. (The results need not be close, in part because of the suppression of the constant in the derivation of TTO pred.) As it is this predicted value which is to the outcome of the overall algorithm, it is important that it represents an unbiased estimate of the observed TTO. Results for the three datasets are reproduced in Figures 5, 6, and 7.

Figure 5. TTO Disutilities Observed vs TTO Predicted (public)



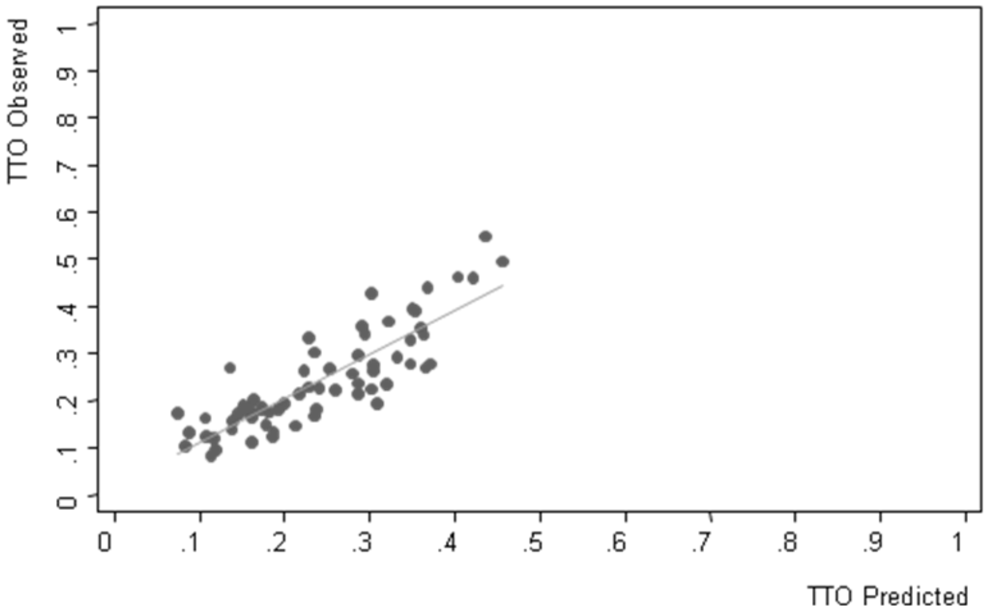
TTO (Obs) = 0.00 + 0.999 TTO (Pred)
R^2 = 0.74, F = .79
RMSE = 0.06

Figure 6. TTO Disutilities Observed vs TTO Predicted (patients)



TTO (Obs) = -0.002 + 1.000 TTO (Pred)
R^2 = 0.63, F = 171
RMSE = 0.05

Figure 7. TTO Disutilities Observed vs TTO Predicted (total)



TTO (Obs)	= 0.05 + 0.78 TTO (Pred)
R^2	= 0.73 F = 171
RMSE	= 0.05

These show that the models for the two separate populations produce estimates which are unbiased. The model resulting from combining the two groups produces a good but imperfect estimate. The root mean error (RME) is only 0.05 but an increase in the predicted TTO of 0.1 corresponds with an increase in the observed TTO of only 0.078; that is, the predicted overestimates the true increase by about 28 percent (1/0.78). This implies that better estimates are produced with separate models for the two populations.

Decomposition of utilities

Population norms were constructed from 366 survey respondents. As norms they are limited by the sample size which in some age cohorts are small (the lowest being 6 males aged above 55 in the population sample). Results are shown in Table 6. Patients generally had lower utilities than the public, with anomalies for the two smallest male cohorts. Overall males had higher utilities except for the oldest cohorts. The pattern with age was similar to other AQoL profiles: an initial decline in utility was followed by an increase in older age groups, attributable to the improved social and mental health states of the elderly.

Table 6. AQoL-7D Norms for Age Groups (n = 8)

	Male		Female		Total	
Patient	**N**	**Utility**	**N**	**Utility**	**N**	**Utility**
Age below 24	16	0.748	20	0.728	36	0.737
Age 25-34	16	0.753	12	0.710	28	0.730
Age 35-44	17	0.700	13	0.712	30	0.705
Age 45-54	20	0.728	26	0.715	46	0.720
Age 55 up	9	0.771	33	0.762	42	0.764
Public						
Age below 24	20	0.757	24	0.758	44	0.758
Age 25-34	11	0.708	28	0.734	39	0.728
Age 35-44	19	0.749	35	0.736	54	0.741
Age 45-54	11	0.750	20	0.733	31	0.739
Age 55 up	6	0.710	8	0.777	14	0.746
Total						
Age below 24	36	0.752	44	0.743	80	0.747
Age 25-34	27	0.730	40	0.722	67	0.729
Age 35-44	36	0.724	48	0.724	84	0.723
Age 45-54	31	0.739	46	0.724	77	0.729
Age 55 up	15	0.740	41	0.769	56	0.755

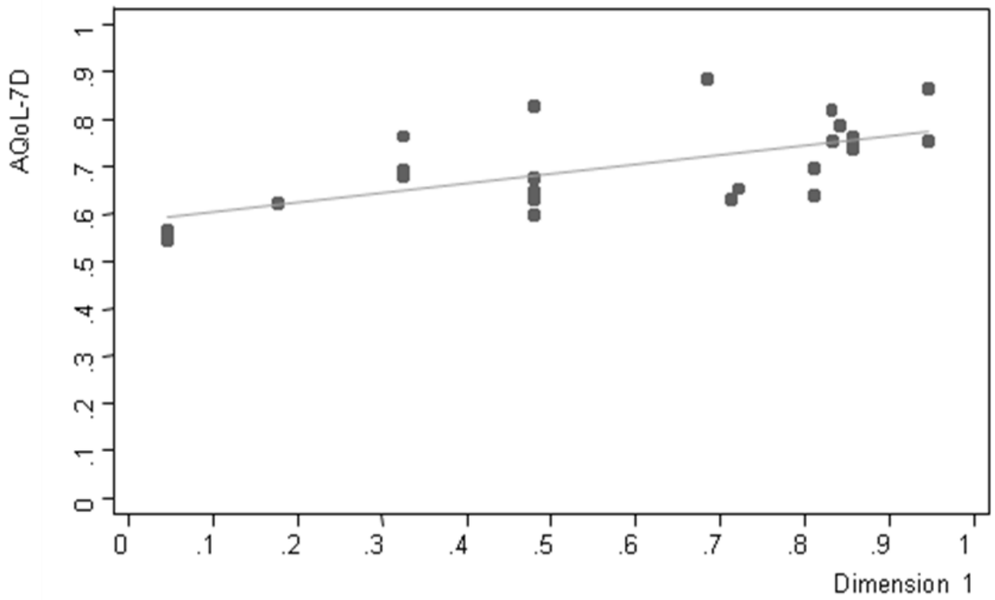
Table 7 reports the association between dimension scores and overall AQoL-7D utility for each of the 7 dimensions. The association is depicted in Figures 8 to14. An important qualification with these results is that they are derived from the health states described earlier and are partial relationships; that is, they are not a ‘pure’ reflection of dimension importance. The health states are combinations of dimensions and with a relatively small sample of states an increasing dimension disutility could be offset, by chance, by a reduced disutility in a second dimension.

Table 7. Regression results: AQoL-7D on dimension scores

Dimension	n (health states)	Constant	b	R^2
Ind. Living	25	0.59	0.2	0.39
Relationships	27	0.6	0.2	0.24
Mental health	27	0.57	0.26	0.32
Coping	27	0.61	0.21	0.21
Pain	26	0.57	2.1	0.31
Senses	35	0.61	0.18	0.25
Visqol	27	1.44	0.48	0.36

Subject to this qualification the results indicate a similar change in AQoL-7D utilities with a change in dimension scores. The b coefficient on the dimension score varies from 0.18 to 0.26 for all dimensions except vision where it is 0.4 indicating, *prima facie*, a greater contribution of vision related QoL to a change in AQoL-7D utilities amongst these health states than from other dimensions. The correlation between dimension and AQoL scores is greatest for independent living followed by vision (R^2 = 0.39; 0.36 respectively) but this is, in part, an artefact of the spread of the health states.

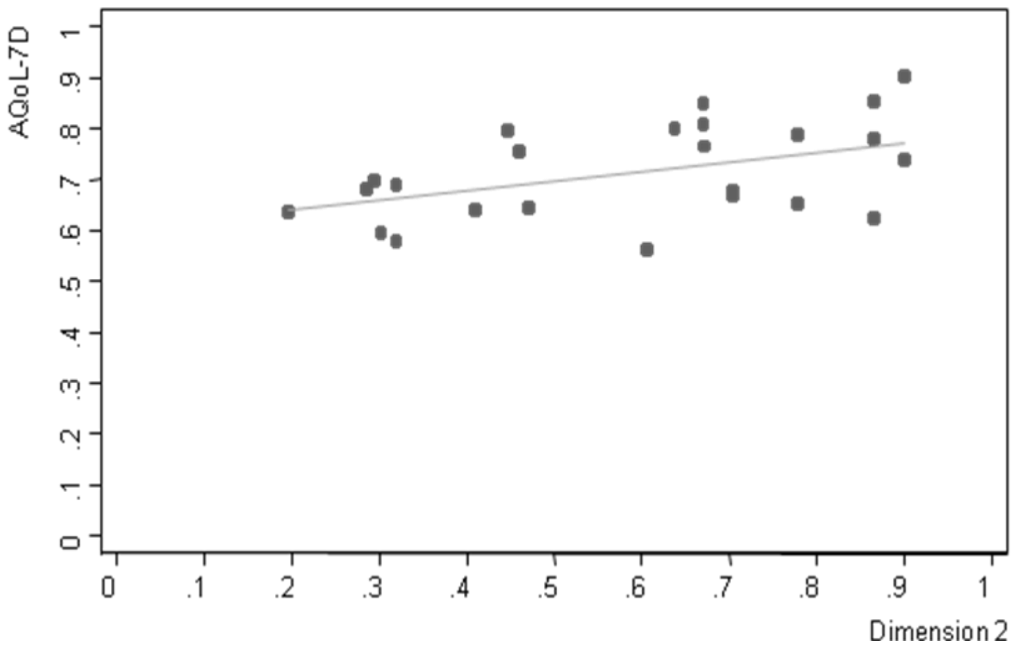
Figure 8. AQoL-7D vs Dimension 1 (independent living)



AQoL-7D = 0.59 + 0.20 Dim 1

R^2 = 0.39

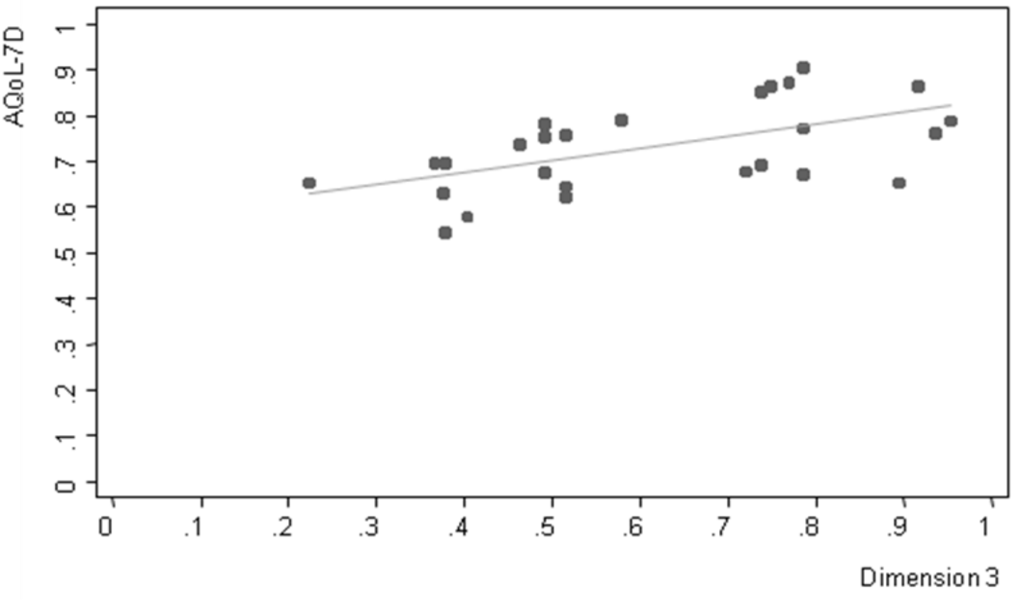
Figure 9. AQoL-7D vs Dimension 2 (Relationships)



AQoL-7D = 0.60 + 0.19 Dimension 2

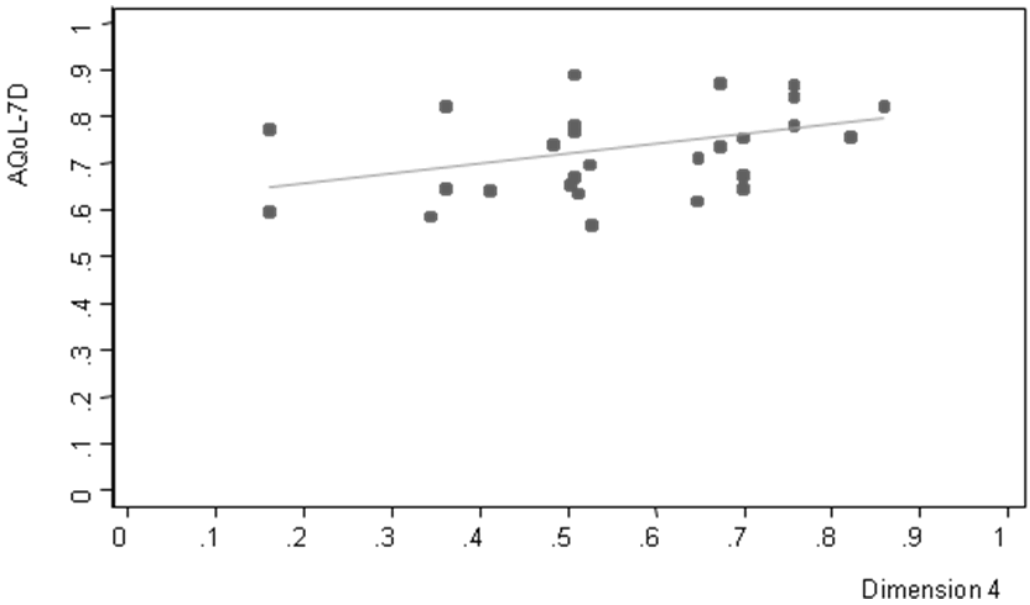
R^2 = 0.24

Figure 10. AQoL-7D vs Dimension 3 (Mental Health)



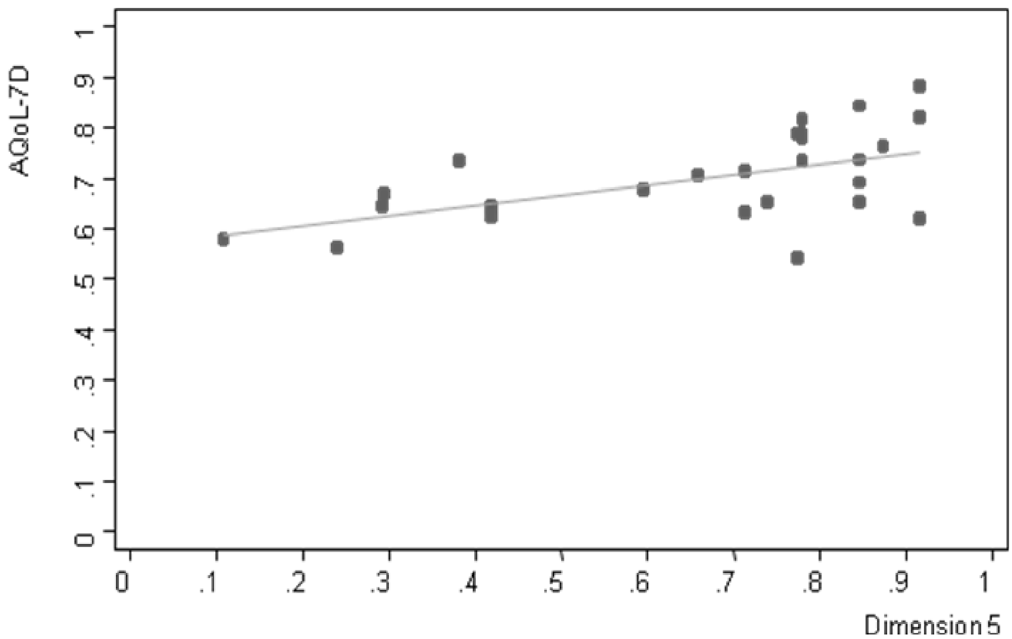
AQoL-7D = 0.57 + 0.27 Dimension 3
R^2 = 0.32

Figure 11. AQoL-7D vs Dimension 4 (Coping)



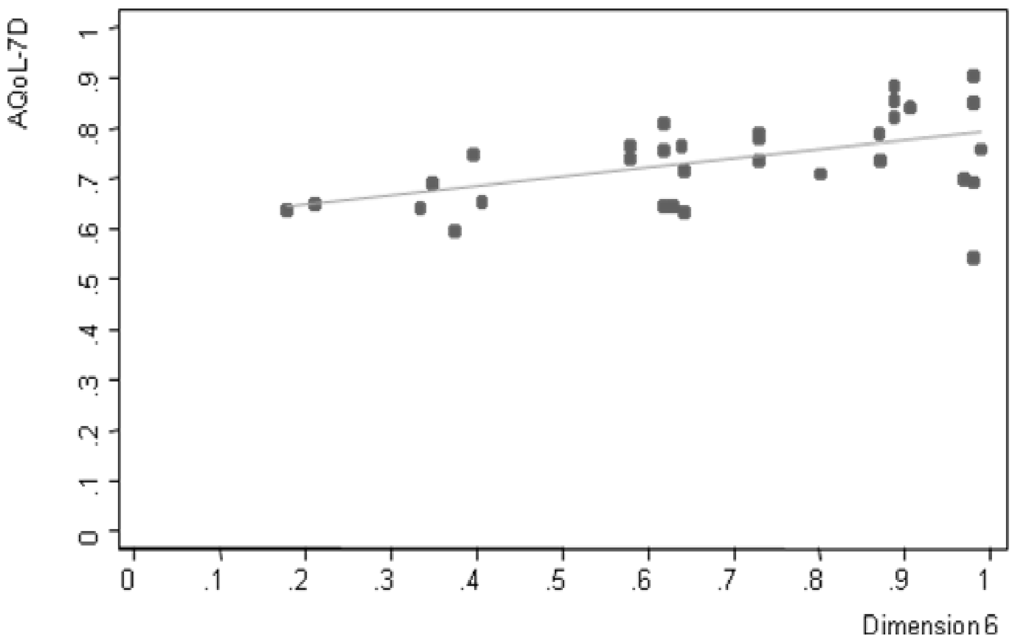
AQoL-7D	= 0.61 + Dimension 4
R^2	= 0.21

Figure 12. AQoL-7D vs Dimension 5 (Pain)



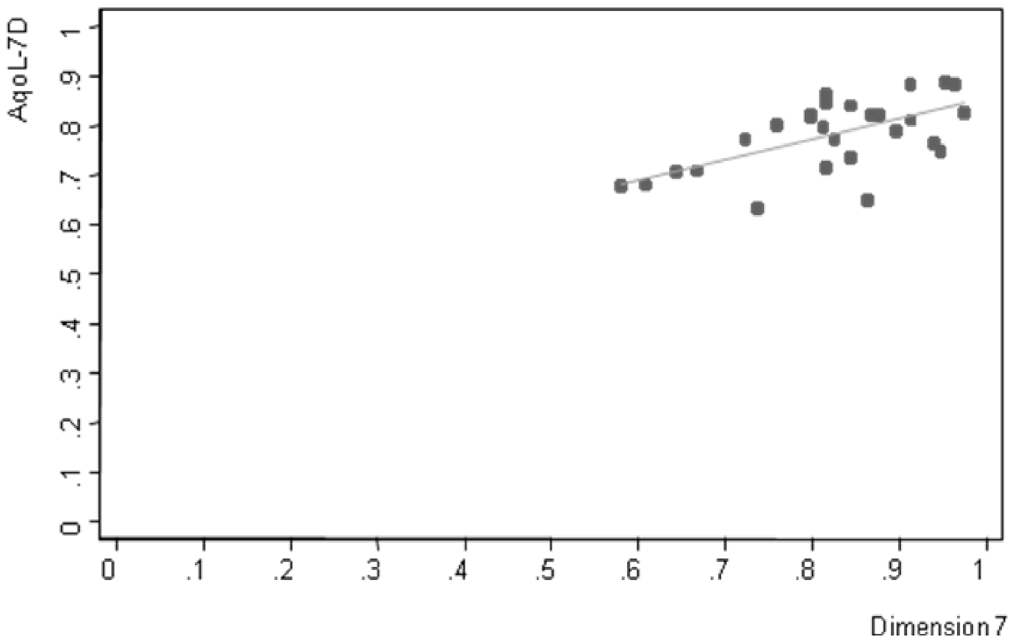
AQoL-7D = 0.51+ 021 Dimension 5
R^2 = 0.31

Figure 13. AQoL-7D vs Dimension 6 (Senses)



AQoL-7D = 0.61 + 0.18 Dimension 6
R^2 = 0.25

Figure 14. AQoL-7D vs Dimension 7 (Visqol)



AQoL-7D = 0.45 + 0.40 Dimension 7
R^2 = 0.36

4 Conclusion

The evidence presented here indicates that the utility scores of the AQoL-7D are plausible and that the algorithms used to derive them produce unbiased estimates. The test of bias used here, the prediction of a large number of TTO MA health states is, to our knowledge, unique to AQoL-6D and AQoL-7D.

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Appendix A. VisQoL instrument (dimension 7 of the AQoL-7D)

Q1 Does my vision make it likely I will injure myself (i.e. when moving around the house, yard, neighbourhood, or workplace)?

- ❑ It is most unlikely I will injure myself because of my vision
- ❑ There is a small chance
- ❑ There is a good chance
- ❑ It is very likely
- ❑ Almost certainly my vision will cause me to injure myself

Q2 Does my vision make it difficult to cope with the demands in my life?
My vision:

- ❑ has no affect on my ability to cope with the demands in my life
- ❑ does not make it difficult at all to cope with the demands in my life
- ❑ makes it a little difficult to cope
- ❑ makes it moderately difficult to cope
- ❑ makes it very difficult to cope
- ❑ makes me unable to cope at all

Q3 Does my vision affect my ability to have friendships?
My vision:

- ❑ makes having friendships easier
- ❑ has no effect on my friendships
- ❑ makes friendships more difficult
- ❑ makes friendships a lot more difficult
- ❑ makes friendships extremely difficult
- ❑ makes me unable to have friendships
- ❑ Not applicable; I have no friendships

Q4 Do I have difficulty organising any assistance I may need:

- ❑ I have no difficulty organising any assistance I may need
- ❑ I have a little difficulty organising assistance
- ❑ I have moderate difficulty organising assistance
- ❑ I have a lot of difficulty organising assistance
- ❑ I am unable to organise assistance at all
- ❑ Not applicable; I never need to organise assistance

Q5 Does my vision make it difficult to fulfil the roles I would like to fulfil in life (e.g. family roles, work roles, community roles etc)?
My vision:

- ❑ has no effect on my ability to fulfil these roles
- ❑ does not make it difficult to fulfil these roles
- ❑ makes it a little difficult to fulfil these roles
- ❑ makes it moderately difficult to fulfil these roles
- ❑ makes it very difficult to fulfil these roles
- ❑ means I am unable to fulfil these roles

Q6 Does my vision affect my confidence to join in everyday activities?
My vision:

- ❑ makes me more confident to join in everyday activities
- ❑ has no effect on my confidence to join in everyday activities
- ❑ makes me feel a little less confident
- ❑ makes me feel moderately less confident
- ❑ makes me feel a lot less confident
- ❑ makes me not confident at all

Appendix B. Definition of MA health states and Pseudo states

Key: E = Health states used in TTO interviews;

PS1, PS2 = derivative Pseudo health states

	Ind Liv				Rel			Mental Health				Coping			Pain			Senses			Visqol					
E4	1	1	1	1	1	1	1	1	1	1	1	1	4	3	2	3	3	3	4	1	1	1	1	1	1	1
E4ps1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	2	3	1	3	1	1	1	1	1	1	1	1
E4ps2	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	3	1	4	1	1	1	1	1	1	1
E5	1	1	1	1	1	2	2	1	1	3	3	1	1	1	1	1	1	2	1	2	1	1	1	1	1	1
E5ps1	1	1	1	1	1	1	2	1	1	3	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1
E5ps2	1	1	1	1	1	2	1	1	1	1	3	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
E6	1	1	1	1	3	3	1	1	4	3	1	4	4	1	3	3	4	1	1	1	1	1	1	1	1	1
E6ps1	1	1	1	1	3	1	1	1	1	3	1	1	4	1	3	1	4	1	1	1	1	1	1	1	1	1
E6ps2	1	1	1	1	1	3	1	1	4	1	1	4	1	1	1	3	1	1	1	1	1	1	1	1	1	1
E7	1	3	3	1	1	1	1	1	1	2	2	1	1	1	2	2	2	1	4	3	1	1	1	1	1	1
E7ps1	1	3	1	1	1	1	1	1	1	2	1	1	1	1	2	1	2	1	1	3	1	1	1	1	1	1
E7ps2	1	1	3	1	1	1	1	1	1	1	2	1	1	1	2	2	1	1	4	1	1	1	1	1	1	1
E8	1	1	5	1	1	1	1	1	3	4	1	4	1	3	1	1	1	1	1	1	1	1	1	1	1	1
E8ps1	1	1	1	1	1	1	1	1	3	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1
E8ps2	1	1	5	1	1	1	1	1	1	4	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E10	1	1	5	1	1	3	3	1	1	1	1	1	4	4	1	1	1	4	5	1	1	1	1	1	1	1
E10ps1	1	1	1	1	1	1	3	1	1	1	1	1	4	1	1	1	1	4	1	1	1	1	1	1	1	1
E10ps2	1	1	5	1	1	3	1	1	1	1	1	1	1	4	1	1	1	1	5	1	1	1	1	1	1	1
E12	1	1	1	1	4	1	3	1	4	1	3	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1
E12ps1	1	1	1	1	1	1	3	1	1	1	3	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1
E12ps2	1	1	1	1	4	1	1	1	4	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1
E13	1	1	1	1	1	2	2	4	1	4	1	1	3	3	1	2	1	1	1	1	1	1	1	1	1	1
E13ps1	1	1	1	1	1	2	1	1	1	4	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
E13ps2	1	1	1	1	1	1	2	4	1	1	1	1	1	3	1	2	1	1	1	1	1	1	1	1	1	1
E14	4	5	5	4	1	1	1	1	4	1	3	1	1	1	2	2	1	2	1	1	1	1	1	1	1	1
E14ps1	1	5	1	4	1	1	1	1	4	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
E14ps2	4	1	5	1	1	1	1	1	1	1	3	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1
E16	4	5	5	4	3	2	1	1	1	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1	1
E16ps1	4	1	5	1	3	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1
E16ps2	1	5	1	4	1	2	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1
E17	2	3	2	1	4	1	2	1	1	1	1	3	4	2	1	1	1	1	5	3	1	1	1	1	1	1
E17ps1	1	3	1	1	1	1	2	1	1	1	1	1	4	2	1	1	1	1	1	3	1	1	1	1	1	1
E17ps2	2	1	2	1	4	1	1	1	1	1	1	3	1	2	1	1	1	1	5	1	1	1	1	1	1	1
E18	1	1	1	1	3	3	3	1	1	1	1	1	1	1	1	1	1	4	5	3	1	1	1	1	1	1
E18ps1	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1	1	1	4	1	3	1	1	1	1	1	1
E18ps2	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1
E19	2	3	2	1	1	1	1	3	1	4	1	4	3	1	1	1	1	1	1	1	1	1	1	1	1	1
E19ps1	2	1	2	1	1	1	1	3	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
E19ps2	2	3	1	1	1	1	1	1	1	4	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	1	4	2	3	1	1	3	1	1
E20ps1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	3	1	1
E20ps2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	4	1	3	1	1	1	1	1
E21	4	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	3
E21ps1	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
E21ps2	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
E22	1	1	1	1	2	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	5
E22ps1	1	1	1	1	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5
E22ps2	1	1	1	1	2	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1
E23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	4	1	3	1	3	1	1
E23ps1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	3	1	1	1	1
E23ps2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	3	1	1
E24	3	3	1	1	1	1	1	1	1	1	1	1	1	1	2	1	3	1	4	2	1	1	4	1	4	1
E24ps1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	1	4	1
E24ps2	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	4	1	1	1	4	1	1	1
E25	1	1	1	1	1	1	1	1	1	1	1	3	3	1	1	1	1	1	3	2	1	1	4	4	1	1
E25ps1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	2	1	1	1	4	1	1
E25ps2	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	3	1	1	1	4	1	1	1
E26	1	1	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1	1	1	1	4	5	1	1	1	1
E26ps1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1
E26ps2	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1
E27	1	1	1	1	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	1	1	4	1	1	3	1
E27ps1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	4	1	1	1	1
E27ps2	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	1	3	1
E28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1	1	1	4	1	1	4	1	1
E28ps1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	4	1	1	1	1	1
E28ps2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	4	1	1

Appendix C. Multiplicative Disutility Equations: AQoL-7D

Dimensions	
General Formula	$DU_d = \frac{1}{k}\left[1 - \prod_{i=1}^{n}(1 - kw_i DU_i)\right]; k_d > 0$
Independent Living	$DU_1 = 1.02[1 - (1 - 0.38du_1)(1. - 0.58du_2)(1 - 0.62du_3)(1 - 0.77du_4)]$
Social and Family	$DU_2 = 1.08[1 - (1 - 0.59du_5)(1. - 0.65du_6)(1 - 0.47du_7)]$
Mental Health	$DU_3 = 1.02[1 - (1 - 0.63du_8)(1. - 0.66du_9)(1 - 0.64du_{10})(1 - 0.70du_{11})]$
Coping	$DU_4 = 1.08[1 - (1 - 0.39du_{12})(1. - 0.60du_{13})(1 - 0.72du_{14})]$
Pain	$DU_5 = 1.08[1 - (1 - 0.69du_{15})(1 - 0.57du_{16})(1 - 0.57du_{17})]$
Senses	$DU_6 = 1.18[1 - (1 - 0.49du_{18})(1 - 0.39du_{19})(1 - 0.51du_{20})]$
Vision	$DU_7 = 1.20[1 - (1 - 0.22du21\ )(1 - 0.31du_{22})(1 - 0.26du_{23})$ $(1 - 0.25du_{24})(1 - 0.27du_{25})(1 - 0.23du_{26})]$
AQoL General Formula	$DU_{AQoL} = \frac{W}{k}[1 - \prod_d((1 - kw_d DUx_i))]; k > 0$

Overall Quality of Life Score for VisQoL

$$DU_{AQoL7D} = 1.02[1 - (1 - .407DU_1)(1 - .387DU_2)(1 - .413DU_3)(1 - .298DU_4)(1 - .511DU_5)(1 - .550DU_6)(1 - .747DU_7)]$$