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Comparing UK, USA and Australian values for EQ-5D as a health utility measure of oral health

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Objectives: Using generic measures to examine outcomes of oral disorders can add additional information relating to health utility. However, different algorithms are available to generate health states. The aim was to assess UK-, US- and Australian-based algorithms for the EuroQol (EQ-5D) in relation to their discriminative and convergent validity. ***Methods:*** Data were collected from adults in Australia aged 30-61 years by mailed survey in 2009-10, including the EQ-5D and a range of self-reported oral health variables, and self-rated oral and general health. ***Results:*** Responses were collected from n=1,093 persons (response rate 39.1%). UK-based EQ-5D estimates were lower (0.85) than the USA and Australian estimates (0.91). EQ-5D was associated ($p<0.01$) with all seven oral health variables, with differences in utility scores ranging from 0.03 to 0.06 for the UK, from 0.04 to 0.07 for the USA, and from 0.05 to 0.08 for the Australian-based estimates. The effect sizes (ESs) of the associations with all seven oral health variables were similar for the UK (ES=0.26 to 0.49), USA (ES=0.31 to 0.48) and Australian-based (ES=0.31 to 0.46) estimates. EQ-5D was correlated with global dental health for the UK (rho=0.29), USA (rho=0.30) and Australian-based estimates (rho=0.30), and correlations with global general health were the same (rho=0.42) for the UK, USA and Australian-based estimates. ***Conclusions:*** EQ-5D exhibited equivalent discriminative validity and convergent validity in relation to oral health variables for the UK, USA and Australian-based estimates.

Key words: *oral health, quality of life, health utility, validity, EQ-5D, Australia, UK, USA*

Introduction

Measurement of patient-based outcomes can involve both specific and generic measures. While specific measures are commonly used in oral health research, generic health instruments can provide standardised measures of health that tap domains of relevance to the patient (Kane and Radosevich, 2011), and provide index scores with applications to economic evaluation (Cunningham, 2000).

The generic EuroQol (EQ-5D) instrument has been reported to have adequate construct and convergent validity, but may be skewed and lack sensitivity in disease-based outcomes research (Bowling, 2001). However, there has been previous research relating EQ-5D to oral health (Brennan *et al*., 2007; Brennan and Singh, 2011; Brennan and Spencer, 2004a; 2004b; Miksad *et al*., 2011), with the EQ-5D instrument having performed well in terms of convergent validity and discriminant validity (Brennan, 2013; Brennan and Spencer, 2005).

To estimate health states using the EQ-5D requires the adoption of preference weights from a value set to calculate a health utility value. One commonly used algorithm is based on UK preferences (Dolan, 1997). Other algorithms have also been developed such as one based on USA preferences (Shaw *et al*., 2005), and more recently one based on Australian preferences (Viney *et al*., 2014). However, there may be differences between national value sets that could reflect the methods used to value health states and potentially cultural differences between countries (Knies *et al*., 2009; Norman *et al*., 2009)

In adopting the EQ-5D as an outcome measure it is important to assess whether the choice of algorithm and the value set upon which it is based has an impact on the findings. Hence, the aim of this paper was to assess UK-, USA- and Australian-based algorithms for the EQ-5D in relation to their discriminative validity (i.e., the ability to differentiate between different levels of oral health) and convergent validity (i.e., through their correlation with global measures of oral and general health).

Methods

A random sample of adults aged 30-61 years living in Australia was drawn from the Australian Electoral Roll. The only inclusion criteria were being enrolled to vote and being an adult of working age. Since voting is compulsory in Australia the Electoral Roll provides a comprehensive sampling frame for adults aged 18 years or older. Data were collected by mailed self-complete questionnaires in 2009-2010, with up to four follow-up mailings to non-respondents. Variables that were collected included the 5-item EQ-5D and a range of self-reported oral health variables, and self-rated oral and general health were also collected.

The number of health problems was measured using the five items from the EQ-5D instrument which assessed health problems today on a 3-point scale of none, some or extreme (Brooks, 1996). The items were mobility, self-care, usual activities, pain/discomfort and anxiety/depression. EQ-5D item responses were converted to health state values, where each set of responses on the standard 5-item instrument was

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matched to a health state value where 0=death and 1.0=perfect health by algorithms based on values from the UK, USA and Australia. The UK algorithm was derived from modelling values (Dolan, 1997) using health state preferences from a UK general population (Brooks, 1996). The USA algorithm was based on values from a representative sample of the general adult USA population (Shaw *et al*., 2005). The Australian algorithm was derived from a discrete choice experiment based on an Australia-representative online panel (Viney *et al*., 2014).

Variables on self-reported oral health included the presence or absence of dentures, and the number of teeth present. Number of teeth were recorded for lower and upper jaw and combined for analysis. Self-reported number of teeth was classified as an inadequate dentition if fewer than 21 teeth were present, consistent with the UK adult oral health survey (Kelly *et al*., 2000). Data were collected on frequency of toothache, sore gums, and sensitive teeth in the last 12 months. These oral symptoms were measured on a 5-point scale and combined into the coded categories 'sometimes/often/very often' and 'never/hardly ever'. The presence or absence of chipped teeth and orofacial pain in the last 12 month period was also recorded.

Self-ratings of health were assessed using single-item global ratings measured on 5-point scales (Krause and Jay, 1994). These comprised the questions 'How would you rate your general health?' and 'How would you rate your oral health?'. The responses comprised the ordinal categories of 'poor', 'fair', 'good', 'very good' and 'excellent'.

Due to the low prevalence of edentulism in the age range of the sample, analysis was restricted to dentate persons who had some natural teeth but could also include those with partial dentures. The response and sample characteristics were described and compared to population profile data using confidence intervals. Discriminative properties of the health utility scores were assessed by their associations with self-reported oral health variables. It was expected that health utility scores would be lower for worse oral health conditions such as dentures, fewer teeth, presence of toothache, sore gums, sensitive teeth, chipped teeth and orofacial pain. Associations were tested using p values from general linear models. The differences between levels of each of the oral health variables (e.g., between those with dentures versus those without dentures) were described by their mean differences. Relative validity (RV) was computed as the ratio of two F-statistics, with the Australian-based EQ-5D health utility score used as the reference (Fayers and Machin, 2000). Across each oral health variable, scores that were more sensitive than the Australian-based EQ-5D health utility score would have RVs>1, and less sensitive measures would have RVs<1. Effect sizes (ES) were calculated as the difference in mean scores between levels of each oral health variable divided by the standard deviation. ES statistics can be used to measure sensitivity in the ability to detect differences between groups as in this cross-sectional study, as well as responsiveness to change (Fayers and Machin, 2000). Generally, an ES of 0.2 is considered small, 0.5 as moderate and 0.8 or greater as large (Kazis *et al*., 1989). Convergent validity was assessed by correlation of the EQ-5D health utility scores with global ratings of oral health and general health. It was expected that health utility scores would be positively correlated with oral and general health.

The research was approved by the Human Research Ethics Committee of the University of Adelaide.

Results

Responses were collected from n=1,093 persons (response rate 39.1%). Of these, 4% (n=44) were edentulous or of unknown dentate status and were excluded from analyses. The respondents showed a similar profile to comparable population survey data in terms of making a dental visit in the last 12 months, place of birth and education level (Table 1). However, a lower percentage of the study

Table 1. Distribution of explanatory variables and comparison of dentate study participants with the population profile

	Census data [a]	*Population survey data* [b]		*Study participants*	
	n	*n*	*(95% CI)*	*n*	*(95% CI)*
Oral health status					
Number of teeth – mean	-	25.2	(24.8, 25.6)	26.5	(26.1, 26.8)
Denture (upper jaw) - %	-	7.8	(6.8, 8.9)	11.7	(9.8, 13.8)
Denture (lower jaw) - %	-	2.1	(1.6, 2.7)	3.9	(2.8, 5.3)
Dental access					
Last dental visit <12 months - %	-	60.5	(58.3, 62.6)	59.7	(56.7, 62.7)
Check-up at last dental visit - %	-	57.2	(54.9, 59.5)	50.4	(47.4, 53.5)
Dental insurance - %	-	60.0	(57.9, 62.1)	53.9	(51.0, 57.0)
Socio-demographics					
Male gender - %	49.2	49.8	(47.6, 51.9)	42.3	(39.3, 45.4)
Age 30-39 years - %	34.4	34.1	(31.9, 36.4)	24.7	(22.1, 27.4)
Age 40-49 years - %	35.0	33.0	(31.1, 35.0)	32.9	(30.0, 35.8)
Age 50-61 years - %	30.6	32.9	(31.1, 34.8)	42.5	(39.4, 45.5)
Australian born - %	-	79.6	(77.8, 81.3)	80.7	(78.2, 83.1)
English main language at home - %	-	88.2	(86.6, 89.7)	94.6	(93.1, 95.9)
Education level of diploma or degree - %	-	44.6	(42.5, 46.8)	44.6	(41.5, 47.7)
Socio-economic status					
Household income up to $60,000 - %	-	24.2	(22.2, 26.2)	35.2	(32.2, 38.2)
Household income >$60,000-100,000 - %	-	37.2	(35.1, 39.3)	32.2	(29.3, 35.1)
Household income >$100,000 - %	-	38.7	(36.5, 40.9)	32.6	(29.7, 35.6)

[a] Census 2006: Australia, 30-59 year-olds
[b] National Dental Telephone Interview Survey 2010: Australia, dentate 30-61 year-olds

Table 2. Discriminative properties across the three algorithms: EQ-5D with oral health and visit variables

	UK EQ-5D			*USA EQ-5D*			*Australia EQ-5D*		
	Difference, mean (SE)	*RV*	Effect Size	*Difference, mean (SE)*	*RV*	Effect Size	*Difference, mean (SE)*	*RV*	Effect Size
Dentures vs no dentures	0.05 (0.01)	1.10	0.40	0.05 (0.01)	0.95	0.43	0.07 (0.02)	1.00	0.38
Number of teeth: <20 vs 21+	0.06 (0.01)	1.08	0.44	0.07 (0.01)	0.90	0.48	0.08 (0.02)	1.00	0.46
Toothache vs none	0.06 (0.01)	1.13	0.49	0.06 (0.01)	0.96	0.44	0.08 (0.01)	1.00	0.45
Gums sore vs not sore	0.05 (0.01)	1.03	0.41	0.05 (0.01)	0.95	0.42	0.07 (0.01)	1.00	0.39
Teeth sensitive vs not	0.03 (0.01)	1.10	0.26	0.04 (0.01)	1.11	0.31	0.05 (0.01)	1.00	0.31
Chipped teeth vs not	0.04 (0.01)	1.00	0.41	0.05 (0.01)	0.90	0.35	0.06 (0.01)	1.00	0.34
Orofacial pain vs no pain	0.05 (0.01)	1.10	0.41	0.06 (0.01)	0.97	0.37	0.07 (0.01)	1.00	0.46

All differences at significance $p<0.01$; RV, Relative validity

participants were males, younger (aged 30-39 years), in the higher (>$100,000) income category, had dental insurance, or visited for a check-up at their last visit. Study participants also tended to have more teeth but a higher percentage with dentures, spoke English at home, and in the lower ($60,000) income group compared to the population survey data.

The UK-based estimate had a mean of 0.85 (sd 0.11, range 0.23 to 0.92), the USA-based estimate had a mean of 0.91 (sd 0.13, range 0.28 to 1.00) and the Australian-based estimate had a mean of 0.91 (sd 0.16, range 0.01 to 1.00). The estimates were highly correlated, with rho=0.99 for the UK and USA-based EQ-5D estimates, rho=0.98 for the UK and Australian-based estimates, and rho=0.98 for the USA and Australian-based estimates.

EQ-5D was associated ($p<0.01$) with all seven oral health variables for the UK, USA and Australian-based estimates (Table 2). Differences in utility scores ranged from 0.03 to 0.06 for the UK-based EQ-5D estimates, from 0.04 to 0.07 for the USA-based estimates and from 0.05 to 0.08 for the Australian-based estimates.

The relative validity measures tended to be slightly higher for the UK-based estimates and slightly lower for the USA-based estimates. Compared to the reference of the Australian-based EQ-5D utility scores, they ranged from RV 1.0 to 1.1 for the UK-based estimates and from 0.90 to 1.11 for the USA-based estimates.

The effect sizes of the associations with all seven oral health variables were similar for the UK, USA and Australian-based estimates. They ranged from ES 0.26 to 0.49 for UK-based estimates, from ES 0.31 to 0.48 for USA-based estimates of EQ-5D, and from ES0.31 to 0.46 for Australian-based EQ-5D estimates.

The health utility scores showed a similar level of correlation with self-rated global dental health ratings for the UK (rho=0.29), USA (rho=0.30) and Australian-based (rho=0.30) EQ-5D estimates (Table 3). The correlations of the EQ-5D estimates with global general health ratings were the same (rho=0.42) for the UK, USA and Australian-based estimates.

Table 3. Spearman rho associations of EQ-5D with self-rated health

	EQ-5D		
	UK	*USA*	*Australia*
General Health	0.42	0.42	0.42
Dental Health	0.29	0.30	0.30

All values $p<0.01$

Discussion

The findings showed that generic health utility scores were related to oral health conditions regardless of whether they were based on UK, USA or Australian algorithms. These statistically significant associations demonstrated validity in terms of their discriminative properties. The correlations between the health utility index scores with both oral health and general health demonstrated convergent validity. The demonstrated associations with oral health variables in terms of both discriminative and convergent properties, supports the more widespread adoption of health utility measures in oral health studies. Further, the correlation of oral health with generic health utility scores, while not large, can demonstrate linkage between oral health and general health that could be interpreted as oral health having an impact on self-reported health status.

The generic EQ-5D instrument is a standardised instrument for valuing health-related quality of life (Brooks, 1996). Advantages include ease of administration, high completion rates, and sensitivity to change (Holland *et al*., 2004), but EQ-5D may be insensitive at the top of the range near values of 1.00, and be more sensitive to health states associated with some diseases or conditions than others (Hawthorne *et al*., 2001). There is some question whether different EQ-5D national value sets are transferable between countries as differences between the value sets could reflect the valuation methods that were used and cultural differences between countries (Knies *et al*., 2009; Norman *et al*., 2009)

Comparisons have been reported between the initially developed UK algorithm and those generated later in other countries. For example, differences in EQ-5D valuations have been reported between the UK and USA (Johnson *et al*., 2005), but responsiveness to change was reported to be similar (Luo *et al*., 2007). In this study we also found that the EQ-5D estimates varied in magnitude with higher health states estimated from the USA and Australian algorithms compared to the UK. Estimates reported for EQ-5D using the UK-based algorithm were however similar to the Australian-based health utility score, the AQoL (Brennan, 2013). Therefore comparisons of absolute values of health states need to be made cautiously. While the estimates of health states in this study varied in their absolute levels, the associations with oral health variables were stable across the national value sets modelled through the algorithms indicating their applicability in such comparisons, with the caveat regarding their absolute levels. This finding was consistent with the reported comparison of UK and USA

EQ-5D preferences which found that they had equivalent psychometric properties such that adoption of either set of preference weights in the algorithm would not change inferences when they were used as an outcome measure (Huang *et al*., 2007).

The differences in mean EQ-5D between levels of oral health variables observed from the UK, USA and Australian-based algorithms may have application in sample size determination involving health utility measures considering the relative paucity of studies reporting associations of oral health with health utility and cost-utility (Cunningham, 2000). The differences in reported mean EQ-5D levels from the UK, USA and Australian-based estimates can also add to the evidence in relation to minimally important differences (MIDs) for health utility measures in oral health research.

The MID is important in the interpretation of study findings by defining a value considered the smallest difference in an outcome measure which a patient may perceive as beneficial (Tsakos *et al*., 2012). A mean MID of 0.07 has been reported for the EQ-5D from a review of 11 studies (Walters and Brazier, 2005). The differences in EQ-5D in this study ranged between 0.03 to 0.08 across the oral health conditions and UK, USA and Australian-based algorithms, suggesting a range of possible MIDs that may be applicable to EQ-5D studies of health utility in relation to oral health conditions. Variations in mean differences in EQ-5D (and possible MIDs) across the three national algorithms were less pronounced when compared within specific oral conditions; a difference of 0.02 in each case. For example, the difference between those with and without dentures was 0.05 for both the UK and USA-based estimates and was 0.07 for the Australian-based estimate. While there was general agreement in the mean differences in EQ-5D observed across the algorithms, the UK estimates tended to be lower and the Australian-based estimates highest. For example, the comparison of those with and without orofacial pain showed a mean difference in EQ-5D of 0.05 for the UK, and 0.07 for the Australian-based estimate.

The EQ-5D health utility score estimates showed a range of effect sizes in the vicinity of 0.03-0.05 across the UK, USA and Australian-based algorithms. These effect sizes would be considered as moderate or between small to moderate in size. In general, there was agreement across the algorithms in effect sizes. For example, higher effect sizes such as the comparison of those with less than 20 teeth versus those with 21 or more teeth resulted in effect sizes of 0.44, 0.48 and 0.46 respectively for the UK, USA and Australian-based algorithms, while at the lower end we observed effect sizes of 0.26, 0.31 and 0.31 respectively for the comparison of sensitive teeth.

While the response yield provided sufficient numbers for analysis, the response rate was low. Key demographic characteristics from the census showed the study participants were less likely to be male and from the younger adult age group (Australian Bureau of Statistics, 2006). Other comparable population sample data also showed the survey respondents were more likely to be from the lower income group, and have lower levels of dental insurance and check-ups at the last dental visit. The older study sample with a higher percentage from the lower income group plus lower percentages insured and reporting check-up visiting seems consistent with worse oral health which was reflected in a higher percentage with dentures, but not in terms of number of teeth which was higher in the study sample. While the study respondents had a higher percentage from the lower income group there was no difference in the percentage with tertiary education. Hence, while there are differences between the study respondents and both the census and population survey data these differences were not consistent in terms of oral health or socio-economic status.

Conclusion

All three of the health state estimates derived from the UK, USA and Australian algorithms performed similarly in terms of discriminative and convergent validity. They demonstrated statistically significant differences between the levels of the seven oral health status variables and were correlated with global ratings of general health and oral health. Use of any of the algorithms as an outcome measure would not change the inferences observed. However, the USA and Australian-based values were higher in absolute terms than the UK values. Hence, interpretations related to specific levels of health would need to be made cautiously. However, the effect sizes and range of potential minimally important differences were similar for the UK, USA and Australian-based estimates. The findings support the use of appropriate generic measures in oral health studies.

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