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Does Selecting Covariates Using Factor Analysis in Mapping Algorithms Improve Predictive Accuracy? A Case of Predicting EQ-5D-5L and SF-6D Utilities from the Women's Health Questionnaire

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ABSTRACT

Background: In addition to theoretical justifications, many statistical methods have been used for selecting covariates to include in algorithms mapping nonutility measures onto utilities. However, it is not clear whether using exploratory factor analysis (EFA) as one such method improves the predictive ability of these algorithms. **Objective:** This question is addressed within the context of mapping a non–utility-based outcome, the core 23-item Women's Health Questionnaire (WHQ-23), onto two utility instruments: five-level EuroQol five-dimensional questionnaire (EQ-5D-5L) and the six-dimensional health state short form (derived from short form 36 health survey) (SF-6D). **Methods:** Data on all three outcomes were collected from 455 women from the Australian general population participating in a study assessing attitudes toward in vitro fertilization. Statistical methods for selecting covariates included stepwise regression (SW), including all covariates (Include all), multivariable fractional polynomial (MFP), and EFA. The predictive accuracy of 108 regression models was assessed using five criteria: mean absolute error, root mean squared error, correlation, distribution of predicted utilities, and proportion of predictions with absolute errors of less than 0.0.5. Validation of "primary" models was carried out on random samples of the in vitro fertilization study. **Results:** The best results for EQ-5D-5L and SF-6D predictions were obtained from models using SW, "Include all," and MFP covariate-selection approaches. Root mean squared error (0.0762–0.1434) and mean absolute error (0.0590–0.0924) estimates for these models were within the range of published estimates. EFA was outperformed by other covariate-selection methods. **Conclusions:** It is possible to predict valid utilities from the WHQ-23 using regression methods based on SW, "Include all," and MFP covariate-selection techniques.

Keywords: EQ-5D-5L, factor analysis, mapping, SF-6D, utilities, WHQ-23.

Introduction

Assessing health-related quality of life (QOL) in the general population and for those with chronic or life-threatening conditions has been increasingly recognized as providing an important marker of health outcome and for informing patient management and policy decisions [1]. QOL can be measured using both utility and non–utility-based generic and population-specific tools. Two methods of obtaining utilities for health states include responses to utility-based tools (multi-attribute utility instruments [MAUIs]) administered directly to respondents, or from mapping algorithms predicting the utilities from nonutility tools. A number of MAUIs are available in the literature [2,3]. An attraction of using utility scores, anchored on a 0 to 1 (death to full health) scale, is that they can be converted to quality-adjusted life-years (QALYs), which allow for cross-study comparability [1,4]. QALYs feed into cost-utility analysis (CUA), a type of economic evaluation recommended for establishing value for money of services by many decision bodies including UK's National Institute for Health and Care Excellence and the Australian Pharmaceutical Benefits Advisory Committee and Medical Services Advisory Committee [5–7]. However, MAUIs are often perceived as being less sensitive to particular conditions than nonutility population-specific QOL measures [8].

One such population-specific non–utility-based QOL measure increasingly being used to measure women's emotional and physical health is the core 23-item Women's Health Questionnaire (WHQ-23) [9]. The WHQ-23 is derived from the 37-item Women's Health Questionnaire originally designed to study possible changes in health and well-being during menopausal

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transition in mid-aged women [10,11]. The WHQ-23 has been shown to have better psychometric properties compared with the 37-item Women's Health Questionnaire [9] and is likely to be associated with a lower respondent burden because it consists of fewer questions. Use of the WHQ-23 within economic evaluation is however limited because it does not have utility weights that can be used to estimate QALYs as needed for CUA.

This limitation may be overcome by developing an algorithm that predicts utility scores from the WHQ-23. Of the several methodologies developed for mapping non–utility-based measures onto utility scores, regression analysis is the most common due to its simplicity and efficiency in terms of data needs but it requires careful selection of covariates for inclusion in the mapping algorithms [12]. In conjunction with theoretical considerations, many statistical approaches have been used in this selection process. Despite the growth in regression mapping studies in recent years, however, it is not clear whether using one such approach, exploratory factor analysis (EFA) [13], improves the predictive ability of mapping algorithms compared with other approaches. Our study addresses this question by examining the possibility of developing reliable regression-based mapping functions that use WHQ-23 and participant demographic characteristics to predict utility values for two of the most commonly used MAUIs to facilitate future CUA in cases in which only the WHQ-23 was available. The two MAUIs considered were the five-level EuroQol five-dimensional questionnaire (EQ-5D-5L) [14] and the six-dimensional health state short form (derived from short form 36 health survey) (SF-6D) [15].

Methods

The target instruments for mapping were the EQ-5D-5L and the SF-6D while the source instrument was the WHQ-23. Our analysis followed the newly developed Mapping to Estimate Health-State Utility from Non-Preference-Based Outcome Measures' International Society for Pharmacoeconomics and Outcomes Research guidelines [16] as well as the "Mapping onto Preference-based measures reporting Standards" checklist [17].

Instruments

WHQ-23

This instrument measures women-specific QOL using 23 items, each with four levels of impairment (1 = no impairment to 4 = worst impairment), which can be summarized into six dimensions: anxiety/depressed mood, well-being, somatic symptoms, memory/concentration, vasomotor symptoms, and sleep problems [9]. Optional modules evaluate two extra dimensions, namely, menstrual symptoms and sexual behavior. Results are reported as average untransformed and reversed raw scores for each of the six dimensions ranging from 1 to 4, where 4 is an indicator of "good health status" and 1 is an indicator of "poor health status" [9,18]. Transformed and reversed scores for each dimension can also be calculated and these range from 0 (poor health status) to 100 (good health status) [9,18]. It is however not possible to calculate a summary score across all six dimensions. The core version (without optional modules) and raw untransformed scores of the WHQ-23 were used in this study. The WHQ-23 has been used in multiple patient populations [19–22] and has proven validity when used on groups of women with different clinical symptom severity levels [9].

EQ-5D-5L

This is a generic five-dimensional MAUI designed to measure health-related QOL for individuals 18 years and older. The EQ-5D-5L measures the following dimensions of health: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression [23] It was derived from the original three-level EuroQol five-dimensional questionnaire to include five rather than three levels of impairment in each domain: no, slight, moderate, severe, and extreme problems in the relevant dimension of health [14]. A total of 3125 EQ-5D-5L health states can be distinguished using responses relating to these levels of impairment. The EQ-5D-5L health descriptions were converted into valuations ranging from −0.59 to 1 using a UK-specific crosswalk value set [24] in line with recent National Institute for Health and Care Excellence guidance [25]. Scores equal to 1 represent "full health" states, whereas those less than 0 represent health states that are worse than death [26]. The EQ-5D-5L has been validated in diverse clinical populations [27–29].

SF-6D

The SF-6D version used in this study was derived from the 12-Item Short Form Health Survey, a 12-item generic health-related QOL instrument designed to measure general health concepts across different ages, diseases, and treatment groups [30]. The SF-6D measures the following six dimensions whose number of levels varies from four to six: vitality, physical functioning, pain, role functioning, social functioning, and mental health [31]. UK valuations, based on the standard gamble approach, can be derived from 7 of the 12 items in the 12-Item Short Form Health Survey and range from 0.3 to 1 [15]. The validity of the SF-6D has been demonstrated in differentiated populations with variable clinical conditions [32–35].

Figure 1 depicts the conceptual overlap between these instruments obtained by comparing the dimensions of the WHQ-23 and those of the two MAUIs. This comparison was informed by a review of description of these dimensions by the developers of the instruments and subsequent discussion among the authors.

Data

Data for 455 Australian women of child-bearing age (18–45 years) were obtained from a study that used discrete-choice experiment methodology to determine women's preferences in relation to the use of acupuncture treatment for enhancing outcomes of women undergoing infertility treatment. Participants from the Australian general population were recruited by "PureProfile," an Australian online panel company that specializes in conducting online polls and surveys with members of the general community. A discrete-choice experiment survey, administered via the PureProfile online portal in August 2016, included questions on the WHQ-23, EQ-5D-5L, SF-6D, and participant demographic characteristics. Informed consent was obtained from all participants before their inclusion in the study. The Flinders University Social and Behavioural Research Ethics Committee granted ethical approval for the study.

Statistical Analysis

STATA version 14.1 [36] was used for all analyses conducted in two steps. The first step was an assessment of the correlation between the WHQ-23 item/dimension scores and the MAUI dimension/utility scores using Spearman rank correlation coefficients.

The second step was the estimation of the primary regression models followed by their validation. Potential covariates for these models were identified on theoretical grounds. Because all WHQ-23 items and dimensions broadly measure QOL constructs [9] (just like the EQ-5D-5L [14] and the SF-6D [31]), they were all deemed to be potential covariates. As recommended in the literature [16], other respondent characteristics (including age) were included so as to avoid model misspecification and to