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Using the Analytic Hierarchy Process to Derive Health State Utilities from Ordinal Preference Data

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ABSTRACT

Background: The EuroQol five-dimensional questionnaire is a standardized instrument used in the economic evaluation of health care to measure health state preferences across disease groups. A time trade-off (TTO) approach is commonly used to elicit preferences from the public. However, there are issues regarding how best to measure worse-than-dead states; at present, extreme valuations are rounded up to more acceptable values. TTO elicitation is also cognitively demanding for respondents and is therefore expensive to investigate. **Objectives:** To describe how the analytic hierarchy process approach could be used to generate utilities from the ordinal relationships between the health states instead of the ordinal relationships between health states, allowing potentially useful preference data to be incorporated rather than excluded as they are at present. It was applied to the Measurement and Valuation of Health study data set, measuring health state preferences for the United Kingdom. **Methods:** The analytic hierarchy process approach was explained. Five

approaches to structure pairwise comparisons of health state preference were described (two concave, two convex, and one linear). **Results:** All approaches described predicted the rankings of health states well. However, utilities derived followed an unconventional, bunched shape compared with the original Measurement and Valuation of Health TTO study. An approach was identified by optimizing the parameters, minimizing the sum of squared errors between the ordinal “health state ranking” approach and the original TTO-derived utilities. **Conclusions:** This approach outlined offers the potential to convert ordinal preference data into cardinal utilities. It is simpler than TTO studies to carry out and removes the need to directly alter results of the preference ranking exercise. **Keywords:** analytic hierarchy process, EQ-5D, health state valuation, utilities.

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Background

Over recent decades, economic evaluation of health care issues has become increasingly important in structuring and informing subsequent decisions. Given a limited available budget, the provision of a new drug or other intervention is assumed to carry an opportunity cost, displacing “health” somewhere else in the system. This must be compared against the benefits arising from its provision. There are a number of approaches for doing so, but cost-utility analysis is favored by Ireland’s National Centre for Pharmacoeconomics [1], UK’s National Institute for Health and Care Excellence [2], and elsewhere. Utility can be defined in a number of ways, but it is commonly measured for these purposes in incremental “quality-adjusted life-years,” a combination of cumulative improvements in length of life and health-related quality of life likely to be achieved by the population if the service is provided.

One approach for measuring health-related quality of life is the three-level EuroQol five-dimensional questionnaire, as developed by EuroQol [3]. The technique measures five dimensions of health (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) on three levels (no problems, moderate problems, and severe problems), thus representing 243 (3⁵) potential health states (HSs); unconsciousness and death are also included. By convention, full health is represented by a utility of 1 and dead is represented by a utility of 0. Some HSs may be considered worse than dead (WTD), and are given a negative utility.

This article explores how the analytic hierarchy process (AHP), as described by Saaty [4], might offer an appropriate framework to allow participants to assign utilities to HSs using ordinal valuation methods. AHP has been used in various health care settings [5]. The approach is tested using the data generated by the Measurement and Valuation of Health (MVH) study carried out in the United Kingdom in 1993 [6].

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The MVH study surveyed about 3000 members of the general public randomly selected as participants [6]. Forty-five HSs (including full health, unconsciousness, and death) were investigated, with 13 of these scored by each participant, ranging from “very mild” to “severe problems.” HSs under consideration were first placed in order from best (1st) to worst (13th) by participants (referred to henceforth as *health state ranking* [HSR]), followed by cardinal ratings using the visual analogue scale (VAS) and time trade-off (TTO) approaches. Participants carried out VAS scoring directly after the HSR, and the approach required participants to give each HS a score from 0 (worst imaginable HS) to 100 (best imaginable HS).

The TTO approach asked patients to choose between living for 10 years in a given HS, or fewer years in full health. Utilities could be derived from their choices, and subsequently published on the basis of results of this method. For states considered WTD, various approaches have been used, but the MVH survey asked participants how many years of subsequent good health would be necessary to balance time in a given HS.

The TTO approach used in the MVH study allowed participants to value WTD HSs with utilities theoretically as low as -39 (where 3 months of poor health would be balanced only by 9 years and 9 months of subsequent full health). The authors of the original study considered that such results were unrealistic and artifactual. Utilities assigned for HSs were therefore bound between +1 and -1 before the mean utility for each mean HS was calculated. This method therefore requires some information (<-1) to be discarded, relies on the fallible and potentially arbitrary judgment of researchers, and inevitably removes potentially useful preference information. This approach has been acknowledged as imperfect, and other techniques have been tested [7] though none has been universally accepted as having solved the underlying issue. The AHP approach outlined in this article does not discard the information in this way and instead ultimately converts all information into scores, which might be considered analogous to utilities. We propose a simple method to derive utilities from these.

This article offers a preliminary analysis testing possible new approaches to examine population’s HS preferences. The AHP approach outlined is derived explicitly from decision theory. It structured the process of transforming ordinal preference information into potentially meaningful utilities. The potential to derive utilities from ordinal data is what distinguishes this approach from similar approaches previously carried out investigating pairwise comparisons of the data, including an approach outlined in the original MVH report [8].

Theoretically, such an approach could allow participants to simply rank HSs in terms of preference and, given sufficient numbers of participants, conclusions could be drawn regarding the relative performance of each in terms of utilities. Estimates of the utility of HSs not ordered directly might be possible using the standard econometric approaches.

There are other relevant reasons to investigate the AHP approach. The original MVH study applied Thurstone’s [9] Law of Comparative Judgment to investigate the strength of pairwise comparisons, which bears a clear resemblance to AHP [10]. AHP is one of a variety of multiple criteria decision analysis techniques available designed to help structure complex problems. It also seems timely, in a climate in which such techniques are increasingly being advocated for use in national health services [11], to investigate whether AHP might be useful in drawing meaningful conclusions from the data in determining HS preferences.

The aim of this study was therefore to investigate whether an approach based on AHP can be used to calculate meaningful utilities on the basis of analysis of pairwise comparisons of the ordinal preference data in a national EuroQol five-dimensional questionnaire survey.

Methods

AHP allows decision makers to build up a numerical score, based on their preferences derived from pairwise comparisons. When comparing how well each alternative under consideration has performed, these are reflected in an ordinal scale, derived by Saaty [4], which reflects the magnitude of how well each has done in qualitative, easy-to-understand statements, which are converted to a 1 to 9 numerical scale, as presented in Table 1. Over time, all such pairwise comparisons can be carried out and subsequently analyzed, and scores for each derived.

In this study, a similar protocol that compared the preferences of the general public, two HSs at a time, was followed. Doing this for every possible pair of HSs allowed scores for each to be generated. Utilities could subsequently be derived.

This scale has been used elsewhere as part of AHP analyses to allow qualitative descriptions of criteria derived from Delphi-style processes to be translated into a numerical scale, and subsequently analyzed [4,12,13]. In such cases, the importance of criteria and the subsequent performance of alternative courses of action on these criteria can be assessed. These can ultimately be combined to give each alternative course of action a unique overall score. AHP is therefore normally considered a multistage process, but for this study, only one such stage is required, comparing the proportion of participants who preferred each HS. The AHP approach is used as a framework by which to combine the matrix of ordinal relationships into normalized scores, indicating the relative performance of each HS.

In the MVH study, each participant ranked 13 semi-randomly selected HSs using the three previously described approaches. These states were considered simultaneously for HSR, and one at a time for both VAS and TTO. These can be considered as pairwise comparisons by examining how often one HS is preferred over another.

For any two states, the number of times they were compared by the same participant was measured, and subsequently on what proportion of occasions each HS was “preferred” ordinally. For HSR, this meant whichever HS was ranked higher by the

Table 1 – Scale derived by Saaty [4], used to convert pairwise qualitative relationships into a cardinal scale.

Intensity of weight	Definition
1	Equal importance
3	Weak moderate importance of one over another
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values between two adjacent scales
Reciprocals of above nonzero number	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

Note. The analytic hierarchy process uses a Likert-type scale following the template explained above. A number between 1 and 9 represents the more important/preferred of the pair, and the less preferred is given the reciprocal of this number. Comparisons of the public’s preferences between health states were converted into this scale to generate scores for each health state, and subsequently to calculate utilities.

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