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A New Valuation Method: Directly Eliciting Personal Utility Functions

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ABSTRACT

Background: Standard methods for eliciting the preference data upon which 'value sets' are based vary in underlying approach but generally have in common an aim to 'uncover' people's preferences by asking them to evaluate a sub-set of health states, then using their responses to infer their preferences over all dimensions and levels. An alternative approach is to ask people directly about the relative importance to them of the dimensions, levels and interactions between them.

Objectives: To describe a new stated preference approach for directly eliciting personal utility functions (PUFs), and to report the methods and findings of a pilot study to test its feasibility and acceptability for valuing EQ-5D.

Methods: We developed an innovative questionnaire designed to directly elicit PUFs from respondents via face-to-face interviews, with a focus on helping them to reflect and deliberate on their preferences. The approach is informed by existing techniques and is based on the premise that individuals construct their preferences in response to stated preference tasks. The interview comprises the following exercises: warm-up tasks; dimension rating task; level rating task; paired comparison validation tasks; task designed to identify respondent's personal location of dead; task designed to examine interactions; debrief and background questions. The questionnaire was piloted in England, following earlier pre-piloting in Australia, England and the Netherlands.

Results: Seventy-six interviews with general public respondents were conducted in December 2015. Overall, pain/discomfort and mobility were found to be the most important of the EQ-5D dimensions. The ratings for intermediate improvements (from level 3 to level 2 problems) in each dimension show heterogeneity, both within (i.e. most respondents' ratings differed across dimensions) and between respondents. Almost a quarter of respondents indicated that no EQ-5D health states are worse than dead.

Discussion: The PUF approach appears to be feasible, and has the potential to: (a) yield meaningful, well-informed preference data from respondents; and (b) provide individual preference data that can be aggregated to yield a value set for the EQ-5D. A deliberative approach to health state valuation also has the potential to complement and develop existing valuation methods. Further refinement of some elements of the approach are required.

1. INTRODUCTION

1.1. Background

The end product of stated preference valuation studies for patient-reported outcome (PRO) instruments is an algorithm describing, on average for a given population, the utility decrements associated with varying levels of problems on each item (and, potentially, interaction effects between them). This generates a 'value set': every possible health state that can be described by the items and response options available in the PRO can be summarised by a number (in order to be used in the calculation of quality-adjusted life years, these numbers should lie on a scale anchored at 0 = dead and 1 = full health), with negative values denoting states valued or modelled as worse than dead.

Standard methods for eliciting the preference data upon which these algorithms are based – discrete choice experiments (DCE), standard gamble (SG), time trade-off (TTO) and visual analogue scale (VAS) – vary considerably both in underlying approach and theoretical foundations. For example, while SG is grounded in expected utility theory (von Neumann and Morgenstern, 1944), DCE arises from random utility theory (McFadden, 1974). TTO is often described as a more pragmatic means of proxying SG utilities, but has also been placed in the context of Hicks utility theory (Buckingham and Devlin, 2006; 2009). VAS has its roots in psychology (Parkin and Devlin, 2006). For more detail on these and other established methods, see Ryan et al. (2001) and Brazier et al. (2017).

These differences in theoretical foundation have been well described and there continues to be much debate over the relative merits of the various methods. But notably, the methods currently used to preference-weight PRO instruments (such as the EQ-5D) tend to have one important thing in common – they aim to 'uncover' people's preferences by asking them evaluate a sub-set of health *states* described by the PRO, and then use their responses to infer their preferences over all dimensions and levels.

An alternative approach is to ask people to construct their own personal utility functions (PUFs). Instead of asking people to value a selection of health states, this approach involves directly asking people about the relative importance to them of the dimensions and levels described by the PRO, and potential interactions between them. In effect, the approach entails helping people to construct their own PUFs for a PRO instrument by engaging them in a series of structured tasks aimed at getting them to reflect on their preferences for different aspects of health and associated levels of severity. The aim of this paper is to describe this approach for directly eliciting PUFs, and to report the methods and findings of a pilot study to test its feasibility and acceptability for valuing a widely used generic PRO, the EQ-5D.

We begin by explaining the rationale for developing a new approach to eliciting stated preferences. We then detail prototype methods we developed to pilot the approach, and report the results from piloting work. We conclude by highlighting the potential merits of the approach and aspects of it that require further development and testing.

1.2. What is the matter with the current valuation approaches?

Current valuation tasks rely on survey respondents being able to imagine living in health states that they are unlikely to have ever experienced, and which are described in a highly abstract and structured way that they are unlikely to be familiar with. They have to translate the broad, generic descriptions of each health state provided into something tractable that they can think about and imagine experiencing. It is likely that this process introduces heuristics along the way – for example qualitative work has suggested that respondents may focus only on a subset of the dimensions presented, in order to simplify the process (Mulhern et al., 2014). Further, some valuation methods then require them to reflect on what it would be like to live with those problems, unrelieved, for a certain number of years. The task is made more difficult still because respondents often encounter what they consider to be 'unrealistic' health states (combinations of dimensions and levels which to them are not plausible), which affects the acceptability and realism of the task. This means that respondents cannot imagine such states, let alone value them. This whole process of 'imagining' health states is expected to happen within a very short time period.

In all conventional stated preference valuation approaches – including TTO, SG, DCE or VAS – the purpose of the exercises is not really transparent to respondents. The tasks are often seen by respondents as being quite obscure, and we don't tell respondents how we process and interpret their responses. We (or the interviewers completing the task) do not reflect back the respondent's answers to them, or check whether they agree with our interpretation of them.[1] There may be little real engagement with the tasks, but this is difficult to assess. The increasing popularity of DCE and online panels takes us even further in this direction, with respondents often taking a very short amount time to imagine health states and judge which they prefer.

Most fundamentally of all, current approaches rest on the assumption that respondents have a pre-existing, consistent and stable utility function over (for example) EQ-5D which we merely have to 'tap into' with appropriate questions. Fischoff (1991) refers to this as 'the philosophy of articulated values'. In contrast, the 'philosophy of basic values' suggests that people lack clearly formulated preferences for all but the most familiar of evaluation tasks. The reality of PRO valuation studies is that respondents are *constructing* their utility functions on the spot, engaging in a mental production process to create responses to the tasks they are being asked to perform (Slovic, 1995). This is the reason that framing effects, and also method effects based on methodological choices relating to the tasks, are so important in stated preference studies (Jones-Lee et al., 1995). This is clearly apparent from the extensive literature on health state valuation showing that, for example, EQ-5D health state values differ considerably between methods (Brazier et al., 2017).

We have developed the PUF approach in an attempt to avoid some of these problems in valuing health states. The approach is designed to specifically acknowledge that respondents are constructing their preferences in response to stated preference tasks, and therefore seeks to provide opportunities for reflection and deliberation (by contrast, standard protocols for valuing EQ-5D actually prohibit respondents from changing their responses as they 'learn' and proceed through the valuation tasks). Hence, we are

[1] A 'feedback module' – recently incorporated into the EuroQol protocol for valuing EQ-5D-5L health states (Shah et al., 2014) – is a step in this direction although limited in that it only shows how the TTO health states have been ranked, not how the values themselves are interpreted and used to generate a utility function.

attempting to build on existing research that suggests that a more structured valuation approach in which the respondent is given time to think and reflect on their responses will lead to more valid responses (at the individual level) that are closer to the respondent's 'true' preferences (Dolan, 1999; Sheill et al., 2000; Robinson and Bryan, 2013; Karimi et al., 2016; Karimi et al., 2017).

2. METHODS

2.1. Sample and administration of survey

Initial testing was conducted with small convenience samples in England and Australia (interviews with colleagues, friends and family members conducted by ND and BM, respectively; findings reported in Devlin et al., 2015). A pre-pilot was then conducted with a larger convenience sample (N=30; all respondents were health outcomes professionals working for Pharmerit and colleagues of authors BVH and KP; interviews conducted by KP; findings summarised in Pantiri et al., 2016). The findings of this early pre-piloting work informed the focus of the interviewer training in the main pilot, but did not result in substantial changes to the survey or approach.

For the main pilot, data were collected from a sample of members of the UK general public. In what follows, all results are based on the UK pilot data. An Excel tool and accompanying paper booklet (described in detail below; available from the authors upon request) formed the basis for one-to-one interviews, undertaken by four interviewers working for a research agency, Accent. The interviewers completed a one-day training course on the specifics of the methodology and procedures for the study, and were given a detailed instruction booklet (albeit not a script, as the intention was to encourage natural discussion and deliberation) to guide the interviews.

All interviews took place in the homes of respondents. The sample comprised adult members of the general public in the south of England, recruited using a 'door-knock' approach. Throughout the questions, respondents were encouraged by the interviewers to reflect on their answers and to change any previous responses if appropriate. Following each interview, the interviewers were asked to complete a series of debrief questions regarding their experience of the interview and their perceptions of how well the respondent understood and carried out the tasks. Interviewers were also asked to indicate the start and finish time of each interview. Depending on the task, responses were recorded either in the Excel tool or the paper booklet, or both.

The study was approved by the Research Ethics Committee at the School of Health and Related Research via the University of Sheffield Ethics Review Procedure.

2.2. Survey instrument

The PUF approach combines several different techniques, drawing on previous research and existing methods such as swing-weighting (a method for setting the weights in a multiattribute utility function whereby an improvement from the worst value to the best value on each criteria is described as a 'swing'; see von Winterfeldt and Edwards, 1986), the short form individual quality of life measure direct weighting technique (SEIQoL-DW; an interview-based procedure for measuring the relative importance to the respondent of nominated life areas; see Hickey et al., 1996) and the Patient Generated Index (a self-administered measure that quantifies the effect of a medical condition on patients' quality of life; Ruta et al., 1994). Each respondent completed the tasks described below, in order. Note that a three-level simplification of the EQ-5D-5L (Herdman et al., 2011) was used in this study. The labels of levels 1, 2 and 3 in this study corresponded to levels 1, 3 and 5 (i.e. no problems, moderate problems, extreme problems) in the EQ-5D-5L.[2]

2.2.1. Section A: Warm-up tasks

Respondents were asked to self-report their EQ-5D profile and EQ-VAS rating twice, first for their own health on the day of the interview and then for the worst health problems they have ever experienced.

2.2.2. Section B: Dimension ranking task

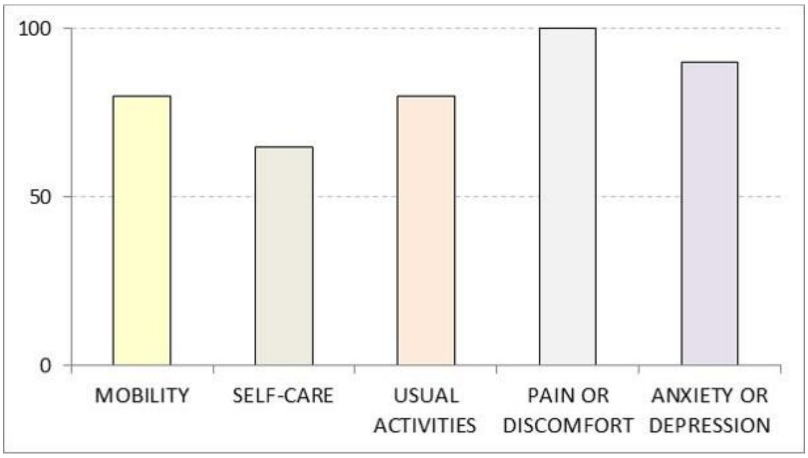
Respondents were asked to rank the five EQ-5D dimensions (with no reference to severity – e.g. 'I have problems in walking about') in order of which problems they would 'least want to have'; ties were permitted.

2.2.3. Section C: Dimension rating task

Respondents were presented with five cards, each describing an improvement (or 'swing') from the worst level (extreme problems) to the best level (no problems) in one of the EQ-5D dimensions. They were asked which card represented the most important or valuable improvement, assigning that improvement a rating of 100 on an accompanying 0-100 scale (where 0 represented an improvement that is not important or valuable at all). They were then asked to rate the other four improvements using the same 0-100 scale; ties (i.e. same ratings) were permitted.

The interviewers were encouraged to raise and discuss potential differences between respondents' section C ratings and section B rankings. Respondents were presented with instant visual representations (bar and pie charts) of their ratings that were used to encourage reflection and comparison with their earlier responses. An example screenshot is shown in Figure 1.

Figure 1. Example diagram used to represent a respondent's section C ratings



2.2.4. Section D: Level rating task

For each dimension (one at a time), respondents were presented with two cards: one describing an improvement from extreme problems to moderate problems on that dimension; the other card describing an improvement from moderate problems to no

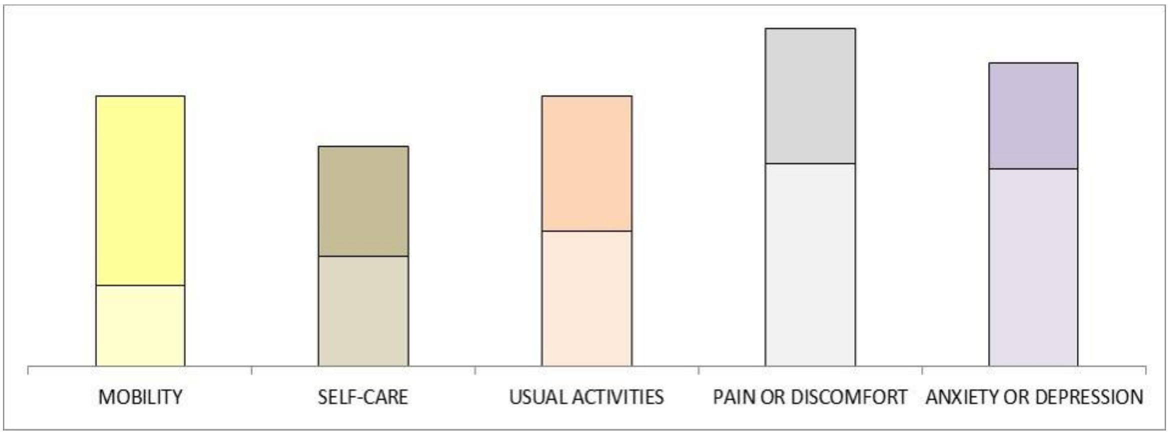
[2] The rationale for this was that we considered the wording of the EQ-5D-5L labels to be more appropriate than those of the EQ-5D-3L labels, and that our ultimate ambition is to apply to method to generate utility functions for the EQ-5D-5L.

problems on that dimension. They were asked which improvement they thought was better, or if they thought that both were about the same.

The respondents were then asked to allocate 100 points between the two improvements, with the help of a 0 to 100 scale. If they considered the improvement from extreme problems to moderate problems to be better, the same as, or worse than the improvement from moderate problems to no problems, they were instructed to give the former improvement greater than 50, exactly 50, or less than 50 points, respectively. Ties (i.e. equal number of points given to intermediate improvement in multiple dimensions) were permitted.

Respondents were presented with visual representations (weighted bar charts) of their ratings – again, these were used to encourage reflection and comparison with earlier responses. An example screenshot is shown in Figure 2.

Figure 2. Example diagram used to represent a respondents section C *and* section D ratings



2.2.5. Section E: Paired comparison validation exercise

Respondents were presented with two paired comparison tasks, each involving a choice between two health states of unspecified duration. The tasks were generated from an algorithm based on each respondent's previous answers, i.e. tailored to their own preferences.

Based on each respondent's responses to sections C and D, the first task was intended to be easier (i.e. comparing health states with a relatively large disparity in estimated personal utility) and the second task was intended to be more difficult (i.e. comparing health states which were close together in terms of estimated personal utility). A restriction was applied to the algorithm such that one health state could not logically dominate the other.

In each task, respondents were asked to choose which health state they thought was better, with no opt out or indifference option permitted – similar to the application of DCE tasks in the EuroQol protocol for the valuation of EQ-5D-5L (Oppe et al., 2014).

2.2.6. Section F: Search for the personal location of dead

Respondents were presented with a series of TTO-type tasks, requiring them to choose between living for 10 years in a given health state (followed by death) and living for 0 years (i.e. dying now). The health state presented in the first task was always 33333 – i.e. the health state ranked 243rd (last) in terms of estimated personal utility for all respondents. Respondents choosing 33333 over immediate death were not given further choice tasks, but were asked if they could think of any health problems that were so bad that they would rather die now than live with those problems for 10 years, and if so, to describe those problems. Respondents choosing immediate death over 33333 proceeded to a second choice task in which 33333 was replaced by the health state ranked 122nd (half-way between 1st and 243rd) in terms of their personal utility function (based on their responses to sections C and D).

Five choice tasks were presented in total, with the health state presented either improved or worsened (in terms of estimated personal utility) depending on the respondent's choice in the preceding task. Expressions of indifference were not permitted. An iterative procedure involving a bisection approach (Lenert et al., 1998) was used to select the health state to be compared to immediate death.

2.2.7. Section G: Examination of interactions

Respondents were presented with two paired comparison tasks, each involving a choice between two improvements in health states. In each task, both improvements described a one-level improvement in a given dimension.

Task 1 involved a choice between: (A) an improvement in the respondent's most important dimension (as indicated in section B), with no problems in any other dimension either before or after the improvement; and (B) an improvement in the respondent's most important dimension (as indicated in section B), with moderate problems in the respondent's least important dimension and no problems in any other dimension either before or after the improvement.

Task 2 involved a choice between: (A) an improvement in the respondent's least important dimension (as indicated in section B), with no problems in any other dimension either before or after the improvement; and (B) an improvement in the respondent's least important dimension (as indicated in section B), with moderate problems in the respondent's most important dimension and no problems in any other dimension either before or after the improvement.

Ties (expressions of indifference) were permitted in both tasks.

2.2.8. Debrief and background questions

Finally respondents were asked a series of debrief questions, seeking feedback on the interview – in particular on aspects that respondents disliked or found difficult to understand; and background questions (gender, age and education).

2.3. Methods of analysis

Responses to each section were analysed using descriptive methods such as means, medians, standard deviations and frequency distributions. Correlation between the rankings in section B and the implied rankings in section C was calculated using Stata's pwcorr command. In sections D and F, preference types (identified *a priori*) were assigned to respondents based on their patterns of responses.

Two methods for dealing with tied ranking data were used. The first was to take an average (AVG) – for example, if the respondent ranked MO and SC as joint number 1 and UA as number 2, this method assigns MO and SC a rank of 1.5 and UA a rank of 3. The second is to skip the next ranking in the sequence, once for each tie (EQ) – this method assigns MO and SC a rank of 1 and UA a rank of 3.

To construct the PUFs, each respondent's personal weights over the dimensions and levels were established on a 0-1 scale. These were then anchored at dead = 0, using the responses to task E. Specifically, the mid-point between the two EQ-5D states where the respondent located 'dead' was used, and other values were rescaled accordingly. The social utility function (SUF) was then reported as the mean and median of the PUFs.

Analyses were conducted using Excel, Stata and R.

3. RESULTS

3.1. Sample

Seventy-six interviews were conducted in December 2015. The background characteristics of the sample are summarised in Table 1. Female respondents are overrepresented in the sample relative to the general population.

Table 1. Sample background characteristics

Characteristic	UK pilot sample	General population[a]
Age (years)		
- 18 to 29	14 (18.4%)	21%
- 30 to 44	28 (36.8%)	26%
- 45 to 59	14 (18.4%)	25%
- 60+	20 (26.3%)	28%
Gender		
- Female	49 (64.5%)	51%
- Male	27 (35.5%)	49%
Degree or equivalent qualification		
- Yes	19 (25.0%)	30%
- No	57 (75.0%)	70%
Self-reported EQ-5D health state		
- 11111	46 (60.5%)	
- Not 11111	30 (39.5%)	
Self-reported EQ-VAS		
- Mean	79	
- Median	85	

[a] Age and gender statistics taken from 2011 UK Census (Office for National Statistics, 2011). Degree statistics refer to residents in England and Wales aged 16 to 64 (Office for National Statistics, 2014).

Interviewers IND1, IND2, IND3 and IND4 each conducted 18, 17, 17 and 24 interviews respectively. The sample composition varied considerably across interviewers. For example, none of the respondents interviewed by IND4 had a degree, compared to 47% of the respondents interviewed by IND3.

The interviews durations ranged from 25 to 90 minutes. The mean (median) duration was 46 (45) minutes. The mean durations by interviewer ranged from 43 to 50 minutes.

3.2. Response data

3.2.1. Section A: Warm-up tasks

As shown in Table 1, 60.5% of the respondents self-reported being in EQ-5D health state 11111 (no problems on any dimension). When asked about the worst health problems they have ever experienced, all respondents reported an EQ-5D profile and EQ-VAS rating worse than those describing their current self-rated health. In total, 41 states were reported by the sample when asked to describe their worst experienced health problems, spanning the dimensions and levels of the descriptive system.

3.2.2. Section B: Dimension ranking task

Ranking data are available for 75 of the 76 respondents (98.7%) and summarised in Table 2. These data were missing from the Excel tool of one respondent. Eleven respondents (14.7%) included one or more ties in their rankings. The remainder (85.3%) gave a unique rank to each of the five dimensions. All statistics suggest that, overall, pain/discomfort and mobility are the highest rank dimensions and usual activities is the lowest ranked dimension.

Table 2. Summary of section B responses

	MO	SC	UA	PD	AD
Mean rank (AVG)	2.7	3.1	3.5	2.6	3.1
Mean rank (EQ)	2.6	3.0	3.5	2.6	3.0
No. times dimension was ranked top or joint top	22	11	8	26	18
No. times dimension was ranked bottom or joint bottom	10	14	24	11	18

3.2.3. Section C: Dimension rating task

Rating data are available for all 76 respondents (Table 3). Nine respondents (11.8%) failed to give any dimensions a rating of 100 (recall that respondents were instructed to give a rating of 100 to the dimension they considered most important or valuable, and had the option of rating more than one dimension at 100). Two of the four interviewers had this issue in their respondents' data. Fifteen respondents (19.7%) gave more than one dimension a rating of 100. Two of those respondents gave a rating of 100 to all five dimensions.

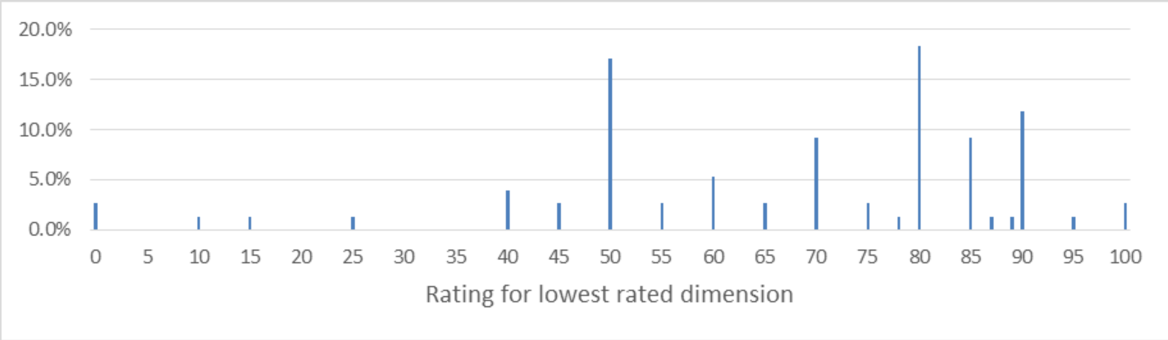
Table 3. Summary of section C responses

	MO	SC	UA	PD	AD
Mean rating	87.0	80.3	80.8	90.9	82.1
Median rating	91.0	86.5	85.0	95.0	85.0
SD rating	16.6	18.5	17.8	12.3	20.8
Implied mean rank (AVG)	2.6	3.4	3.5	2.3	3.2
Implied mean rank (EQ)	2.4	3.2	3.2	2.0	2.9
No. times dimension was given highest or joint highest rating	24	13	13	36	20

The mean and median ratings indicate that pain/discomfort and mobility are the most important dimensions. The implied rankings are similar to those provided in section B (Table 2). The correlation coefficient between mean rankings in section B and implied mean rankings in section C is 0.899 or 0.883, depending on which ranking method is used.

Most ratings given were multiples of 5, as demonstrated by Figure 3. The mean (median) lowest rating was 67.2 (72.5). Two respondents (2.6%) gave a rating of 0 to one of the dimensions (anxiety/depression, in both cases), which implies that this dimension is completely unimportant and does not contribute to their PUF.

Figure 3. Distribution of ratings given to lowest rated dimension in section C



3.2.4. Section D: Level weighting task

Rating data are available for all 76 respondents (Table 4). For four of the five dimensions, the median rating given to the intermediate improvement was 50. Seven respondents (9.2%) gave a rating of 50 to all five intermediate improvements. The most common approach by respondents was to give some improvements a rating of 50, some a rating of less than 50, and some a rating of greater than 50 (Table 5). A minority of respondents (10.5% in both cases) gave a rating of either 0 or 100 to at least one improvement, implying either that the improvement from level 3 to level 2 was completely unimportant (and therefore generates zero utility), or that the improvement from level 2 to level 1 is completely unimportant. Figure 4 shows the distribution of intermediate ratings, pooled across all dimensions.

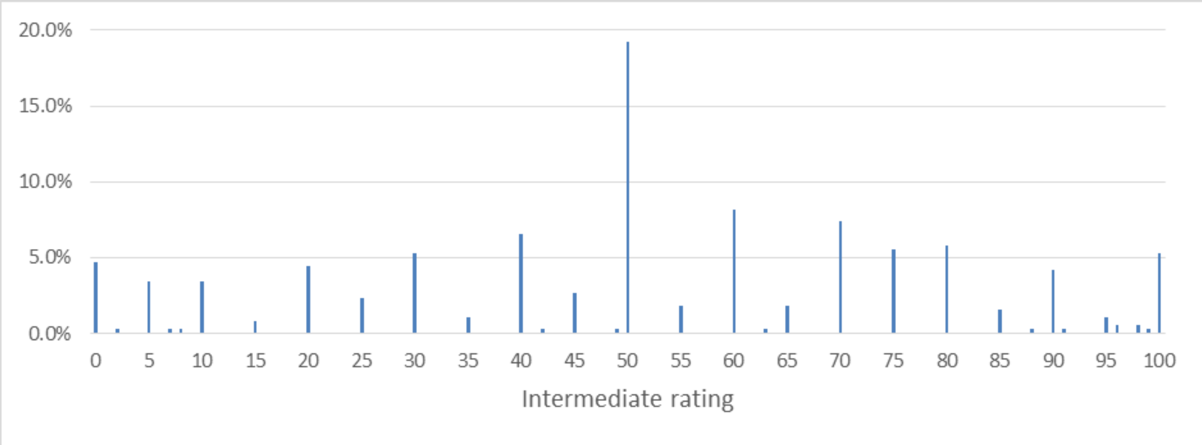
Table 4. Summary of section D responses

	MO	SC	UA	PD	AD
Mean rating	55.2	51.3	53.3	51.1	49.7
Median rating	55.0	50.0	50.0	50.0	50.0
SD rating	28.9	25.8	26.8	29.0	27.7
No. times improvement in this dimension was given highest or joint highest rating	37	31	30	27	28

Table 5. Proportion of respondents following different patterns of responses in section D

	Count	%
All intermediate levels given same rating	12	15.8%
All intermediate levels given different ratings	15	19.7%
Mix of same and different ratings	49	64.5%
All intermediate level rated at 50	7	9.2%
All intermediate levels rated <50	16	21.1%
All intermediate levels rated >50	17	22.4%
Mix of ratings <, > and =50	36	47.4%
At least one intermediate level rating at 0	8	10.5%
At least one intermediate level rating at 100	8	10.5%

Figure 4. Distribution of intermediate ratings in section D (for all dimensions)



3.2.4.1.Issue affecting data for subsequent sections

After the completion of sections A to D, interviewers were instructed to click a button in the Excel tool, designed to run a macro which prepared the tasks for sections E and F based on the respondent's responses to the earlier sections. If the button was not clicked, the tasks for section E and F were prepared, by default, on the assumption that the respondent had given a rating of 100 to all five dimensions in section C and a rating of 50 to all five intermediate improvements in section D.

Interviewer IND2 failed to click the button in any of their 17 interviews, so the section E and F tasks presented to these 17 respondents were prepared based on the default settings rather than being tailored to their earlier responses. The other interviewers followed the instructions as intended.

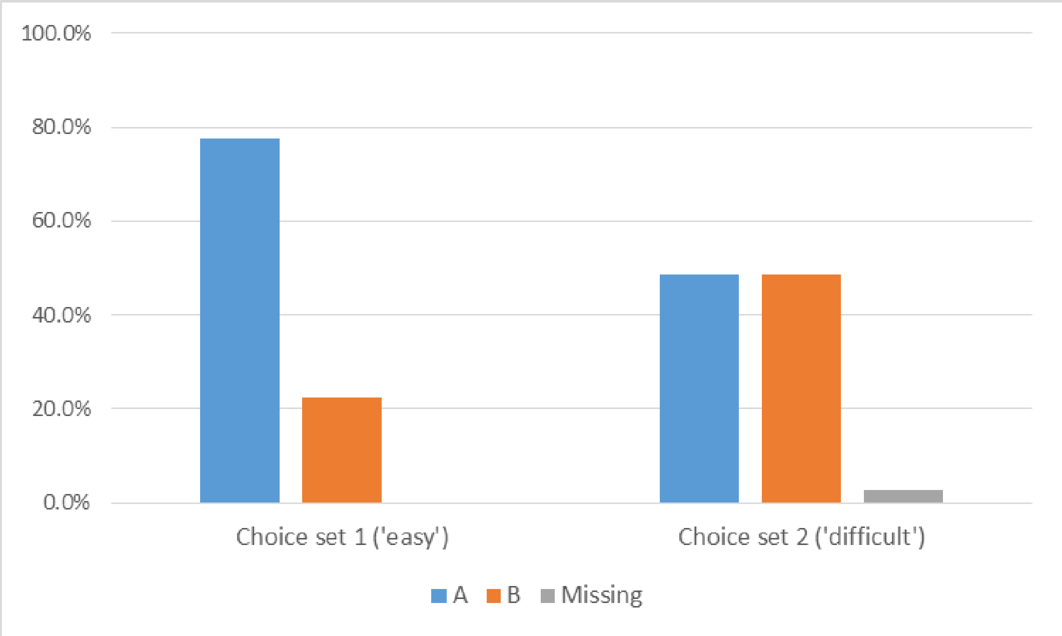
3.2.5.Section E: Paired comparison validation exercise

Complete choice data are available for 74 of the 76 respondents (97.3%). Data were missing from the Excel tools of two respondents.

In the first task, which was intended to be easier, respondents were more likely to choose A (the health state ranked higher in terms of expected personal utility) than B (the health state ranked lower in terms of expected personal utility). In the second task, which was intended to be more difficult, respondents were exactly evenly split between the two options, which were selected on the basis that they were closely ranked in terms of expected personal utility. The proportions of respondents choosing A or B in the two tasks is shown in Figure 5.

In the majority of task 1 pairs, A had a level sum score (sum of the five dimension levels; a proxy for severity) of at least three units smaller than B – hence A could crudely be considered less severe than B. In the majority of task 2 pairs, there was no difference between the level sum scores of A and B. This demonstrates that the selection of pairs from the Excel tool algorithm worked as intended.

Figure 5. Proportions of respondents choosing A or B in the two section E tasks



3.2.6. Section F: Search for personal location of dead

Complete choice data are available for all 76 respondents. Table 6 summarises the responses to the section F tasks, including the number of times respondents switched between option A (i.e. preferring 10 years in the health state presented) and option B (i.e. preferring dying now / immediate death).

Table 6. Summary of section F responses

Choices	Number of switches	Count	%
A	Never switch	18	23.7%
BBBBB	Never switch	2	2.6%
BAAAA	One switch	6	7.9%
BBAAA	One switch	3	3.9%
BBBAA	One switch	1	1.3%
BBBBA	One switch	1	1.3%
BAAAB	Two switches	10	13.2%
BAABB	Two switches	7	9.2%
BBBAB	Two switches	3	3.9%
BBABB	Two switches	3	3.9%
BBAAB	Two switches	4	5.3%
BABBB	Two switches	3	3.9%
BABAA	Three switches	6	7.9%
BABBA	Three switches	2	2.6%
BAABA	Three switches	4	5.3%
BBABA	Three switches	1	1.3%
BABAB	Four switches	2	2.6%

Eighteen respondents (23.7%) never chose B (immediate death). We can infer that for these respondents, dead lies below all of the health states defined by EQ-5D, including 33333. Two respondents (2.6%) never chose A (the health state for 10 years). We can infer that for these respondents, dead lies above the mildest health state presented to them (11113 and 12221, respectively) but we cannot determine an upper bound for the position of dead.

For the remainder of the respondents, it is possible to determine both an upper and lower bound for the position of dead within the descriptive system. For example, there were two respondents who switched choices in each of the five trade-offs (hence, their choices were 'BABAB'). For one of these respondents, we can infer that dead lies above 32212 but below 31313. For the other, we can infer than dead lies above 31231 but below 23213.

3.2.7. Section G: Examination of interactions

Complete choice data are available for 75 of the 76 respondents (98.7%). These data were missing from the Excel tool of one respondent.

The majority of respondents (72.4% in task 1; 75.0% in task 2) indicated that they thought that A was better than B (Table 7). This suggests that the value of an improvement in a given dimension depends on the levels of the other dimensions. If such 'interactions' were irrelevant, then we would expect more respondents to have expressed indifference between the two options. Rather, the majority of respondents indicated that a one-level improvement in a given dimension was better when no problems were present on any other dimensions than when moderate problems were present on one of the other dimensions.

Table 7. Summary of section G responses

	Task 1		Task 2	
	Count	**%**	**Count**	**%**
A	55	72.4%	57	75.0%
B	6	7.9%	9	11.8%
Indifferent	14	18.4%	9	11.8%
Missing	1	1.3%	1	1.3%

3.2.8. Respondent debrief questions

The majority of respondents provided neutral or positive comments when asked what they thought of the questions. Two respondents responded negatively, failing to understand the point of the exercises. One respondent expressed a preference for "straight question and answer" surveys in favour of those requiring detailed discussion. Another respondent said that they liked having the opportunity to discuss and elaborate their choices, but was not able to do so coherently for all of the questions.

The diagrams (used to feed respondents' responses to the tasks in sections C and D back to them) were generally well received, though a few respondents noted that they didn't see the point of them. One respondent suggested that the diagrams should contain more text, information or explanation about what they represent.

When asked to compare section E (which mimics a DCE, asking respondents to compare health states) with sections C and D (which ask about individual dimensions rather than complete health states), opinion was split about which type of task was easier. Twenty-eight respondents claimed that section E was easier than the previous sections (many of these respondents claimed that section D was the most difficult), preferring the simplicity of choosing between two options. Twenty-three respondents expressed the opposite view, making comments such as: "[the section E task was] harder as the health state is impossible to imagine"; "more difficult for me to imagine myself in this state"; and "hypothetical and unrealistic". Most of the respondents stated that the second question presented in section E was more difficult than the first (as was the authors' intention), though there were a very small number of exceptions.

A small number of respondents took issue with section F (which was based on a TTO or 'DCE with dead' task) because they disliked questions that asked them to consider choosing death.

Opinion was split with regard to section G (which attempted to examine interactions by comparing two improvements in health). Several respondents identified section G as being the most difficult section to understand, noting the need to re-read the choice information several times. Others said that it was difficult because the differences between the options were very small, and that they couldn't see what the difference was between them. On the other hand, some respondents described section G as being very easy to complete, with one commenting that it was so "blindingly obviously easy" that it seemed like a trick question.

A general theme amongst comments left by respondents was that sections E to G were difficult because there were so many aspects to think about simultaneously.

A few respondents commented that the use of physical cards in sections C and D made things difficult and overcomplicated, though a similar number of respondents claimed to have enjoyed the card-assisted tasks. One respondent suggested making greater use of symbols, colours and fonts to distinguish between information on the cards (e.g. different levels of severity).

Two respondents questioned the need for the 0 to 100 scale in section D, suggesting that the questions could be made simpler if this element was dropped. Another respondent claimed that they had initially interpreted the scale the "wrong way round" in this section. Three respondents said that they found the task of allocating 100 points between two improvements (also in section D) difficult.

The interviewers were instructed to encourage reflection and to discuss potential inconsistencies with respondents. One respondent acknowledged that the ranking they gave in section B differed from the ranking implied by their ratings in section C, noting that this was because section C referred to 'extreme' problems with the various dimensions whereas section B did not (this task used level-free descriptors).

Some respondents expressed impatience about the length of the survey (based on the early piloting work, we had specified in the information sheet that we expected interviews to last for around 45 minutes on average, which happened to be equal to the actual median interview duration), while others suggested reducing the amount of repetition within and across questions.

3.2.9. Interviewer debrief questions

Responses to the interviewer debrief questions are summarised in Table 8.

Table 8. Responses to the interviewer debrief questions

Interviewer debrief question	IND1	IND2	IND3	IND4	All
Q. How well do you think the respondent understood and carried out the tasks during the interview?					
- Understood and performed tasks easily	10 (55.6%)	11 (64.7%)	12 (70.6%)	22 (91.7%)	55 (72.4%)
- Some problems but seemed to understand the tasks in the end	7 (38.9%)	4 (23.5%)	5 (29.4%)	2 (8.3%)	18 (23.7%)
- Doubtful whether the respondent understood the tasks	1 (5.6%)	1 (5.9%)	0 (0.0%)	0 (0.0%)	2 (2.6%)
- Missing	0 (0.0%)	1 (5.9%)	0 (0.0%)	0 (0.0%)	1 (1.3%)
Q. In terms of effort and concentration, which one of the following statements best describes the way the respondent undertook the tasks?					
- Concentrated very hard and put a great deal of effort into it	9 (50.0%)	11 (64.7%)	7 (41.2%)	24 (100.0%)	51 (67.1%)
- Concentrated fairly hard and put some effort into it	6 (33.3%)	5 (29.4%)	10 (58.8%)	0 (0.0%)	21 (27.6%)
- Didn't concentrate very hard and put little effort into it	3 (16.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (3.9%)
- Concentrated at the beginning but lost interest/concentration before reaching the end	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
- Missing	0 (0.0%)	1 (5.9%)	0 (0.0%)	0 (0.0%)	1 (1.3%)
Total	18 (100.0%)	17 (100.0%)	17 (100.0%)	24 (100.0%)	76 (100.0%)

Feedback obtained from the interviewers was varied. IND1 and IND2 identified section D (level weighting task) as being the most difficult to explain to respondents. IND3 found section D difficult to begin with, but after a few interviews they claimed to have improved their ability to explain this task, and instead identified sections E and F (paired comparison validation exercise; search for location of dead) as being more difficult. IND4 reported that the vast majority of their respondents had understood and performed the tasks easily. When asked which sections caused respondents the most difficulties, IND4 noted that this varied from respondent to respondent, though section G (examination of interactions) was mentioned most often.

IND1 and IND4 were critical of the use of physical cards in sections C and D. Related to this, IND1 suggested that all of the tasks should be computer-based or paper-and-prop-based, but not a combination of both. On the other hand, IND3 expressed the view that the cards and booklets help the respondent to feel more involved in the process.

IND3 and IND4 noted that some respondents had struggled because they found some of health states presented in sections E and F to be 'contradictory'.[3] IND2 and IND4

[3] This problem is regularly reported in valuation studies using more traditional methods such as DCE, and is the very sort of issue that the PUF approach is attempting to overcome.

suggested using bolder colours in the cards and Excel tool in order to help respondents more easily distinguish between the different dimensions and improvements.

IND2, who admitted to finding several elements of the protocol challenging, and whose data contained problems/inconsistencies (see 3.2.4.1), suggested introducing a script to ensure uniformity in instructions and to refer to when respondents were showing signs of confusion.

On the whole, the interviewers (other than IND2) felt that the survey worked well, but that some respondents had struggled to get their heads around the concept of a 'health improvement' – a notion that is central to the current framing of the tasks in sections C, D and G.

3.3. Using PUF data to estimate a social utility function

In this section we show how the PUFs produced from our data can be used to generate an SUF (i.e. a value set). The PUF approach allows each individual's stated preferences regarding the EQ-5D dimensions and levels, and their preferences with respect to health states worse than dead, to be quantified as a PUF anchored at 1 (full health) and 0 (dead). Using these data, a SUF is thus the aggregate of these PUFs.

As noted in 3.2.4.1, one of the interviewers consistently failed to press the button in the Excel tool which would have generated tasks E and F tailored to the respondent's preferences generated in the previous tasks.[4] As the responses to the tasks in F were required to anchor each respondent's PUF to dead = 0, that interviewer's data were dropped for the purposes of generating a value set, leaving n=60 respondents.

First, responses to the tasks in sections C and D were used to generate the aggregated sample's weights (decrements) over the dimensions and levels of the EQ-5D, on a simple 0-1 scale – as shown in Table 9.

Table 9. Weights for EQ-5D dimensions and levels on a 0-1 scale

	Level	Min	1st quartile	Median	Mean	3rd quartile	Max	SD	SE
Mobility	2	0.0000	0.0774	0.1092	0.1133	0.1571	0.2857	0.0630	0.0115
	3	0.0364	0.1955	0.2066	0.2061	0.2236	0.2941	0.0375	0.0069
Self-care	2	0.0000	0.0716	0.0922	0.0954	0.1200	0.2105	0.0448	0.0082
	3	0.0714	0.1745	0.1967	0.1905	0.2081	0.3125	0.0391	0.0071
Usual activities	2	0.0000	0.0736	0.0997	0.1044	0.1397	0.2857	0.0544	0.0099
	3	0.0735	0.1818	0.1929	0.1942	0.2093	0.2857	0.0359	0.0066
Pain/discomfort	2	0.0000	0.0630	0.1105	0.1104	0.1468	0.3571	0.0653	0.0119
	3	0.1266	0.1998	0.2099	0.2188	0.2346	0.3636	0.0413	0.0075
Anxiety/depression	2	0.0000	0.0568	0.0970	0.0916	0.1169	0.2353	0.0518	0.0095
	3	0.0000	0.1800	0.1939	0.1904	0.2131	0.2941	0.0526	0.0096

[4] This was a limitation with the (relatively rudimentary) Excel tool we developed for this study. If the PUF approach was to be taken forward, it would be a simple matter to automate this step, so that it is not subject to interviewer oversight.

The mean/median level 3 decrements all sum to 1, and the decrement for a given dimension is given by calculating its relative importance, based on section C responses.[5] The level 2 decrements are based on section D responses.[6]

The weights were then anchored at dead = 0 using the responses to section F. Of the 60 respondents, 20 indicated that 33333 (and therefore all EQ-5D health states) was not worse than dead. The remaining 40 respondents identified the position of dead within the descriptive system. Section F effectively identifies, within the individual's utility space, the two EQ-5D states between which 'dead' is located. The mid-point between those two states was set at 0 and all other values were re-scaled accordingly.[7] No section F responses were excluded based on judgements about their plausibility.

One respondent indicated their value of dead lay between 12221 and 11111 (with a derived estimate for 33333 = -31). Table 10 below reports the PUF-based value set excluding this respondent, who was considered to constitute an outlier. No account was taken of the responses to the questions regarding possible interactions effects. The SUF derived is an average of the PUFs, and that average could be represented either by the median or mean of the PUFs (see Devlin et al., 2017a). Table 10 presents the SUFs for both (and, for completeness, the corresponding minimum, maximum, 1st quartile, 3rd quartile, standard deviation and standard error).

Table 10. Social utility function (i.e. value set)

	Level	Min	1st quartile	Median	Mean	3rd quartile	Max	SD	SE
Mobility	2	0.0000	0.1238	0.1664	0.1793	0.2341	0.4706	0.1058	0.0137
	3	0.0660	0.2253	0.3025	0.3440	0.3950	0.8444	0.1639	0.0212
Self-care	2	0.0000	0.0948	0.1560	0.1600	0.2025	0.4540	0.0931	0.0120
	3	0.0714	0.2232	0.2794	0.3146	0.3391	0.7111	0.1431	0.0185
Usual activities	2	0.0000	0.1083	0.1456	0.1699	0.2251	0.4191	0.0979	0.0126
	3	0.0735	0.2203	0.2941	0.3198	0.3575	0.8000	0.1418	0.0183
Pain/discomfort	2	0.0000	0.1032	0.1600	0.1801	0.2351	0.4959	0.1197	0.0154
	3	0.1618	0.2345	0.3237	0.3653	0.4338	0.8889	0.1709	0.0221
Anxiety/ depression	2	0.0000	0.0832	0.1426	0.1536	0.2145	0.3944	0.1040	0.0134
	3	0.0000	0.2091	0.2874	0.3234	0.4151	0.7556	0.1697	0.0219

Note that the values in Table 9 and Table 10 do not follow exactly from those in Table 3 and Table 4. This is because Table 3 and Table 4 were based on the full sample of 76 respondents, whereas Table 9 and Table 10 were based on 60 respondents (see 3.2.4.1).

[5] For example, if mobility had a mean rating that was 25% of the sum of all five mean ratings, then MO level 3 would be given a mean decrement of 0.25 in Table 9.
[6] For example, if the mean level 2 rating for mobility were 50, and the mobility level 3 decrement was 0.25, then the mobility level 2 decrement would be 0.25 * 0.5 = 0.125.
[7] For example, if a respondent's location of dead was found to lie between two health states which had 0-1 scale values of 0.45 and 0.55, then we would infer that their approximate location of dead is at 0.5. Since dead needs to be 0, all the decrements would be re-scaled accordingly. If the simple example of dead being re-scaled from 0.5 to 0, all of the decrements would double in size. Once this has been done for each respondent, Table 10 can be produced in a similar manner to Table 9.

The minimum value in this SUF value set (calculated as 1 minus the utility decrement for level 3 on each dimension) is -0.667. This compares to the minimum value of -0.594 for the EQ-5D-3L value set for the UK (Dolan, 1997; often referred to as the MVH value set), and -0.285 for the EQ-5D-5L value set for England (Devlin et al 2017b). The highest value (other than for 11111) is for state 11112, of 0.85, which is identical to the value of that state in the MVH value set. The variation in level 2 and 3 decrements across dimensions is small in the SUF value set (mean level 2 decrements range from 0.1536 to 0.1801; mean level 3 decrements range from 0.3146 to 0.3653) relative to the corresponding variations in the other value sets. The most important dimension in the SUF value set is pain/discomfort, in common with both the MVH value set and the EQ-5D-5L value set for England; followed by mobility and anxiety/depression, in common with the MVH value set. The ordering of the remaining two dimensions, self-care and usual activities, is the reverse of that in the MVH value set. Caution needs to be drawn about the implications of these differences for conclusions about the PUF approach, since our sample was small and this was intended only to be a pilot study.

4. DISCUSSION AND CONCLUSIONS

The PUF approach was feasible to implement, and could readily be used to generate a SUF (value set) which, even from the small sample included in this study, showed plausible characteristics. The process of deliberation and reflection appeared to work without major problems arising (according to the feedback received from respondents and interviewers), although there was evidence of interviewer effects – in part caused by the rudimentary computer-assisted tools we developed ourselves to implement the questions. Ensuring consistency across interviewers (and across studies) will be important with this method, as it is with all other stated preference approaches. Interviewer experience and training will be critical for this. The PUF approach does not eliminate (and indeed probably increases) the need for experienced, thoughtful interviewers, or for the need for quality control during data collection. However the approach, by its nature, does eliminate all logical inconsistencies from the data and therefore eliminates the disordered coefficients sometimes observed in value sets based on conventional approaches (Devlin et al., 2003; Lamers et al., 2006; Cole et al., 2017).

The general PUF approach (in particular, the focus on deliberation) may have potential as a complement to (rather than a substitute for) existing approaches. It may have particular value where existing approaches to valuing PROs (e.g. as currently implemented for the EQ-5D-5L – see Oppe et al., 2014) are too complicated or technology-dependent for certain populations. The PUF approach could also have applications in seeking patients' preferences without the need to differentiate between the state they are experiencing now, and other states which are hypothetical to them, and may seem 'unrealistic'.

In developing the study protocol, we explored a number of different approaches for the weighting tasks – ranking, numeric direct rating, VAS-type valuation, allocation of points, swing-weighting – with mixed results. Some of these approaches can be described as 'choice-based' while others did not involve trade-offs. Still other approaches are possible, and could be improvements on the specific tasks included in our pilot study. While we opted for swing-weighting for the dimension rating exercise, and allocation of points for the level weighting exercise, we don't consider there to be any need to be 'purist' about this: if we accept that we are helping people to construct their preferences – and acknowledge that specific methods will influence what we elicit – this may be an argument for multiple methods, constantly feeding back the results to respondents to aid their deliberation. Further research could explore whether conceptually different methods (such as those used in this study) can be combined in a coherent way, or if greater consistency in approach across tasks is desirable.

There are a number of remaining limitations to the approach reported in this paper. First, we are attempting to validate the results of our approach by using the very sorts of 'state-based' tasks that we claim to be problematic (e.g. DCE-style pairwise choice tasks). Second, anchoring the PUF at dead still requires us to invoke a specific duration for health problems under consideration. In the study reported here, we based this on a duration of 10 years, in order to facilitate comparisons with existing value set protocols. Obviously, any duration could be used. But there is no way around the need to stipulate the duration, since whether any given combination of problems is better or worse than dead may depend on its duration (Attema and Brouwer, 2010). Third, the approach for obtaining information about interactions effects can be improved (as noted in 3.2.8 and 3.2.9, these questions regarding interactions were considered difficult to understand by a number of respondents) and incorporated at an earlier stage in the process, and any data on interaction effects could be taken into account in producing a SUF value set. Fourth, the Excel-based tool we developed for the study could be improved considerably in functionality and presentation. Fifth, the interview is relatively long at 45 minutes per interview. While we obtain a lot of information per respondent, this may suggest a case for offering larger incentives and for being clear with respondents about the time commitment involved. Finally, constructing a SUF value set based on the aggregation on individual PUFs encounters some of the same conceptual challenges as the construction of social welfare functions in welfare economics: our approach here is to treat PUFs as strictly interpersonally comparable – an assumption which is of course implicit in all other stated preference methods. Further, the SUF-value set relies on averaging PUFs and there are a variety of ways of characterising what we mean by 'average' preferences (Devlin et al., 2017a) – the choice between which is normative.

Where next for research on the PUF approach? One direction may be to develop a more sophisticated computer-based tool with minimal need for paperwork. However, if the goal is to improve respondent engagement and to yield more considered, meaningful data, we would urge caution in the use of technology. It has been suggested that interaction elements and physical props can improve respondent engagement and understanding (Lo, 2017). There is considerable scope for improving the methods used in our study, and for methodological experiments comprising direct head-to-head testing of alternative approaches. There is also scope for more sophisticated analysis of the data – e.g. in identifying and recognising preference 'types' in the PUFs, and reflecting those in the SUF. In the pilot study reported here, we used the PUF approach to value a simplified 3-level version of the EQ-5D-5L. The feasibility of using PUF methods to obtain values for the full EQ-5D-5L, and other more complex PRO instruments, remains to be tested.

Further research could also investigate whether the characteristics of the data observed are an artefact of the specific methods used. For example, would alternative operationalisations of the dimension rating and level rating tasks in sections C and D lead to greater variation in level 2 and level 3 decrements in the SUF?

In addition to the potential usefulness of the overall approach, specific elements of the methods developed in this study could find applications alongside existing methods. As noted earlier, the deliberative focus of the tasks might be a useful complement to conventional state-based valuation methods. The range of states reported by respondents as their worst experienced in itself suggests the possibility of asking respondents to recall and value these states as part of 'experience-based' valuation approaches. The novel approach to valuing states worse than dead which we developed for this study could also find applications elsewhere, e.g. in anchoring DCE data, and may be worth exploring and further developing in its own right.

In conclusion, the use of a deliberative approach to collecting stated preference data has, we believe, some merit in generating more meaningful responses from respondents and therefore reinforcing the validity and reasonableness of quality of life weights used in estimating quality-adjusted life years. This study's contribution has been to show that such an approach appears to be feasible to use. It has the potential for use both as a standalone approach to eliciting PUFs and constructing value sets from those data, or as a complement to existing methods.

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