Selecting bolt-on dimensions for the EQ-5D: examining their contribution to health related quality of life

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Abstract

Background: Generic preference based measures may miss dimensions important for the HRQoL of patients. When this happens, a possible solution is adding bolt-ons. Finch et al., (2017) have recently shown that bolt-ons can be systematically identified using factor analysis. However, as for each bolt-on option a complete re-evaluation may be required, methods to select between them are needed. This study investigates the possibility of selecting bolt-ons using their ability to predict differences in HRQoL. It tests six factors, energy/vitality, satisfaction, relationships, hearing, vision and speech, and 37 items loading on them, using the EQ-5D as a case study.

Methods: Data were obtained from the Multi Instrument Comparison study, an online survey on health and wellbeing measures in five countries. Two tests were performed. In the first test, linear regressions were fitted to determine whether different bolt-ons helped explain variations of HRQoL as measured by the Health VAS. The Health VAS upper anchor (100) is excellent physical, mental and social health. The Health VAS lower anchor (0) is death. Bolt-on relevance was judged comparing the strength, direction and statistical significance of unadjusted b coefficient. In the second test, linear regressions were fitted to further investigate whether different factors and items helped explain the negative effect of six chronic conditions on HRQoL. A reduction in the coefficients for the chronic conditions dummies meant that the factor or item detected the effect.

Results: Energy/vitality, relationships and satisfaction reported substantially larger coefficients than speech, vision and hearing. Also items loading on energy/vitality, relationships and satisfaction

generally presented larger coefficient than those of items loading on speech, vision and hearing. The second test did not detect consistent decrements in the chronic conditions coefficients when testing factors but it generally did detect consistent decrements when testing items.

Conclusions: The first test appeared useful for bolt-on selection. Further research is needed before employing the second test.

Introduction

The recent history of health related quality of life (HRQoL) measures can be traced back to the early 1970s[1,2], when these measures started to be developed to operationalize the definition of health proposed by the World Health Organization (WHO)[3]. As the WHO definition did not offer any guidance on the content required in a health measure, developers made their own judgments on which indicators i.e. dimensions or items[4] and which aspects of the definition i.e. physical, mental and social wellbeing to consider[e.g.5,6]. This resulted in HRQoL measures differing in their dimensions and items[1].

Nevertheless, HRQoL measures generally tap on theoretically interrelated domains, and a number of models have been proposed to explain the relationship between them[e.g.7-9]. One of the most influential ones is the Wilson and Cleary (W&C) model[10]. According to the W&C model, HRQoL measures include domains related to one or more of five constructs, namely physiological factors, symptom status, functioning status, general health, and overall quality of life. Some measures include dimensions and items from multiple levels of the model, while others fit only at one level[10].

A particular type of HRQoL measure use preference weights as a scoring system. These measures differ from others, as their scoring responds to the basic rational of economic calculus and can for this reason be used in the assessment of health care interventions[1]. They are sometimes referred to as generic preference based measures (GPBMs), health state utility value measures or multi-attribute utility measures.

Similarly to other HRQoL measures, also GPBMs differ in the health dimensions and items they cover[11]. In an effort to ensure consistency in decisions, health technology bodies tend to express a preference for using only one GPBM in all assessments e.g. the EQ-5D for the National Institute of Health and Care Excellence[12]. Yet, this is not always possible, as some GPBMs may lack validity and responsiveness in some conditions and disease areas[13]. In those cases, using a different generic or specific measure with preferences attached[1] represents the suggested practise. However, the use of a different measure from the reference case undermines the cross-program comparability[14-17], as it implies that different interventions are compared using different dimensions of health.

An option that has gained popularity consists in adding bolt-on dimensions to the measure lacking validity and responsiveness[18]. The use of bolt-ons might restore some form of comparability, as it ensures that the same core set of dimensions is used for all interventions. A recent study has shown that factor analysis can be used for identifying bolt-ons[19]. This study employed a set of measures that are commonly used in economic evaluations and have been shown to cover most of the domains of interest described in the Wilson and Cleary model[20]. Hence, these represent an important and broad pool of candidate bolt-ons. By using factor analysis, Finch and colleagues[19] identified 6 factors, and 37 items loading on them, that were not related to the EQ-5D-5L.

A complexity that makes GPBMs different from other HRQoL measures is that the bolt-ons cannot simply be added to the descriptive system of the original measure, but need to be valued in terms of preferences. Current evidence suggests that bolt-ons impact coefficients also for the pre-existing dimensions of GPBMs[21-25]. This implies that for each bolt-on option, the new descriptive system needs to undergo a complete re-evaluation, a process that can be costly and complex. Hence, even if the bolt-ons measure distinct constructs relevant to expand the descriptive system of the investigated measure, some form of selection is required. However, methods for choosing between bolt-ons after factor analysis identification do not exist to date.

This study aims at covering this gap by exploring the possibility of using the ability of bolt-ons to predict differences in HRQoL to inform on their selection. This is an important aspect as the dimensions added to an HRQoL measure should tap on constructs that are relevant for patients and the general population. It uses linear regressions, a technique that was chosen as it is extremely common and easy to conduct[26]. This maximizes the utility of this research for future applications. The EQ-5D-5L was chosen as a case study, as previous research has identified bolt-on factors and items for this measure[19].

Methods

Data

This study used a large cross-sectional, observational online survey, the multi-instrument database. Data were collected by Richardson and colleagues[20,27] and covered 12 HRQoL and wellbeing measures, among which those employed in the current study. This is to date the largest dataset on health and wellbeing measures available worldwide[20]. A detailed description of collection methods is available elsewhere[27]. Broadly, data were obtained using quotas to ensure a sample with similar socio-demographic characteristics across six countries (Australia, Canada, Germany, Norway, United Kingdom and United States). Responders were members of the general public who had previously agreed to participate in online surveys. Respondents were excluded if: i) they completed the survey in less than 20 minutes; ii) they stated not to have a health problem but reported a self assessed health status below 65 on the Health VAS scale; iii) large differences were found between duplicated questions; iv) more than 2 response levels difference were found in pain questions of the EQ-5D and the Assessment of Quality of Life (AQoL 8D). The final sample comprised 8022 individuals, 6262 of whom self reported to be affected by one of the following 9 chronic health conditions: asthma, cancer, chronic obstructive pulmonary disease (COPD), depression, diabetes, hearing problems, arthritis, heart diseases and stroke. The remaining 1760 individuals did not report to be affected by any chronic health condition.

Questionnaires, items and factors

This study used the Health VAS as a dependent variable. This was intended as a proxy of HRQoL. The Health VAS is a self reported rating scale of health today where 100 and 0 are anchors for excellent health and death, respectively. It differs from the EQ VAS as it describes perfect health from a broader perspective. More specifically, perfect health is defined as excellent physical, mental and social health. Physical health is defined as no pain, discomfort or itching, perfect hearing vision and speech, excellent strength, flexibility, movement and energy. Mental health is defined as very happy, enthusiastic and contented, never sad or depressed, confident and with high self worth. Social health is defined as excellent social and family relationships. As the Health VAS reported an approximately normal distribution, this was considered as a continuous variable.

The current study used the 5L version of the EQ-5D. In addition, items from the Short form 6 dimensions (SF-6D), the Health Utility Index Mark 3 (HUI3), the AQoL 8D, the 15D, the Personal Wellbeing Index (PWI), the Satisfaction with Life Scale (SWLS), the Office of National Statistics (ONS) and the ICEpop CAPability measure (ICECAP) were employed. These items are the 37 identified as potential bolt-ons related to factors not already covered by the EQ-5D presented in Finch and colleagues[20]. This choice was made to allow comparability of results between item and factor regressions. All items from the GPBMs (EQ-5D, SF-6D, HUI3, AQoL 8D and 15D) and subjective wellbeing measures (SWBMs) (PWI, SWLS, ONS and ICECAP) were ordinal categorical, reporting levels varying between 4 and 11. Items for the PWI, SWBMs and ONS were recoded to report level 1 as perfect satisfaction. The EQ-5D and selected items from the SF-6D, HUI3, AQoL 8D, 15D, PWI, SWLS, ONS and ICECAP were used as independent variables, where each item was assigned a dummy for each of its levels. Wording for the items tested is presented in Appendix Table 1.

Finally, the 6 latent factors identified in Finch et al.,[19] namely satisfaction, hearing, vision, energy/sleep, relationships and speech cognition, were employed**.** Latent factors are continuous variables and were used as independent variables.

Analyses

Two tests were performed. The first test was carried out to discriminate between bolt-ons in terms of their ability to detect variations in HRQoL not already accounted for by the EQ-5D-5L. The second test further examined whether detected variations helped explaining differences in HRQoL between patients and the general population in 9 chronic conditions. These information may be used to select between factor and items as for bolt-ons to be relevant they should be able to detect aspects of HRQoL not already covered by the parent measure i.e. EQ-5D, and these aspects should help explaining differences in HRQoL between patients and the general population for one or more conditions. The ability of factors and items to detect differences in HRQoL might suggest that their addition would improve the validity and responsiveness of the EQ-5D.

First test

In order to assess whether factors and items were able to detect differences in HRQoL as measured by the Health VAS, a base model was estimated regressing the Health VAS over the EQ-5D-5L dummies and socio-demographic controls. The model was subsequently extended with the inclusion of factors and items, each of which was added individually. Unstandardized β coefficients for factors and items are reported. For factors, these indicated the amount of decrease in HRQoL as a result of a unit change in the latent factor tested. For items, these indicated the amount of decrease in HRQoL associated with the level of the dummy variable compared to the reference case (best possible health/ satisfaction). The size, direction and statistical significance of the β coefficients were used to compare factors and items. Comparatively larger β coefficients meant that the factor /

item was better in predicting differences in HRQoL not already captured by the EQ-5D-5L. Non statistically significant β coefficients suggested no impact of the factor or item in predicting difference in HRQoL. If the addition of a factor or item made one or more of the EQ-5D-5L dimensions not statistically significant, this meant that it was able to take full account of variations of HRQoL for those dimensions. If the factor or item substantially reduced the coefficient of one or more of the EQ-5D-5L dimensions, this showed a possible interaction between that factor or item and the dimension for which the coefficient was reduced. These latter two pieces of information may be used for selecting factors or items e.g. if a choice between two items related to the same factor has to be made, the item having less impact on the remaining dimensions of the EQ-5D should be chosen as this shows that it has less overlap with the aspects of health already covered by the questionnaire.

Analyses of observable variables (item regressions) were conducted in STATA/MP 14 ©. Analyses of latent variables (factor regressions) were performed in Mplus version 7©.

Second test

In order to assess whether different factors and items were able to explain differences in HRQoL between patients and the general population, the second test replicated the methods employed by Bockerman et al.,[28]. The Health VAS was firstly regressed upon EQ-5D-5L dimensions dummies, socio-demographic controls and dummy variables for asthma, cancer, COPD, depression, diabetes, hearing problems, arthritis, heart diseases or stroke. β coefficients for the conditions indicated the difference in HRQoL between responders in a disease group and the general population, not accounted by the EQ-5D-5L. Subsequently, the model was extended including also factors and items, each of which was added individually. If the factor or item took full account of variations in HRQoL for one condition, then the dummy variable for that condition was expected to be

insignificant. A reduction in the condition β coefficient represented the responsiveness of the bolt-on to differences in HRQoL for that condition, controlling for the EQ-5D-5L. Non statistically significant β coefficients suggested no impact of the factor or item in predicting differences in HRQoL between patients and the general population. If the addition of a factor or item made one or more of the EQ-5D-5L dimensions not statistically significant, this meant that the factor or item was able to take full account of variations in HRQoL for those dimensions in the general population group. If the factor or item substantially reduced the coefficient of one or more EQ-5D-5L dimensions, this showed a possible interaction between that factor or item and the dimension for which the coefficient was reduced in the general population group.

Analyses of observable variables (item regressions) were conducted in STATA/MP 14©. Analyses of latent variables (factor regressions) were performed in Mplus version 7©.

Results

Table 1 summarizes the background characteristics and health status, as measured by the 5L version of the EQ-5D, of the survey responders.

[Insert table 1]

First test

Table 2 presents the results for the base model using the first test. All EQ-5D-5L dimensions except self care were able to explain variations in HRQoL. Removal of usual activities from the regression model resulted in self care level 3 and level 4 becoming statistically significant with coefficients of -3.227 and -5.567, showing a possible interaction between usual activities and self care. β coefficients were larger at increasing levels of severity/ problems for all statistically significant dimensions but for usual activities, where level 4 was associated with a worst decrement than level 5. Mobility reported the smallest β coefficients, while anxiety and depression the largest.

[Insert table 2]

Table 3 presents the results for the regressions using factors and items (each added individually). As it can be seen, all factors explained variations in HRQoL over and above the EQ-5D-5L. The size of the β coefficients varied, with coefficients for relationships and satisfaction being approximately double, and of energy/sleep almost triple, than those for the remaining factors. All statistically significant dummies for the EQ-5D-5L dimensions in the base model remained statistically significant with the addition of latent factors, with their coefficients registering small or no changes.

[Insert table 3]

In the item regressions, the items' performance differed depending on the factor on which they loaded. Items loading on energy/sleep, relationships and satisfaction registered statistically significant results for most of their levels, while items loading on speech/cognition, vision and hearing were frequently non-significant. β coefficients were generally larger for the items loading on energy/sleep, relationships and satisfaction.

Systematic differences in the items' ability to detect variations in HRQoL were seen also between items loading on the same factor. For example, the items measuring energy in the energy/sleep factor reported substantially larger coefficients compared to the two items measuring sleep on the same factor. Similarly, while the two items measuring cognition on the speech/ cognition factor reported moderate and statistically significant coefficients, none of the speech items were statistically significant.

Finally, some items reported β coefficient decrements that were inconsistent with the increase in the level of severities/problems. For example, 15D mental function reported a larger coefficient for

level 2 of the dummy variable than for level 3, and AQoL close relationships (family and friend) a larger coefficient for level 5 than for level 6.

All statistically significant dummies for the EQ-5D-5L in the base model remained statistically significant with the addition of the items. Generally, their coefficients registered small or no changes. However, coefficients for the EQ-5D anxiety and depression dimension often registered large decrements when items related to satisfaction were added, large to moderate decrements when items related to energy were added and moderate reductions when items related to relationships were added. The greatest reductions were noticed for items related to life satisfaction. Coefficients for the EQ-5D usual activities registered moderate decrements when energy items were added.

Second test

Appendix Table 2 presents the base model for the second test. Table 4 and Table 5 report the change in coefficients associated with the inclusion of factors and selected items. In the base model, dummies were statistically significant for all chronic conditions, showing that the EQ-5D-5L only partially captures differences in Health VAS between disease groups and the general population. The smallest coefficients were seen for hearing problems, arthritis and asthma, followed by depression, diabetes and heart diseases. Cancer, COPD and stroke reported the largest coefficients.

[Insert table 4]

[Insert table 5]

None of the factors was able to take full account of differences in Health VAS between patients and the general population, as chronic conditions dummies remained statistically significant and negative for all of them. However, five factors had an impact on one or more of the coefficients of the chronic conditions, reducing their magnitude. More specifically, satisfaction decreased COPD dummy by 0.617, vision decreased depression, diabetes, COPD and stroke dummies by 0.863,

0.503, 0.436 and 2.623, and hearing, speech/cognition and energy/sleep decreased stroke dummy by 0.589, 0.580 and 1.561. Decrements for COPD and stroke dummies should be interpreted with care, as they are based on small samples i.e. 23 observations for stroke and 66 for COPD.

All EQ-5D-5L dimensions that were statistically significant in the base model remained statistically significant with the addition of the latent factors, with their coefficients generally reporting small or no changes.

Also none of the items was able to take into full account differences in HRQoL between patients and the general population, as chronic conditions dummies remained statistically significant and negative. However, numerous items decreased chronic conditions β coefficients, with some of them having a general impact and other a specific one. For example, AQoL energy produced decrements on all chronic condition dummies that varied between -0.907 for arthritis and -3.059 for COPD. By contrast, the 15D hearing and HUI3 hearing substantially reduced only hearing problems (decrement of 0.974 and decrement of 0.706), with the next largest reduction being 4 and 3 times smaller i.e. COPD decreased by 0.226 for 15D hearing and by 0.221 for HUI3 hearing.

As for the first test, all the EQ-5D-5L dimensions that were statistically significant in the base model remained statistically significant with the addition of the items. Once again, coefficients for the EQ-5D anxiety and depression dimension often decreased when items loading on satisfaction, relationships and energy were added, with items related to life satisfaction causing the largest switches.

Items related to energy once again produced decrements in the coefficients for the EQ-5D usual activities. The largest reduction was registered with the addition of AQoL energy.

Discussion

This study investigated the potential of using linear regressions for selecting bolt-ons after factor analysis identification. It assessed the usefulness of two tests. The first test appeared appropriate for selecting between potential independent factors and items. Results for factors and items were concordant in pointing at relationships, energy/sleep and satisfaction factors, and items loading on them, as the mostly relevant bolt-ons. The study also showed systematic differences in items' ability to detect differences in HRQoL when they loaded on the same factor. These results suggest that despite loading on the same factor and being interrelated, energy and sleep measure partially different concepts, as do cognition and speech. As energy and cognition appeared better in explaining variations of HRQoL than sleep and speech, items related to these concepts should be preferred when adapting them into bolt-on dimensions. These findings agree with those of previous research[29,30] that found "happiness", "emotional health", "cognition", "relationships" and "sensory deprivation" (e.g. vision loss) to be the most important aspects of health not covered by the EQ-5D. They also provide additional evidence compared to these studies on the relative importance of these aspects as add-on dimensions.

The second test generated results that are sometimes difficult to interpret. While none of the factors and items was able to fully account for differences in HRQoL between patients and the general population, they were frequently able to explain part of these differences. Decrements for items generally occurred in chronic conditions that were theoretically related to the aspects of health measured by the item. Some reductions occurred in chronic conditions not related to the aspects of health measured by the factor. Despite the number of observations for those conditions were generally small and therefore these results should be taken with care, the discrepancies in the results of factor and item regressions raise some doubts as to the ability of the second test to discriminate between bolt-ons. Further investigation is needed before using this technique.

This study used a set of strategies that were broadly based on the statistical significance of the factors and items tested, the size and direction of their coefficients and the consistency in HRQoL

decrements at increasing levels of severity to discriminate between candidate bolt-ons. The same set of strategies could be also employed to identify dimensions that need bolting off the investigated GPBM. This could be done in isolation, by selecting those dimensions that perform poorly, or comparatively, by comparing the size, direction and interaction of coefficients for the EQ-5D-5L and other measures' dimensions. Using the first approach would suggest, in the case of the current study, to bolt-off the EQ-5D-5L self care dimension, as most of its levels were not statistically significant due to an interaction with usual activities. Using the second approach would suggest, again in the context of the current research, to substitute the EQ-5D-5L self care or the EQ-5D-5L mobility dimensions with a dimension adapted from the items loading on the relationship or the satisfaction factors. Choice between these items could be informed by their impact on the remaining dimensions of the EQ-5D, where items causing smaller interactions should be preferred as they tap into aspects less related to those already covered in the EQ-5D. In addition, as some items reported decrements that were inconsistent with the increase in the levels of severity, it would be preferable to choose an item for a bolt-on dimension that had consistent decrements in HRQoL across severity levels.

Similarly, the size of β coefficients could also be used to set an empirical threshold of bolt-ons relevance. For example, coefficients for the "worst performing item" could be set as a threshold to compare coefficients from bolt-on items. If coefficients for the items are at least as large as those of the worst performing pre-existing dimension, then those items would be considered relevant bolt-on additions. This would result in retaining only items that are at least "as good" as the worst performing GPBM dimension. However, the usefulness of this approach depends on a number of aspects, among which the method used for the current analysis e.g. linear regression, the HRQoL proxy used and the inclusion of possible interaction terms.

This study has some limitations that need mentioning. First, it used linear regressions to model the impact of factors and items on HRQoL. Although this technique has been seen in numerous

occasions to produce reliable estimates in models with self reported rating scales as dependent variable[31-32], other models could have been used to account for the bounding of the Health VAS variable e.g. Two limit tobit models. Second, possible interactions were noticed among some of the items and the EQ-5D dimensions. Interactions were initially calculated but were not reported as the large number of coefficients generated were difficult to interpret. Inclusion of interaction would have improved the precision of the estimates for those items. Third, factors and items tested in this study were identified through previous research that did not use disease specific measures. Hence, other factors and items not tested might be equally relevant additions to the EQ-5D-5L. Fourth, the second test covered only 9 chronic conditions, but also other conditions might have been relevant. Finally, sample sizes for the lowest levels of the scale were small in most of the variables tested. It is important to treat estimates generated from these dummies with care.

Despite these limitations, this study presents a useful method to select between alternative factors and items that can be developed/adapted into bolt-on dimensions. It is generalizable to other HRQoL measures, whether preference based or not, generic or disease specific, and for this reason it has a wide application in the field of measuring health. In addition, it provides evidence on the comparative relevance of a set of bolt-ons for the EQ-5D-5L.

Table 1. Background characteristics and health status of survey participants

Variable	Category	Frequencies	Percentages
Gender	Male	3848	48%
	Female	4174	52%
Age	18-24	513	6%
	25-34	944	12%
	35-44	1137	14%
	45-54	1689	21%
	55-64	2008	25%
	65+	1731	22%
Highest education achieved	High school	2522	31%
	Diploma or Certificate	3241	41%
	University	2259	28%
Self reported chronic health condition	None	1760	22%
	Asthma	856	11%
	Cancer	772	10%
	Chronic obstructive pulmonary disease	66	1%
	Depression	917	11%
	Diabetes	924	11%
	Hearing problems	832	10%
	Arthritis	929	11%
	Heart	943	12%
	Stroke	23	1%
EQ-5D mobility	No problems	5337	67%
	Slight problems	1491	19%
	Moderate problems	824	10%
	Severe problems	340	3%
	Extreme problems / Unable to	30	1%
EQ-5D self-care	No problems	7033	88%
	Slight problems	646	8%
	Moderate problems	273	3%
	Severe problems	62	1%
	Extreme problems / Unable to	8	<1%
EQ-5D usual activities	No problems	5182	65%
	Slight problems	1739	22%
	Moderate problems	794	9%
	Severe problems	256	3%
	Extreme problems / Unable to	51	1%
EQ-5D pain/discomfort	No problems	2340	29%
	Slight problems	3251	41%
	Moderate problems	1619	20%
	Severe problems	697	9%
	Extreme problems / Unable to	115	1%

EQ-5D anxiety / depression	No problems	4012	50%
	Slight problems	2348	29%
	Moderate problems	1107	14%
	Severe problems	393	5%
	Extreme problems / Unable to	162	2%

Note: each variable has a total number of responders of 8022.

Table 2. β coefficients, statistical significance and standard errors of dummy variables for the base model assessing the impact on HRQoL (Health VAS dependent variable)

Variables	β coefficients	Standard error
Constant	80.449**	0.830
Highschool education	*(omitted)*	*(omitted)*
Diploma education	-0.283	0.438
University education	0.991*	0.482
Age 18-24	*(omitted)*	*(omitted)*
Age 25-34	1.105	0.912
Age 35-44	0.009	0.887
Age 45-54	-0.580	0.852
Age 55-64	-0.653	0.843
Age >65	1.250	0.865
Male	*(omitted)*	*(omitted)*
Female	2.729**	0.378
EQ5D-5L mobility level 1	*(omitted)*	*(omitted)*
EQ5D-5L mobility level 2	-3.346**	0.573
EQ5D-5L mobility level 3	-5.788**	0.852
EQ5D-5L mobility level 4	-9.479**	1.302
EQ5D-5L mobility level 5	-10.543**	3.249
EQ5D-5L self care level 1	*(omitted)*	*(omitted)*
EQ5D-5L self care level 2	-2.202**	0.762
EQ5D-5L self care level 3	0.296	1.213
EQ5D-5L self care level 4	-0.941	2.313
EQ5D-5L self care level 5	1.710	5.924
EQ5D-5L usual activities level 1	*(omitted)*	*(omitted)*
EQ5D-5L usual activities level 2	-7.495**	0.560
EQ5D-5L usual activities level 3	-12.164**	0.900
EQ5D-5L usual activities level 4	-17.338**	1.428
EQ5D-5L usual activities level 5	-16.764**	2.584
EQ5D-5L pain discomfort level 1	*(omitted)*	*(omitted)*
EQ5D-5L pain discomfort level 2	-4.043**	0.474
EQ5D-5L pain discomfort level 3	-7.834**	0.646
EQ5D-5L pain discomfort level 4	-10.341**	0.912
EQ5D-5L pain discomfort level 5	-14.691**	1.776
EQ5D-5L anxiety depression level 1	*(omitted)*	*(omitted)*
EQ5D-5L anxiety depression level 2	-6.221**	0.448
EQ5D-5L anxiety depression level 3	-12.851**	0.603
EQ5D-5L anxiety depression level 4	-21.522**	0.921
EQ5D-5L anxiety depression level 5	-26.102**	1.378
R^2	0.439	

***Note:** * P≤0.05; ** P≤0.01*

Table 3. β coefficients, statistical significance and standard errors of factors and items for the first test

Factor to which the item is related	Factor / Item tested	VAS dependent variable	
		β coefficients	Standard errors
/	Satisfaction	*-4.323***	*0.112*
/	Relationships	*-5.298***	*0.235*
/	Hearing	*-1.209***	*0.353*
/	Speech / cognition	*-2.269***	*0.287*
/	Vision	*-2.185***	*0.257*
/	Energy / Vitality	*-7.648***	*0.217*
Satisfaction	PWI satisfaction standard of living 1	*(omitted)*	*(omitted)*
	PWI satisfaction standard of living 2	*-1,010*	*0.811*
	PWI satisfaction standard of living 3	*-2.830***	*0.751*
	PWI satisfaction standard of living 4	*-6.449***	*0.776*
	PWI satisfaction standard of living 5	*-8.040***	*0.844*
	PWI satisfaction standard of living 6	*-10.477***	*0.87*
	PWI satisfaction standard of living 7	*-9.834***	*0.937*
	PWI satisfaction standard of living 8	*-12.078***	*0.993*
	PWI satisfaction standard of living 9	*-14.152***	*1.108*
	PWI satisfaction standard of living 10	*-12.871***	*1.402*
	PWI satisfaction standard of living 11	*-11.483***	*1.438*
Satisfaction	PWI satisfaction achievement 1	*(omitted)*	*(omitted)*
	PWI satisfaction achievement 2	*-0.102*	*0.86*
	PWI satisfaction achievement 3	*-2.648***	*0.815*
	PWI satisfaction achievement 4	*-5.257***	*0.832*
	PWI satisfaction achievement 5	*-8.485***	*0.89*
	PWI satisfaction achievement 6	*-11.226***	*0.869*
	PWI satisfaction achievement 7	*-12.363***	*0.998*
	PWI satisfaction achievement 8	*-14.630***	*1.058*
	PWI satisfaction achievement 9	*-17.779***	*1.123*
	PWI satisfaction achievement 10	*-18.501***	*1.258*
	PWI satisfaction achievement 11	*-18.922***	*1.330*
Satisfaction	ONS satisfaction with life 1	*(omitted)*	*(omitted)*
	ONS satisfaction with life 2	*-0.361*	*0.88*
	ONS satisfaction with life 3	*-4.489***	*0.845*
	ONS satisfaction with life 4	*-7.720***	*0.883*
	ONS satisfaction with life 5	*-10.704***	*0.946*
	ONS satisfaction with life 6	*-11.733***	*0.949*
	ONS satisfaction with life 7	*-14.496***	*1.050*
	ONS satisfaction with life 8	*-17.586***	*1.081*
	ONS satisfaction with life 9	*-20.457***	*1.095*
	ONS satisfaction with life 10	*-22.250***	*1.217*
	ONS satisfaction with life 11	*-24.863***	*1.236*
Satisfaction	PWI satisfaction with life as a whole 1	*(omitted)*	*(omitted)*
	PWI satisfaction with life as a whole 2	*-1.018*	*0.875*
	PWI satisfaction with life as a whole 3	*-4.575***	*0.8*
	PWI satisfaction with life as a whole 4	*-8.823***	*0.829*
	PWI satisfaction with life as a whole 5	*-12.252***	*0.911*
	PWI satisfaction with life as a whole 6	*-12.376***	*0.916*
	PWI satisfaction with life as a whole 7	*-15.976***	*1.043*
	PWI satisfaction with life as a whole 8	*-19.238***	*1.060*
	PWI satisfaction with life as a whole 9	*-21.300***	*1.149*
	PWI satisfaction with life as a whole 10	*-19.737***	*1.558*
	PWI satisfaction with life as a whole 11	*-22.271***	*1.604*
Satisfaction	SWLS satisfaction with life 1	*(omitted)*	*(omitted)*

	SWLS satisfaction with life 2	*-3.511***	*0.68*
	SWLS satisfaction with life 3	*-7.887***	*0.721*
	SWLS satisfaction with life 4	*-12.342***	*0.819*
	SWLS satisfaction with life 5	*-14.587***	*0.828*
	SWLS satisfaction with life 6	*-19.591***	*0.891*
	SWLS satisfaction with life 7	*-24.868***	*1.145*
Satisfaction	SWLS condition of life are excellent 1	*(omitted)*	*(omitted)*
	SWLS condition of life are excellent 2	*-3.293***	*0.821*
	SWLS condition of life are excellent 3	*-6.843***	*0.828*
	SWLS condition of life are excellent 4	*-11.123***	*0.884*
	SWLS condition of life are excellent 5	*-14.229***	*0.902*
	SWLS condition of life are excellent 6	*-19.105***	*0.951*
	SWLS condition of life are excellent 7	*-23.262***	*1.130*
Satisfaction	SWLS life close ideal 1	*(omitted)*	*(omitted)*
	SWLS life close ideal 2	*-2.136*	*0.951*
	SWLS life close ideal 3	*-6.733***	*0.952*
	SWLS life close ideal 4	*-9.657***	*1.014*
	SWLS life close ideal 5	*-11.826***	*1.031*
	SWLS life close ideal 6	*-17.383***	*1.049*
	SWLS life close ideal 7	*-20.917***	*1.192*
Satisfaction	SWLS gotten important things in life 1	*(omitted)*	*(omitted)*
	SWLS gotten important things in life 2	*-1.909**	*0.623*
	SWLS gotten important things in life 3	*-6.409***	*0.658*
	SWLS gotten important things in life 4	*-8.394***	*0.75*
	SWLS gotten important things in life 5	*-10.542***	*0.781*
	SWLS gotten important things in life 6	*-14.878***	*0.859*
	SWLS gotten important things in life 7	*-17.962***	*1.064*
Satisfaction	ONS life is worthwhile 1	*(omitted)*	*(omitted)*
	ONS life is worthwhile 2	*-0.991*	*0.752*
	ONS life is worthwhile 3	*-4.001***	*0.729*
	ONS life is worthwhile 4	*-6.368***	*0.76*
	ONS life is worthwhile 5	*-10.142***	*0.81*
	ONS life is worthwhile 6	*-11.748***	*0.808*
	ONS life is worthwhile 7	*-15.392***	*1.057*
	ONS life is worthwhile 8	*-17.329***	*1.129*
	ONS life is worthwhile 9	*-18.589***	*1.127*
	ONS life is worthwhile 10	*-19.099***	*1.234*
	ONS life is worthwhile 11	*-22.434***	*1.403*
Satisfaction	SWLS if I could live life over 1	*(omitted)*	*(omitted)*
	SWLS if I could live life over 2	*-1.143*	*0.83*
	SWLS if I could live life over 3	*-3.139***	*0.838*
	SWLS if I could live life over 4	*-4.461***	*0.885*
	SWLS if I could live life over 5	*-6.846***	*0.838*
	SWLS if I could live life over 6	*-8.685***	*0.857*
	SWLS if I could live life over 7	*-12.862***	*0.898*
Satisfaction	ONS happiness yesterday 1	*(omitted)*	*(omitted)*
	ONS happiness yesterday 2	*-1.693*	*0.719*
	ONS happiness yesterday 3	*-4.224***	*0.712*
	ONS happiness yesterday 4	*-7.323***	*0.749*
	ONS happiness yesterday 5	*-11.050***	*0.816*
	ONS happiness yesterday 6	*-12.203***	*0.793*
	ONS happiness yesterday 7	*-13.346***	*1.002*
	ONS happiness yesterday 8	*-15.807***	*1.095*
	ONS happiness yesterday 9	*-17.041***	*1.061*
	ONS happiness yesterday 10	*-18.303***	*1.203*
	ONS happiness yesterday 11	*-19.570***	*1.139*
Satisfaction	PWI satisfaction personal relationships 1	*(omitted)*	*(omitted)*
	PWI satisfaction personal relationships 2	*-1.220*	*0.611*
	PWI satisfaction personal relationships 3	*-2.475***	*0.627*
	PWI satisfaction personal relationships 4	*-4.891***	*0.683*
	PWI satisfaction personal relationships 5	*-5.323***	*0.793*
	PWI satisfaction personal relationships 6	*-7.147***	*0.729*

	PWI satisfaction personal relationships 7	*-8.671***	*0.963*
	PWI satisfaction personal relationships 8	*-10.254***	*1.004*
	PWI satisfaction personal relationships 9	*-10.511***	*1.059*
	PWI satisfaction personal relationships 10	*-11.847***	*1.210*
	PWI satisfaction personal relationships 11	*-13.028***	*1.248*
Satisfaction	PWI satisfaction part of the community 1	*(omitted)*	*(omitted)*
	PWI satisfaction part of the community 2	*-1.042***	*0.801*
	PWI satisfaction part of the community 3	*-3.284***	*0.753*
	PWI satisfaction part of the community 4	*-5.634***	*0.783*
	PWI satisfaction part of the community 5	*-7.638***	*0.845*
	PWI satisfaction part of the community 6	*-9.274***	*0.757*
	PWI satisfaction part of the community 7	*-10.975***	*1.029*
	PWI satisfaction part of the community 8	*-14.776***	*1.112*
	PWI satisfaction part of the community 9	*-14.396***	*1.149*
	PWI satisfaction part of the community 10	*-15.078***	*1.298*
	PWI satisfaction part of the community 11	*-15.551***	*1.380*
Satisfaction	PWI satisfaction future security 1	*(omitted)*	*(omitted)*
	PWI satisfaction future security 2	*-1.059*	*0.88*
	PWI satisfaction future security 3	*-2.746***	*0.832*
	PWI satisfaction future security 4	*-4.238***	*0.849*
	PWI satisfaction future security 5	*-6.783***	*0.905*
	PWI satisfaction future security 6	*-8.868***	*0.863*
	PWI satisfaction future security 7	*-9.674***	*0.977*
	PWI satisfaction future security 8	*-10.433***	*1.013*
	PWI satisfaction future security 9	*-13.005***	*1.060*
	PWI satisfaction future security 10	*-13.540***	*1.138*
	PWI satisfaction future security 11	*-14.227***	*1.153*
Satisfaction	PWI satisfaction spirituality 1	*(omitted)*	*(omitted)*
	PWI satisfaction spirituality 2	*0.01*	*0.619*
	PWI satisfaction spirituality 3	*-0.236*	*0.628*
	PWI satisfaction spirituality 4	*-3.311***	*0.729*
	PWI satisfaction spirituality 5	*-4.225***	*0.875*
	PWI satisfaction spirituality 6	*-5.102***	*0.517*
	PWI satisfaction spirituality 7	*-7.263***	*1.160*
	PWI satisfaction spirituality 8	*-6.449***	*1.345*
	PWI satisfaction spirituality 9	*-8.618***	*1.593*
	PWI satisfaction spirituality 10	*-6.562***	*1.738*
	PWI satisfaction spirituality 11	*-10.234***	*1.348*
Satisfaction	PWI satisfaction safety 1	*(omitted)*	*(omitted)*
	PWI satisfaction safety 2	*-1.557*	*0.617*
	PWI satisfaction safety 3	*-3.609***	*0.618*
	PWI satisfaction safety 4	*-6.792***	*0.68*
	PWI satisfaction safety 5	*-7.524***	*0.808*
	PWI satisfaction safety 6	*-9.551***	*0.761*
	PWI satisfaction safety 7	*-10.360***	*1.053*
	PWI satisfaction safety 8	*-13.351***	*1.156*
	PWI satisfaction safety 9	*-13.584***	*1.209*
	PWI satisfaction safety 10	*-16.936***	*1.587*
	PWI satisfaction safety 11	*-15.295***	*1.574*
	AQoL enjoyment close relationships 1	*(omitted)*	*(omitted)*
Relationships	AQoL enjoyment close relationships 2	*-2.410***	*0.411*
	AQoL enjoyment close relationships 3	*-6.705***	*0.633*
	AQoL enjoyment close relationships 4	*-9.235***	*0.986*
	AQoL enjoyment close relationships 5	*-11.097***	*3.265*
	ICECAP Love and support 1	*(omitted)*	*(omitted)*
Relationships	ICECAP Love and support 2	*-1.468***	*0.42*
	ICECAP Love and support 3	*-5.282***	*0.604*
	ICECAP Love and support 4	*-7.657***	*1.561*
Relationships	AQoL close relationships (family and friends) 1	*-2.964***	*0.425*
	AQoL close relationships (family and friends) 2	*-6.841***	*0.619*
	AQoL close relationships (family and friends) 3	*-11.169***	*0.885*
	AQoL close relationships (family and friends) 4	*-15.310***	*1.815*

	AQoL close relationships (family and friends) 5	*-7.748***	*2.095*
Relationships	AQoL close relationships (including sexual) 1	*(omitted)*	*(omitted)*
	AQoL close relationships (including sexual) 2	*-2.619***	*0.449*
	AQoL close relationships (including sexual) 3	*-7.399***	*0.570*
	AQoL close relationships (including sexual) 4	*-7.383***	*0.920*
	AQoL close relationships (including sexual) 5	*-11.277***	*1.365*
Hearing	AQoL hearing 1	*(omitted)*	*(omitted)*
	AQoL hearing 2	*-1.936***	*0.443*
	AQoL hearing 3	*-2.576***	*0.512*
	AQoL hearing 4	*-4.927***	*1.126*
	AQoL hearing 5	*1.584*	*3.571*
	AQoL hearing 1	*8.191*	*5.420*
Hearing	15 D hearing 1	*(omitted)*	*(omitted)*
	15 D hearing 2	*-1.227**	*0.49*
	15 D hearing 3	*-1.360*	*0.754*
	15 D hearing 4	*-0.047*	*2.090*
	15 D hearing 5	*1.965*	*4.522*
Hearing	HUI 3 hearing 1	*(omitted)*	*(omitted)*
	HUI 3 hearing 2	*-0.216*	*0.654*
	HUI 3 hearing 3	*-0.025*	*0.943*
	HUI 3 hearing 4	*-1.665*	*1.086*
	HUI 3 hearing 5	*-4.335**	*1.478*
	HUI 3 hearing 6	*9.290*	*5.761*
Speech / Cognition	AQoL communication 1	*(omitted)*	*(omitted)*
	AQoL communication 2	*-0.842*	*0.606*
	AQoL communication 3	*-1.707*	*1.243*
	AQoL communication 4	*-1.457*	*2.042*
Speech / Cognition	HUI 3 speech 1	*(omitted)*	*(omitted)*
	HUI 3 speech 2	*-1.445*	*0.749*
	HUI 3 speech 3	*0.804*	*1.299*
	HUI 3 speech 4	*-2.176*	*2.655*
	HUI 3 speech 5	*-6.090*	*6.177*
Speech / Cognition	15 D speech 1	*(omitted)*	*(omitted)*
	15 D speech 2	*-3.441*	*0.702*
	15 D speech 3	*0.381*	*1.833*
	15 D speech 4	*3.228*	*3.752*
	15 D speech 5	*-9.872*	*8.141*
Speech / Cognition	15 D mental function 1	*(omitted)*	*(omitted)*
	15 D mental function 2	*-3.557***	*0.471*
	15 D mental function 3	*-3.438**	*1.215*
	15 D mental function 4	*-5.656*	*2.338*
	15 D mental function 5	*-1.006*	*6.211*
Speech / Cognition	HUI 3 cognition 1	*(omitted)*	*(omitted)*
	HUI 3 cognition 2	*-3.022***	*0.674*
	HUI 3 cognition 3	*-3.674***	*0.560*
	HUI 3 cognition 4	*-4.940***	*1.056*
	HUI 3 cognition 5	*-7.719***	*1.993*
	HUI 3 cognition 6	*5.787*	*4.269*
Vision	AQoL vision 1	*(omitted)*	*(omitted)*
	AQoL vision 2	*-2.390***	*0.494*
	AQoL vision 3	*-4.070***	*0.548*
	AQoL vision 4	*-8.383***	*1.513*
	AQoL vision 5	*-33.079**	*11.450*
	AQoL vision 6	*14.274*	*8.131*
Vision	HUI 3 vision 1	*(omitted)*	*(omitted)*
	HUI 3 vision 2	*-1.489***	*0.420*
	HUI 3 vision 3	*-2.187*	*1.046*
	HUI 3 vision 4	*-1.321*	*1.049*
	HUI 3 vision 5	*-9.856***	*2.178*
	HUI 3 vision 6	*-2.377*	*6.165*
Vision	15D vision 1	*(omitted)*	*(omitted)*
	15D vision 2	*-2.286***	*0.458*

	15D vision 3	*-3.653***	*1.062*
	15D vision 4	*-1.448*	*1.595*
	15D vision 5	*-1.779*	*5.148*
	15D vitality 1	*(omitted)*	*(omitted)*
	15D vitality 2	*-9.071***	*0.456*
Energy / Sleep	15D vitality 3	*-17.609***	*0.665*
	15D vitality 4	*-22.761***	*0.862*
	15D vitality 5	*-29.180***	*1.279*
	AQoL energy 1	*(omitted)*	*(omitted)*
	AQoL energy 2	*-5.036***	*0.844*
Energy / Sleep	AQoL energy 3	*-12.392***	*0.885*
	AQoL energy 4	*-19.350***	*0.947*
	AQoL energy 5	*-25.957***	*1.194*
	SF-6D vitality 1	*(omitted)*	*(omitted)*
	SF-6D vitality 2	*-3.228***	*0.879*
Energy / Sleep	SF-6D vitality 3	*-8.685***	*0.898*
	SF-6D vitality 4	*-14.132***	*0.961*
	SF-6D vitality 5	*-19.493***	*1.014*
	AQoL enthusiasm 1	*(omitted)*	*(omitted)*
	AQoL enthusiasm 2	*-1.937**	*0.627*
Energy / Sleep	AQoL enthusiasm 3	*-7.473***	*0.662*
	AQoL enthusiasm 4	*-14.735***	*0.826*
	AQoL enthusiasm 5	*-19.979***	*1.358*
	AQoL sleeping 1	*(omitted)*	*(omitted)*
	AQoL sleeping 2	*-2.119***	*0.620*
Energy / Sleep	AQoL sleeping 3	*-4.776***	*0.633*
	AQoL sleeping 4	*-7.722***	*0.735*
	AQoL sleeping 5	*-9.646***	*0.893*
	15 D sleeping 1	*(omitted)*	*(omitted)*
	15 D sleeping 2	*-2.452***	*0.461*
Energy / Sleep	15 D sleeping 3	*-5.180***	*0.580*
	15 D sleeping 4	*-7.396***	*0.781*
	15 D sleeping 5	*-10.056***	*1.673*

Note: ** P≤0.05; ** P≤0.01*

Table 4. Changes in chronic condition β coefficients after factor were included individually

		Factors – change in coefficients					
Chronic conditions	Base model coefficients	Energy/ Sleep	Relationships	Satisfaction	Speech/ Cognition	Vision	Hearing
Cancer	-14.008	0.005	0.067	0.045	-0.070	-0.397	-0.069
Asthma	-9.587	-0.003	0.048	0.019	-0.042	-0.206	-0.040
COPD	-15.570	0.638	0.294	**-0.617**	-0.115	**-0.436**	-0.093
Depression	-11.123	-0.022	0.053	0.037	-0.055	**-0.863**	-0.055
Diabetes	-12.565	-0.050	0.053	0.062	-0.071	**-0.503**	-0.074
Hearing Problems	-6.890	0.027	0.031	-0.014	-0.014	-0.274	-0.009
Arthritis	-7.731	0.010	0.039	0.003	-0.029	-0.060	0.026
Heart diseases	-13.323	-0.030	0.063	0.047	-0.069	-0.322	-0.069
Stroke	-20.651	**-1.561**	0.010	1.735	**-0.580**	**-2.623**	**-0.589**

Note: Bold indicates reduction in b coefficients ≥0.5. All coefficients were statistically significant at $p \leq 0.05$.

Table 5. Changes in chronic condition coefficients after items were included individually

		Factors on which items loaded									
		Energy / Sleep						*Relationships*			
		Items (change in coefficients)									
Chronic condition	Base model coefficients	15D vitality	AQoL8 enthusiasm	15D sleep	AQoL energy	SF6D vitality	AQoL sleeping	ICECAP love, friendship support	AQoL close rel (family friends)	AQoL close rel (sexual)	AQoL enjoment close relationships
Cancer	-14.008	**-1.733**	-0.383	-0.263	**-1.802**	**-1.048**	-0.434	0.107	0.174	-0.066	0.07
Asthma	-9.587	**-1.709**	-0377	-0.455	**-1.618**	**-1.02**	-0.439	0.008	-0.089	0.073	-0.062
COPD	-15.570	**-2.162**	-0.36	-0.590	**-3.059**	**-2.187**	-0.451	0.179	0.213	0.062	0.605
Depression	-11.123	**-2.707**	**-1.763**	**-0.649**	**-2.836**	**-1.975**	**-0.807**	-0.138	**-0.677**	-0.537	-0.696
Diabetes	-12.565	**-1.835**	**-0.544**	-0.279	**-1.914**	**-1.160**	-0.459	0.070	-0.118	-0.139	-0.111
Hearing Problems	-6.890	**-1.13**	-0.448	-0.111	**-1.194**	**-0.561**	-0.296	-0.074	-0.231	-0.106	-0.275
Arthritis	-7.731	**-0.786**	-0.403	-0.340	**-0.907**	-0.427	-0.477	0.097	-0.020	0.248	-0.013
Heart	-13.323	**-2.031**	**-0.635**	-0.355	**-2.284**	**-1.363**	-0.444	0.020	0.027	0.111	0.143
Stroke	-20.651	**-2.959**	**-1.136**	**-0.561**	**-2.401**	-0.265	-0.484	-1.010	0.009	-0.473	-0.28

Note: Bold indicates reduction in b coefficients ≥0.5. All coefficients remained statistically significant at p≤0.05.

		Factors on which items loaded														
		Satisfaction														
		Items (change in coefficients)														
Chronic conditions	Base model coefficients	ONS life	SWLS condition life	SWLS live life over	PWI standard living	PWI achievement	PWI life as whole	SWLS life as whole	SWLS life close ideal	SWLS got important things	ONS things worthwhile	ONS happiness	PWI personal rel	PWI part community	PWI future security	PWI spirituality
Cancer	-14.008	**-0.841**	**-0.943**	0.138	0.023	**-0.446**	-0.397	**-0.782**	**-0.573**	-0.062	-0.408	**-0.627**	0.019	-0.282	-0.102	-0.252
Asthma	-9.587	-0.259	**-0.513**	0.065	-0.212	-0.254	-0.206	-0.252	-0.339	-0.195	-0.169	-0.381	-0.064	-0.059	-0.094	0.084
COPD	-15.570	**-0.537**	0.036	0.176	0.155	-0.168	-0.436	0.155	0.472	**-0.725**	-0.103	-0.276	0.200	-0.132	-0.138	-0.174
Depression	-11.123	**-0.598**	**-0.883**	**-0.591**	-0.232	**-0.911**	**-0.863**	**-0.981**	**-0.65**	**-0.556**	**-0.802**	**-0.517**	-0.314	-0.592	-0.256	-0.127
Diabetes	-12.565	**-0.888**	**-0.832**	-0.170	-0.453	**-0.810**	**-0.503**	**-0.900**	**-0.674**	**-0.616**	**-0.832**	-0.393	-0.166	-0.376	-0.28	-0.078
Hearing Problems	-6.890	-0.284	0.045	0.155	0.149	-0.167	-0.274	-0.228	0.040	0.119	-0.204	-0.193	-0.087	-0.199	0.003	0.034
Arthritis	-7.731	-0.223	-0.177	-0.165	0.156	-0.111	-0.060	-0.329	-0.238	-0.251	-0.097	0.114	-0.087	-0.008	0.048	0.051
Heart	-13.323	**-0.537**	**-0.512**	0.085	-0.153	**-0.593**	-0.322	-0.342	-0.316	0.074	-0.372	-0.25	0.028	-0.18	-0.169	0.022
Stroke	-20.651	**-2.582**	**-3.519**	**-1.648**	**-1.293**	**-0.904**	**-2.623**	**-2.290**	**-1.263**	**-2.258**	**-0.828**	**-0.734**	**-0.532**	**-1.596**	**-1.732**	**-0.746**

Note: Bold indicates reduction in b coefficients ≥0.5. All coefficients remained statistically significant at p≤0.05.

Table 5. (continued)

		Factors on which items loaded										
		Vision			*Hearing*			*Speech / cognition*				
		Items (change in coefficients)										
Chronic condition	Base model coefficients	AQoL Vision	HUI3 Vision	15D Vision	AQoL Hearing	15D Hearing	HUI 3 Hearing	HUI 3 speech	15D mental function	AQoL communication	15D speech	HUI3 cognition
Cancer	-14.008	-0.194	-0.023	-0.052	-0.322	-0.112	-0.062	0.001	-0.296	-0.027	-0.019	-0.273
Asthma	-9.587	-0.218	-0.043	-0.038	-0.165	-0.073	-0.007	0.017	-0.070	0.002	-0.059	-0.101
COPD	-15.570	-0.284	-0.043	0.058	-0.441	-0.226	-0.221	-0.017	0.080	0.019	0.148	0.281
Depression	-11.123	-0.098	-0.101	0.052	-0.153	-0.055	-0.037	0.005	-0.456	-0.048	-0.100	-0.440
Diabetes	-12.565	-0.323	-0.139	-0.149	-0.181	-0.089	-0.067	0.016	-0.136	0.008	-0.008	-0.087
Hearing Problems	-6.890	-0.364	-0.184	-0.208	**-1.663**	**-0.974**	**-0.706**	-0.022	-0.327	-0.224	-0.171	-0.376
Arthritis	-7.731	-0.187	-0.055	-0.004	-0.182	-0.059	-0.023	0.032	-0.01	0.020	-0.017	0.013
Heart	-13.323	-0.208	-0.063	-0.057	-0.305	-0.108	-0.083	0.010	-0.08	-0.003	-0.057	-0.154
Stroke	-20.651	**-0.832**	**-0.751**	-0.477	-0.650	-0.153	-0.147	-0.139	**-1.137**	-0.202	**-0.916**	**-1.293**

Note: Bold indicates reduction in b coefficients ≥0.5. All coefficients remained statistically significant at p≤0.05

References

1 Brazier J, Ratcliffe J, Salomon JA, Tsuchiya A. Measuring and valuing health for economic evaluations. Oxford: Oxford University Press; 2012

2 Karimi M, Brazier J. Health, Health related quality of life and quality of life: what is the difference?. *Pharmacoeconomics*. 2016. 34; 7: 645-649.

3 World Health Organization. Constitution of the World Health Organization. Geneva: World Health Organization; 1948

4 Lerner M. Conceptualization of health and social well-being. *Spring*. 1973. 8; 1: 6-12.

5 Newhouse J. Free for All? Lessons from the RAND Health Insurance Experiment. Cambridge: Harvard University Press; 1993

6 Ware J. Conceptualization and Measurement of Health for Adults in the Health Insurance Study: Volume 1. Model of Health and Methodology. Santa Monica, CA: RAND; 1980

7 Bergner M. Measurement of health status. *Med Care*. 1985; 23: 696-704.

8 Nagi S. Some conceptual issues in disability and rehabilitation. In: Sussman MB, ed. Sociology and Rehabilitation. Washington, DC: American Sociological Association; 1965.

9 Read JL, Quinn RJ, Hoefer MA. Measuring overall health: an evaluation of three important approaches. *J Chronic Dis*. 1987; 40: 7S-21S.

10 Wilson IB, Cleary PD. Linking clinical variables with health related quality of life: a conceptual model of patient outcomes. *JAMA*. 1995. 273; 1.

11 Brazier J, Rowen D. (2011) Nice DSU Technical Support Document 11: Alternatives to EQ5D for generating health state utilitiy values. Report by Decision Support Unit. Mar. Available at: http://www.nicedsu.org.uk/TSD11%20Alternatives%20to%20EQ-5D_final.pdf

12 National Institute of Health and Clinical Excellence NICE Guide to the Methods of Technology Appraisal. London: NICE; 2008

13 Finch AP, Brazier JE, Mukuria C. What is the evidence for the performance of generic preference-based measures? A systematic overview of reviews. *European Journal of Health Economics*. 2018; 4: 557-570.

14 Dowie J. Decision validity should determine whether generic or condition specific HRQOL measures is used in health care decisions. *Health economics*. 2002; 11: 1-8.

15 Moock J, Kohlmann T. Comparing preference-based quality-of-life measures: results from rehabilitation patients with musculoskeletal, cardiovascular, or psychosomatic disorders. *Quality of Life Research*. 2008; 17: 485–495.

16 Brazier J, Tsuchiya A. Preference-based condition specific measures of health: what happens to cross programme comparability. *Health Economics*. 2010; 192: 125-129.

17 Brazier JE, Rowen D, Mavranezouli I, et al. Developing and testing methods for deriving preference-based measures of health from condition-specific measures (and other patient-based measures of outcome). *Health Technology Assessment*. 2012. 16; 32: 1-114.

18 EuroQol Group symposium. New research for future approaches to measuring and valuing health. Berlin, Germany: International Society for Pharmacoeconomics and Outcomes Research (ISPOR). 2012.

19 Finch AP, Brazier JE, Mukuria C, Bjorner JB. An exploratory study on using principal component analysis and confirmatory factor analysis to identify bolt-on dimensions: The EQ-5D case study. Value in Health. 2017; 10: 1362-1375.

20 Richardson J, Iezzi A, Maxwell A. Cross-National Comparison of Twelve Quality of Life Instruments: MIC paper 1 Background, Questions, Instruments. Centre for Health economics. 2012.

21 Longworth L, Yang Y, Young T, et al. Use of generic and condition-specific measures of health-related quality of life in NICE decision-making: a systematic review, statistical modelling and survey. *Health Technology Assessment*. 2014; 9: 1-224.

22 Krabbe PFM, Stouthard MEA, Essink-Bot ML, Bonsel GJ. The effect of adding a cognitive dimension to the EuroQol multi-attribute health status classification system. *Journal of Clinical Epidemiology*. 1999; 4: 293-301.

23 Yang Y, Brazier JE, Tsuchiya A. Effect of adding a sleep dimension to the EQ5D descriptive system: A "bolt-on" experiment. *Medical decision making*. 2014; 34: 42-53.

24 Yang Y, Rowen D, Brazier J, Tsuchiya A, Young T, Longworth L. An Exploratory Study to Test the Impact on Three "Bolt-On" Items to the EQ-5D. *Value in Health*. 2015; 18: 52-60.

25 Brazier J, Rowen D, Tsuchiya A, Yang Y, Young TY. The impact of adding an extra dimension to a preference-based measure. *Social science and medicine*. 2011; 73: 245-253.

26 Pedhazur EJ, Schmelkin LP. Measurement, Design and Analysis: An integrated approach. New Jersey: Lawrence Erlbaum Associates . 1991

27 Richardson J, Khan MA, Iezzi A, Maxwell A. Cross national comparison of twelve quality of life

instruments. Research papers 78, 80-83, 85. MIC Report 2. Melbourne: Centre for Health Economics, Monash University. 2012

28 Bockerman P, Johansson E, Saarni SI. Do established health-related quality-of-life measures adequately capture the impact of chronic conditions on subjective well-being? *Health Policy*. 2011; 100: 91–95.

29 Devlin NJ, Hansen P, Selai C. Understanding health state valuations: a qualitative analysis of respondents' comments. *Quality of Life Research*. 2004; 7: 1265-1277.

30 Saha K, Mulhern B, Longworth L, Janssen B. Important aspects of health not captured by the EQ-5D. Views of the general public. EuroQol working group series. . 2016

31 Barton GR, Sach TH, Avery AJ, Doherty M, Jenkinson C, Muir KR. Comparing the performance of the EQ-5D-3L and SF-6D when measuring the benefits of alleviating knee pain. *Cost Effective Resource Allocation*. 2009; 7: 12.

32 Whynes DK. Does the correspondence between EQ-5D-3L health state description and VAS score vary by medical condition? *Health and Quality of Life Outcomes*. 2013; 11: 155.

Appendix Table 1. Items wording

Measure	Items	Wording of the first level of the item
EQ-5D-5L	EQ-5D-5L mobility	I have no problems in walking about
	EQ-5D-5L self care	I have no problems washing or dressing myself
	EQ-5D-5L usual activities	I have no problems doing my usual activities
	EQ-5D-5L pain/discomfort	I have no pain or discomfort
	EQ-5D-5L anxiety/depression	I am not anxious or depressed
SF-6D	SF-6D vitality	I have a lot of energy all of the time
HUI 3	HUI 3 vision	Able to see well enough to read ordinary newsprint and recognize a friend on the other side of the street, without glass
	HUI 3 hearing	Able to hear what is said in a group conversation with at least three other people, without a hearing aid
	HUI 3 speech	Able to be understood completely when speaking with strangers or people who know me well
	HUI 3 cognition	Able to remember most things, think clearly and solve day to day problems
AQoL 8D	AQoL energy	[Thinking about how much energy you have to do the things you want to do: I am] Always full of energy
	AQoL close relationships (family and friends)	[Your close relationships (family and friends) are:] Very satisfying
	AQoL communication	[How well can you communicate with others? (e.g., by talking, listening, writing or signing)] I have no trouble speaking to them or understanding what they are saying
	AQoL sleeping	[How often do you have trouble sleeping?] Never
	AQoL enthusiasm	[How enthusiastic do you feel?] Extremely
	AQoL enjoyment close relationships	[How much do you enjoy your close relationships (family and friends)?] Immensely
	AQoL vision	[How is your vision (while using any visual aids you need)?] I have excellent sight
	AQoL hearing	[How is your hearing (while using any hearing aids you need)?] I have excellent hearing
	AQoL close relationships (including sexual)	[Your close and intimate relationships (including any sexual relationships) make you:] Very happy
15D	15D vision	I see normally, i.e. I can read newspapers and TV text without difficulty (with or without glasses)
	15 D hearing	I can hear normally, i.e. normal speech (with or without a hearing aid)
	15 D sleeping	I am able to sleep normally, i.e. I have no problems with sleeping
	15 D speaking	I am able to speak normally, i.e. clearly, audibly and fluently

	15 D mental function	I am able to think clearly and logically, and my memory functions well
	15 D vitality	I feel healthy and energetic
ICECAP	ICECAP Love and support	I can have a lot of love, friendship, and support
ONS	ONS satisfaction with life	[Overall, how satisfied are you with your life nowadays?] Completely satisfied
	ONS life is worthwhile	[Overall, to what extent do you feel that the things you do in your life are worthwhile?] Completely worthwhile
	ONS happiness yesterday	[Overall, how happy did you feel yesterday?] Completely happy
PWI	PWI satisfaction with life as a whole	[Thinking about your own life and personal circumstances, how satisfied are you with your life as a whole?] Completely satisfied
	PWI satisfaction standard of living	[How satisfied are you with your standard of living?] Completely satisfied
	PWI satisfaction achievement	[How satisfied are you with what you are achieving in life?] Completely satisfied
	PWI satisfaction personal relationships	[How satisfied are you with your personal relationships?] Completely satisfied
	PWI satisfaction safety	[How satisfied are you with how safe you feel?] Completely satisfied
	PWI satisfaction part of the community	[How satisfied are you with feeling part of your community?] Completely satisfied
	PWI satisfaction future security	[How satisfied are you with your future security?] Completely satisfied
	PWI satisfaction spirituality	[How satisfied are you with your spirituality or religion?] Completely satisfied
SWLS	SWLS life close ideal	[In most ways my life is close to my ideal] How content are you with your life. Strongly agree
	SWLS condition of life are excellent	[The conditions of my life are excellent] How content are you with your life. Strongly agree
	SWLS satisfaction with life	[I am satisfied with my life] How content are you with your life. Strongly agree
	SWLS gotten important things in life	[So far I have gotten the important things I want in life] How content are you with your life. Strongly agree
	SWLS if I could live life over	[If I could live my life over, I would change almost nothing] How content are you with your life. Strongly agree

Appendix Table 2. β coefficients, statistical significance and standard errors of the base model assessing the impact on chronic health conditions HRQoL (Health VAS dependent variable)

	Variables	β coefficients	Standard error
	Constant	*80.449***	*0.830*
	High school education	*(Omitted)*	*(Omitted)*
	Diploma education	*0.121*	*0.422*
	University education	*1.746***	*0.465*
	Age 18-24	*(Omitted)*	*(Omitted)*
	Age 25-34	*1.196*	*0.877*
	Age 35-44	*0.312*	*0.855*
	Age 45-54	*0.409*	*0.829*
	Age 55-64	*-1446*	*0.830*
	Age >65	*3.551***	*0.855*
	Male	*(Omitted)*	*(Omitted)*
	Female	*2.365***	*0.368*
	EQ5D-5L mobility level 1	*(Omitted)*	*(Omitted)*
	EQ5D-5L mobility level 2	*-2.718***	*0.553*
	EQ5D-5L mobility level 3	*-5.272***	*0.823*
	EQ5D-5L mobility level 4	*-9.427***	*1.256*
	EQ5D-5L mobility level 5	*-9.955***	*3.126*
	EQ5D-5L self care level 1	*(Omitted)*	*(Omitted)*
	EQ5D-5L self care level 2	*-2.381***	*0.734*
	EQ5D-5L self care level 3	*0.043*	*1.168*
	EQ5D-5L self care level 4	*-1.955*	*2.225*
	EQ5D-5L self care level 5	*1.183*	*5.697*
	EQ5D-5L usual activities level 1	*(Omitted)*	*(Omitted)*
	EQ5D-5L usual activities level 2	*-6.296***	*0.543*
	EQ5D-5L usual activities level 3	*-10.466***	*0.870*
	EQ5D-5L usual activities level 4	*-15.217***	*1.379*
	EQ5D-5L usual activities level 5	*-15.299***	*2.488*
	EQ5D-5L pain discomfort level 1	*(Omitted)*	*(Omitted)*
	EQ5D-5L pain discomfort level 2	*-2.917***	*0.462*
	EQ5D-5L pain discomfort level 3	*-6.388***	*0.634*
	EQ5D-5L pain discomfort level 4	*-9.293***	*0.889*
	EQ5D-5L pain discomfort level 5	*-12.988***	*1.713*
	EQ5D-5L anxiety depression level 1	*(Omitted)*	*(Omitted)*
	EQ5D-5L anxiety depression level 2	*-5.074***	*0.435*
	EQ5D-5L anxiety depression level 3	*-10.437***	*0.614*
	EQ5D-5L anxiety depression level 4	*-18.642***	*0.945*
	EQ5D-5L anxiety depression level 5	*-23.198***	*1.380*
	Cancer	*-14.008***	*0.729*
	Asthma	*-9.587***	*0.680*
	COPD	*-15.570***	*2.008*
	Depression	*-11.123***	*0.753*
	Diabetes	*-12.565***	*0.682*
	Hearing problems	*-6.890***	*0.688*
	Arthritis	*-7.731***	*0.714*
	Heart diseases	*-13.323***	*0.686*
	Stroke	*-20.651***	*3.304*
R^2	0.483		

***Note:** * P≤0.05; ** P≤0.01*