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6 September 2013

The University Of Sheffield.

School Of Health And Related Research.

Health Economics and Decision Science (HEDS)

Discussion Paper

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DP 13.12

HEDS Discussion Paper

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Happy and Healthy: A Joint Model of Health and Life Satisfaction

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Abstract

Subjective well-being has been proposed as an alternative to preference based values of health benefit for use in economic evaluation. We develop a latent factor model of health and well-being in order to compare reported satisfaction with life, satisfaction with health and SF-6D responses. This approach provides a coherent, integrated statistical framework for assessing differences between these outcomes on the same scale. Using panel data from the British Household Panel Survey we find that SF-6D and satisfaction with health are influenced to a similar degree by changes in latent health and satisfaction with life is less responsive. For the average individual, there are no substantial differences in the relative impacts of physical versus mental health conditions between the three measures. These findings suggest that the differences between experienced and hypothetical values of health and life satisfaction may not lead to substantial differences in the assessment of value from health technologies.

Keywords: satisfaction with life, SF-6D, preferences, quality-adjusted life years
JEL: I10, I31

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September 6, 2013

1. Introduction

Economic evaluation of health technologies is often conducted using quality adjusted life years (QALYs) as the measure of benefit. The calculation of a QALY involves applying a utility weighting to the period of time that patients experience in a given health state. The most widespread approach for estimating health benefits is through the use of generic preference-based measures (PBMs), such as the EQ-5D and SF-6D. These approaches involve the description of health states via a simple classification system coupled with valuations of those health states derived from the general population that will usually not have experienced those states. This allows health to be described in consistent, standard terms across disease areas and for those health descriptions to then be valued according to the preferences of the general population.

In recent years, interest in the concept of subjective well-being (SWB) or happiness as an outcome measure has gained significant ground in a range of policy areas, underpinned by a general recognition that standard measures of economic good such as GDP may not provide a complete picture of performance. For example, the OECD recently published international guidelines on how to collect, publish and analyse SWB data (OECD, 2013) in support of their prioritisation of SWB as a key component for the assessment of societal progress across 11 different areas, including health. In the UK, there has been government support and investment in the collection of SWB data with the production of a national, well-being index published first in 2012 (Self et al., 2012).

In addition to the use of SWB as a supplementary outcome measure for comparing across countries and time, it has also been advocated that SWB, rather than health preferences, be used to value health states for use in economic evaluation (Gandjour, 2001; Dolan, 2008, 2011b, 2013). This is on the basis that SWB overcomes several potential difficulties associated with using decision utility to value hypothetical health states (Dolan and Kahneman, 2007; Dolan, 2011a). Generic preference based approaches entail the elicitation of preferences only for those dimensions of health that are referred to explicitly within the descriptive system. They encourage a focus on those dimensions of health and provide preferences for health states as imagined by the individual rather than for states they have actually experienced.

Several studies suggest there may be substantial differences between the valuations of health, and changes in health, according to whether those valuations are estimated using SWB or a preference-based approach. Furthermore, existing studies conclude that the use of SWB in place of current preference elicitation methods would result in a greater weight being placed on mental aspects of health and a lower weight on physical aspects of health. This has been shown using the SF-6D (Dolan et al., 2012; Mukuria and Brazier, 2013) and the EQ-5D (Dolan and Metcalfe, 2012; Graham et al., 2011). Dimensions such as pain may be less valuable (though the opposite is found by Graham et al. (2011)) and aspects of health such as vitality and social functioning may be of greater value.

However, there are a number of factors that make comparisons between SWB and generic PBMs complex.

First, preference-based measures are jointly determined with measures of wellbeing and satisfaction. That is, health is determined partly by wellbeing and vice versa. This simultaneity gives rise to endogeneity and violates the assumptions of standard single equation models.

Second, measures of health such as the EQ-5D and SF-6D are potentially subject to measurement error arising from several sources. Utility values assigned to health state descriptors are estimated parameters, and so have associated error that ought not be ignored. When describing health states using generic classification systems, individuals do not always report the same health state in test-retest situations, resulting in an additional source of measurement error. These issues are of fundamental importance because both endogeneity and measurement error lead to biased coefficient estimates in models where PBMs are used as explanatory variables.

Third, whilst preferences elicited through methods such a the time trade-off or standard gamble represent a cardinal scale anchored on full health and death, SWB has no such anchor and is ordinal only. In order to estimate well-being weights, authors have previously had to ignore the true nature of the data; assuming that the levels have interval properties and can be considered to be on a 0 to 1 scale, arbitrarily assigning values to labels (Mukuria and Brazier, 2013; Cubí-Mollá et al., 2013; Dolan, 2011b; Dolan and Metcalfe, 2012; Dolan et al., 2012). This has been applied to questions that ask about present well-being on a 7- or 10-point scale (e.g. from 'completely dissatisfied' to 'completely satisfied') (Dolan et al., 2012), as well as questions that ask about frequency (e.g. "How often have you been happy over the past 4 weeks", with responses from "none of the time" to "all of the time") (Mukuria and Brazier, 2013). Whilst such an assumption may not be detrimental where one wishes to draw conclusions based on the qualitative findings of the analysis (Ferrer-i Carbonell and Frijters, 2004), it is not supportable where conclusions are based on the magnitude of estimated coefficients as is the case here. Assuming cardinality and using a linear model imposes the restriction that the predicted effect of a change in health is the same for all individuals, while in models that only assume ordinality the predicted effect depends on the individual characteristics, with effects of the same change in health being different for different individuals. This is a fundamental difference between linear and nonlinear models and emphasizes that the size of the coefficients between linear and nonlinear models are not comparable as they have fundamentally different meanings.

Fourth, the dimensions of health reflected in various generic preference based measures are correlated with each other, and with other dimensions of health not explicitly referred to in their descriptive systems. When calculating the marginal effects of an SF-6D dimension in standard SWB regression models, all other covariates, including the other SF-6D dimensions, are assumed to remain unchanged. This is unrealistic. For example, one would not expect an individual who is suddenly confined to bed to have no change in the self-care or usual activities dimensions. Because the dimensions of the PBMs are assumed exogenous, there is no way of addressing this correlation in the model predictions properly.

All these issues are of fundamental importance because they lead to biases in the estimated coefficients and predictions. Therefore, the ability to make meaningful comparisons of the magnitude of the impact of factors on SWB versus preferences is compromised. This paper develops a framework which overcomes these limitations. A joint, latent factor model of health and well-being is used to provide an integrated statistical framework for the simultaneous assessment of differences between health and well-being on the same scale. The model deals appropriately with the problems of endogeneity and measurement error of health and it does not require arbitrary assumptions of cardinality when utility weights of the PBMs are used. We use data from the British Household Panel Survey (BHPS) to compare satisfaction with life (SwL), satisfaction with health (SwH) and SF-6D. SwL and SwH are similar in that they are reported on the same satisfaction scale and are reported directly from respondents. Of course, they differ in terms of the scope of concerns that the individual is asked to consider. SF-6D is based on a description of health defined by the categories of physical functioning, role limitation, social functioning, pain, mental health and vitality. The range of outcomes considered can therefore help us to understand the influences of outcomes which focus on health, or specific aspects of health, versus overall well-being and the impact of experienced utility compared to preferences for non experienced health states.

2. Methods

2.1. Data

This study uses data from the British Household Panel Survey (BHPS). The BHPS is a UK-based survey run by the Institute for Social and Economic Research at the University of Essex. The survey has been carried out every year since 1991 using a nationally representative panel of individuals. The most recent waves of the BHPS include data on over 15000 individuals.

Waves 9 and 14 of the BHPS include the SF-36 questionnaire, which can be used to generate a generic PBM; the SF-6D (Brazier et al., 2002). Preference weights for the SF-6D have been elicited from the general public using the standard gamble technique. The survey also contains a subjective assessment of individuals' health and other aspects of their life. The question is phrased as follows: *"Please tick the number which you feel best describes how dissatisfied or satisfied you are with the following aspects of your current situation. a) Your health"*. The individual answers this question on a scale from 1, labelled ‘Not satisfied at all’, to 7, labelled ‘Completely satisfied’. In addition, those same waves of the BHPS also include the question *“Using the same scale how dissatisfied or satisfied are you with your life overall?”*. The BHPS also includes information on a number of health problems and ailments. The questionnaire simply asks *“Do you have any of the health problems or disabilities listed on this card?”*. Individuals are asked to exclude any temporary conditions. *“Do you consider yourself to be a disabled person?”* is also included. Individuals respond yes or no to each of these. The health problems included are (verbatim):

- Problems or disability connected with: arms, legs, hands, feet, back, or neck (including arthritis and rheumatism)
- Difficulty in seeing (other than needing glasses to read normal size print)
- Difficulty in hearing
- Skin conditions/allergies
- Chest/breathing problems, asthma, bronchitis
- Heart/blood pressure or blood circulation problems
- Stomach/liver/kidneys or digestive problems
- Diabetes
- Anxiety, depression or bad nerves
- Migraine or frequent headaches

- Other health problems

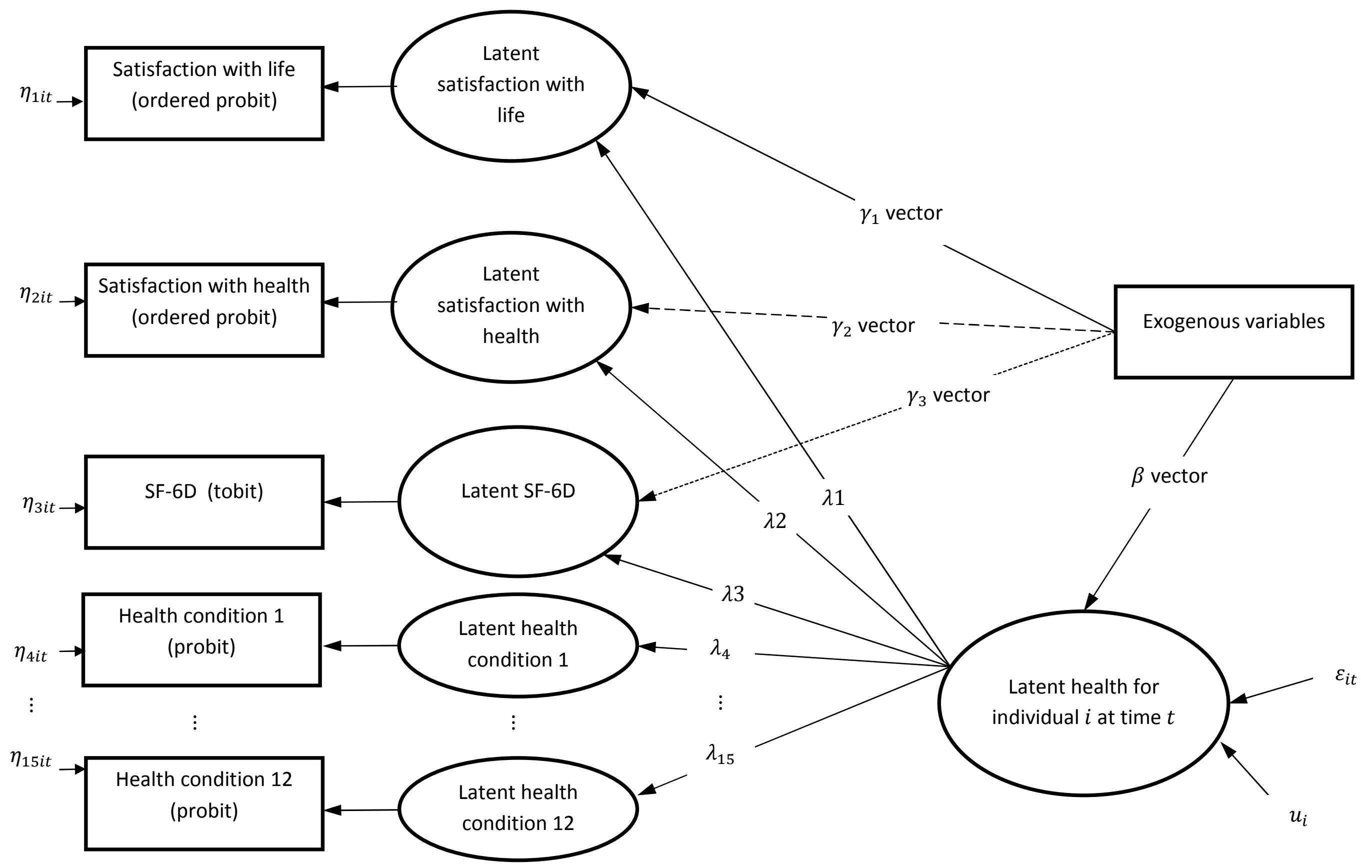
There are two other health problems reported; epilepsy and alcohol/drug related problems. These are excluded from the analysis due to the very low numbers reporting these issues in the survey. The survey also includes information on a range of socioeconomic variables, which have been shown to be important determinants of health and well-being in the literature (Dolan et al., 2008). These include age, gender, ethnicity, marital status, number of children, education, household income, employment status, working hours and regular attendance at religious services. In the empirical analysis we use equivalised household income calculated using the McClements equivalence scale. The final sample used in estimation is of 8,008 individuals who have sufficient data across the two waves of data.

2.2. Econometric approach

Statistical models that have been applied in the existing literature ignore the fact that SF-6D, SwL and SwH are jointly determined and, in particular, that SF-6D is a measure of underlying health possibly subject to measurement error (Ades et al., 2013). Ignoring endogeneity and measurement error leads to biased estimates of the relationship between health and SwL. In order to address these and other methodological problems identified above a joint model of health and well-being is required. We develop a latent factor model to address the problems of endogeneity and measurement error and thereby provide a coherent framework for the simultaneous consideration of self-reported SwL, SwH and SF-6D.

The model uses SF-6D (either utility weights or the set of dimensions), SwH and additional indicators of ill health in the survey as imperfect measures of an unobservable latent health. These various outcome measures are related to SwL (and to each other) via this underlying latent health. Additional, sociodemographic variables can influence all outcomes directly, or via latent health. Individual heterogeneity is incorporated using an individual random effect. Figure 1 illustrates how the various components of the model are linked. By specifying the model in this way, we are able to deal with the problems of endogeneity and measurement error. Furthermore, there are a number of additional advantages of our framework. When we model SwL, SwH and SF-6D utility values simultaneously we are able to set the scale of both SwL and SwH to be the same as that underlying SF-6D utility. This makes it possible to make direct comparisons across the three outcome measures to changes in underlying health. Specifically we can compare the responsiveness of a subjective measure of health, SwH, with a more objective measure, such as SF-6D, and both can be simultaneously compared to the responsiveness of SwL. This requires no additional assumptions or reliance on the assumption of cardinality of the SwL and SwH responses: the model still remains unchanged. Given the findings of this first model specification, we also estimate a second model using each separate dimension of SF-6D as outcome measures instead of the summary utility score. This model allows us to compare the likely results of changes in the levels of the SF-6D dimensions on SwL and SwH responses. For example, the analysis is able to contrast the impact of changes in physical function versus mental function. This second model cannot be scaled using SF-6D summary utility weights since this is no longer an element of the model. However, we can make direct comparisons between SwL and SwH and indirect comparisons with SF-6D utilities.

Figure 1: Model diagram (time t)



We denote the unobserved or latent health for an individual i at time t by θ_{it} so that

$$\theta_{it} = \mathbf{X}_{it}\beta + u_i + \varepsilon_{it} \tag{1}$$

where $\mathbf{X}_{it}$ is a matrix of exogenous variables presumed to affect the level of underlying health, β is the corresponding vector of coefficients, u_i is a time-invariant unobserved individual effect with a distribution $N(0, \sigma_u^2)$ and ε_{it} has a standard normal distribution and is independent over time and across individuals.

The BHPS dataset contains answers to a number of questions $\left(\mathbf{Y}_{jit}, j = 1, \ldots, J\right)$, which measure this latent health but potentially with error. These include questions to construct the individual dimensions of the SF-6D (and from this the SF-6D index), a range of indicators on health conditions and questions on individuals' satisfaction with health and with life. In principle, we can incorporate into the model either the individual SF-6D dimensions or the overall index. Figure 1 displays the latter but we present both versions in the results section. Probits are used to model each of the health condition indicators (binary outcomes), ordered probits for the two satisfaction questions and each of the SF-6D dimensions (ordered categorical data) and a tobit model when the SF-6D index is used rather than the individual dimensions (continuous data on a limited scale). The system of J latent variables underlying the set of outcome measures $\left(\mathbf{Y}_{jit}\right)$ can be written as

$$\mathbf{Y}^*_{jit} = \mathbf{Z}_{jit}\gamma_j + \lambda_j\theta_{it} + \eta_{jit} \tag{2}$$

Each discrete model has a set of associated threshold parameters $\left\{\Gamma_j^s\right\}$ $s = 0, \ldots, m$ where m is the number of response categories. $\Gamma_j^0 = -\infty$ and $\Gamma_j^m = \infty$

so that $\mathbf{Y}_{jit} = m$ if $\Gamma_j^{m-1} < \mathbf{Y}^*_{jit} \leq \Gamma_j^m$. For the tobit model, the dependent variable is defined as $\mathbf{Y}_{jit} = min\left(\mathbf{Y}^*_{jit}, 1\right)$. The λ_j parameters are the factor loadings and represent the responsiveness of the latent variables, $\mathbf{Y}^*_{jit}$, to a change in the underlying level of health. $\mathbf{Z}_{jit}$ are matrices of exogenous variables (not necessarily the same across equations) and represent other variables apart from the latent level of health that might have a direct effect on the reported outcome measure. Variables that appear in $\mathbf{Z}_{jit}$ and in $\mathbf{X}_{it}$ have both a direct effect on the outcome measure through the coefficients γ_j in equation (2) and an indirect effect through their effect on latent health θ_{it} in equation (1), which will have an additional effect on the outcome measure through the factor loadings λ_j in equation (2). For instance, we would expect income to have an effect on the level of reported satisfaction with life over and above the effect that income will have on the level of health itself. Finally, η_{jt} are classical measurement errors with a contemporaneous diagonal covariance matrix $\Sigma_{\eta\eta}$. These diagonal elements are set to one for binary and ordered categorical variables and σ^2_η for the model using the SF-6D tariff. Thus, the observed correlation between the dependent variables is explained both by the effect of a common underlying health level and the joint effect of shared exogenous variables.

SwL covers the broadest concept including health as well as other non-health related matters and therefore we include the full set of selected explanatory variables $\mathbf{Z}_{jit}$ in this part of the model (equation (2)). For SwH we exclude marital status, number of children, employment status and working hours as it is unlikely that these variables would affect SwH directly over and above the effect they might have on underlying health. For the SF-6D we only include age, age-squared and gender.

We also include all explanatory variables in equation (1) and thus we allow for the possibility that they affect directly the underlying level of health, with the exception of working hours. We tried alternative specifications including this variable but the results were counterintuitive; altering substantially the coefficients of income, education, and unemployment. We suspect that this is caused by the collinearity between these variables and hours of work and we exclude it from this part of the model. We would like to have a more dynamic specification of the variable to capture the effect on health of persistently long hours of work, however with our data we cannot capture this concept reliably.

As a first step, a model using the SF-6D index is estimated. This model has the advantage of allowing direct comparisons of the responsiveness of SF-6D, SwL and SwH to changes in underlying health. The scale of the latent SwL and SwH variables in the model is the same, because they are estimated as ordered probit models, but this differs from the scale of the SF-6D. Because ordered categorical variables are simply labels with no associated value, the scale of the model cannot be identified and it is customary to set it equal to one, i.e. $\mathbf{V}ar\left(\eta_j\right) = 1$. It can be set to any other value, such as the variance of the part of the model using the SF-6D utility index, and this has no effect on the model and its predictions. It will, however, affect the size of the estimated parameters and their standard errors as they are being measured on a different metric. After estimation of the model, the scale of the latent SwL and SwH variables can be set to be the same as that of the estimated SF-6D model and new rescaled factor loadings can be calculated as:

$$\hat{\lambda}_j^* = \hat{\lambda}_j \hat{\sigma}_\eta$$

and their sizes directly compared. Associated standard errors and confidence intervals can easily be computed for these new parameters by using the delta method. This is therefore a rescaling of the underlying latent SwH and SwL and does not change in any way the model or its assumptions. Importantly, this is not the same as assuming the SwL/SwH data are cardinal.

The previous model does not allow us to examine issues relating to the individual SF-6D dimensions. For this reason a second model is estimated using each individual dimension of SF-6D. Based on the estimated model, the expected probabilities of being at any particular level on one or more outcome measures can be calculated conditional on specific values of other measures. For example, we can calculate the expected probabilities of each level of SwL for a person with a given set of characteristics conditional on reporting, say, a level 1 in the physical functioning dimension of the SF-6D. We can then consider how those probabilities change when we condition on the same person reporting instead, say, level 6. Similarly, we are also able to calculate the expected drop in SF-6D when the same person moves from reporting 'completely satisfied' with life to, say, 'not satisfied at all'. One advantage of this approach is that there is no need to condition on specific values of other outcome variables, though this could be done if one wanted. Two individuals with the same observable characteristics — one reporting a level 1 in the SF-6D physical functioning level and the other reporting a level 6 — will be very unlikely to have the same levels on the other SF-6D dimensions. This is an implicit assumption used when calculating the marginal effects in standard models that use SF-6D as an exogenous variable; they are the expected effects when we change one level of SF-6D conditional on all the other exogenous variables (including other SF-6D dimensions) remaining at their initial values. In the approach presented here, the correlation structure between the various outcome measures is estimated and preserved within the model, allowing us to condition on the value of one SF-6D dimension with the estimated changes in other dimensions simultaneously and automatically adjusted accordingly. Alternatively we can condition on a set of values for all six dimensions or, in theory, for other outcomes, bearing in mind that some of these combinations might have a near-zero probability of occurrence.

As the model is non-linear, different individuals will, in general, have different effects. We highlight this in the results section. For illustrative purposes comparisons are drawn for a hypothetical individual with average (median for discrete variables) characteristics.

The models are estimated by maximum likelihood using adaptive quadrature with 15 integration points in Mplus 6.1. The calculations of the conditional expectations and probabilities require the computation of a double integral as both the individual effect and the latent health need to be integrated out and are calculated by Monte Carlo simulation using 200,000 Halton draws in GAUSS 9.

3. Results

The rescaled factor loadings, $\hat{\lambda}_j^*$, of the unobserved latent health in the SwL, SwH and SF-6D equations indicate the extent to which changes in underlying latent health lead to changes in latent SwL, SwH and SF-6D, on the same scale. Table 1 presents those estimated parameters with 95% and 99% confidence intervals. According to the estimated coefficients, SwH shows the highest response to a change in latent health followed closely by SF-6D. SwL shows the lowest response. The 95% confidence intervals for the three estimated parameters do not overlap, though those corresponding to SwH and SF-6D are extremely close

Table 1: Rescaled factor loadings and confidence intervals (CI)

	Factor loading ($\hat{\lambda}_j^*$)	95% CI	99% CI
SwL	0.0294	$(0.0237, 0.0316)$	$(0.0267, 0.0322)$
SwH	0.0512	$(0.0475, 0.0550)$	$(0.0463, 0.0562)$
SF-6D	0.0450	$(0.0429, 0.0471)$	$(0.0423, 0.0477)$

and, in fact, the 99% confidence intervals do overlap. However, the confidence intervals of the factor loading corresponding to SwL are quite some distance from the other two at both levels of significance. Satisfaction with life as a measure is clearly less responsive to changes in the level of underlying health. The effect of a change in health is diluted, compared to the outcomes that explicitly focus on health, since there are other additional influences on an individuals level of SwL.

A second model using the individual dimensions of SF-6D was estimated and the factor loadings of this model are presented in Table 2. The parameter estimates for the model using the SF-6D index (equations (1) and (2)) are very similar and therefore presented in the Appendix, Table A.1 and A.2. Note that the estimated model parameters in Table 2 are in their original scale (variance set to one) as we do not have the SF-6D index in this model. The factor loadings all have the expected signs. The probabilities of being ‘completely satisfied’ with life and health increase as health increases and, as before, the factor loading is significantly larger for SwH compared to SwL. Note that even though these are not scaled using the SF-6D index, both SwL and SwH are on the same scale and can therefore be directly compared. All health conditions have an associated parameter which is negative, so that an increase in health decreases the probability of having the health condition to varying degrees depending on the condition. Individual SF-6D dimensions also have a negative associated coefficient, which is consistent with expectations as higher SF-6D values in the dimensions correspond to worse health states. Concentrating on just the factor loadings of the six SF-6D dimensions we find that the mental health dimension is the smallest in absolute value, significantly smaller than the rest of the factor loadings and in particular that of the physical functioning dimension. At the same time, the role limitations and social functioning dimensions have the largest factor loadings. It is important to note however that this does not lead to the conclusion that the SF-6D weighs physical function more than mental health. This is because whilst SF-6D has two dimensions, physical functioning and mental health, which are related exclusively to those domains, the remaining dimensions have some overlap and are measures of both. For example, the dimension of role limitations combines those which result both from physical as well as mental impairment. Looking at the estimated factor loadings of the SF-6D dimensions in isolation ignores that mental or physical health problems will be measured not only on that particular dimension of SF-6D but will also alter the other dimensions. Taking into account these correlations is therefore fundamental to be able to make reliable inferences. The section on model predictions looks at this is more detail.

Table 2: Factor loadings and confidence intervals (CI)

	Coefficient	95% CI	99% CI
SwL	0.353	(0.333,0.373)	(0.327,0.379)
SwH	0.603	(0.5756,0.630)	(0.567,0.639)
SF-6D Phys	-0.501	(-0.525,-0.477)	(-0.532,-0.470)
SF-6D Role	-0.585	(-0.616,-0.554)	(-0.626,-0.544)
SF-6D Social	-0.612	(-0.645,-0.579)	(-0.656,-0.568)
SF-6D Pain	-0.522	(-0.547,-0.497)	(-0.556,-0.488)
SF-6D Mental	-0.359	(-0.379,-0.339)	(-0.385,-0.333)
SF-6D Vitality	-0.481	(-0.503,-0.459)	(-0.509,-0.453)
Disabled	-0.426	(-0.455,-0.397)	(-0.465,-0.387)
Arms, legs, hands	-0.39	(-0.410,-0.370)	(-0.416,-0.364)
Sight	-0.21	(-0.228,-0.192)	(-0.233,-0.187)
Hearing	-0.202	(-0.218,-0.186)	(-0.223,-0.181)
Skin	-0.033	(-0.047,-0.019)	(-0.051,-0.015)
Chest	-0.157	(-0.173,-0.141)	(-0.178,-0.136)
Heart	-0.292	(-0.308,-0.276)	(-0.313,-0.271)
Stomach	-0.191	(-0.207,-0.175)	(-0.212,-0.170)
Diabetes	-0.166	(-0.186,-0.146)	(-0.192,-0.140)
Anxiety	-0.22	(-0.240,-0.200)	(-0.246,-0.194)
Migraine	-0.061	(-0.075,-0.047)	(-0.079,-0.043)
Other	-0.116	(-0.132,-0.100)	(-0.137,-0.095)

Table 3: Estimated parameters in the latent health equation and in the SwL and SwH outcome measures equations

	Latent health		SwL		SwH	
	Coefficients	S.E.	Coefficients	S.E.	Coefficients	S.E.
Age/10	-0.783***	0.098	0.091*	0.05	0.297***	0.058
$(\text{Age}/10)^2$	-0.013	0.009	0.026***	0.005	0.016***	0.005
Female	-0.168***	0.064	0.049*	0.029	0.044	0.035
Mixed background	-0.075	0.427	0.063	0.181	0.182	0.209
Other background	-0.783***	0.169	-0.09	0.083	-0.041	-0.442
Black	-0.195	0.388	-0.376	0.235	-0.353	-1.607
Higher education	0.161***	0.041	-0.115***	0.022	-0.057**	-2.434
Log of household income	0.239***	0.030	0.049**	0.019	-0.038*	-1.943
Weekly religious services	0.191***	0.061	0.185***	0.037	0.148***	4.002
Couple	0.055	0.06	0.313***	0.033		
Separated/divorced	-0.242***	0.088	-0.102**	0.047		
Widow	-0.083	0.094	0.064	0.056		
Number of children	0.052**	0.022	-0.092***	0.012		
Unemployed	-0.159*	0.095	-0.320***	0.067		
Hours of work/10			-0.114***	0.017		
$(\text{Hours of work}/10)^2$			0.011***	0.003		
Γ_0			-2.096***	0.164	-2.476***	0.186
Γ_1			-1.564***	0.161	-1.888***	0.184
Γ_2			-0.935***	0.160	-1.134***	0.183
Γ_3			-0.185	0.159	-0.391**	0.183
Γ_4			0.780***	0.160	0.494***	0.183
Γ_5			1.989***	0.161	1.733***	0.184
σ_u^2	2.551***	0.120				

Tables 3 and 4 show the estimated coefficients of the exogenous variables in equations (1) and (2) for the latent health equation and the outcomes SwL, SwH and SF-6D dimensions. A.3 in the appendix shows the estimated thresholds of the remaining outcome equations. As expected, we find that health decreases with age (at an increasing rate although insignificant). Individuals who are female, of mixed race background, separated/divorced or unemployed all tend to have lower levels of health. Conversely, individuals with a greater number of children, a degree, higher levels of income, and who attend weekly religious services tend to have higher levels of health. All these variables have an indirect effect on the outcome measures of interest through their effect on the level of health. In terms of the variables affecting the outcome equations directly, as age increases, the probability of reporting being 'completely satisfied' with life and health increase and the probability of reporting being in the worst levels of the SF-6D dimensions decreases. This is separate to the indirect effect ageing has on these outcomes via its impact on health status. Females are more likely to report being in the highest group of satisfaction with life and health but are also more likely to be at the worst level of SF-6D dimensions. We find no direct effect of ethnicity on satisfaction with life and health. Having a degree lowers the probability of reporting the highest satisfaction with life and health and the reverse is true for individuals who attend weekly religious services. The direct effects of income have the opposite effects; while higher income increases the probability of reporting being completely satisfied with life, it decreases the probability of being completely satisfied with health. In addition, couples have higher probabilities of reporting being completely satisfied with life, while separated/divorced individuals, the unemployed, those with a greater number of children and those with more working

Table 4: Estimated coefficients in the outcome measures equations of SF-6D

		Coefficients	S.E.
SF-6D Phys	Age/10	-0.287***	0.049
	$(Age/10)^2$	0.029***	0.004
	Female	0.217***	0.029
SF-6D Role	Age/10	-0.482***	0.064
	$(Age/10)^2$	0.014**	0.006
	Female	0.191***	0.039
SF-6D Social	Age/10	-0.675***	0.063
	$(Age/10)^2$	0.028***	0.006
	Female	0.166***	0.039
SF-6D Pain	Age/10	-0.265***	0.051
	$(Age/10)^2$	-0.003	0.005
	Female	0.190***	0.030
SF-6D Mental	Age/10	-0.386***	0.043
	$(Age/10)^2$	0.001	0.004
	Female	0.266***	0.028
SF-6D Vitality	Age/10	-0.466***	0.052
	$(Age/10)^2$	0.020***	0.005
	Female	0.259***	0.032

Table 5: Observable characteristics and estimated SF-6D of five hypothetical individuals

	Individuals				
Age	46	46	46	66	26
Gender	female	female	female	male	male
Ethnicity	white	white	white	white	white
Marital status	couple	couple	couple	widow	single
Children	1	1	1	0	0
Education	below higher education	below higher education	higher education	higher education	higher education
Household income (£)	2150	1500	5000	3000	3000
Employment status	employed	unemployed	employed	retired	employed
Hours of work	35	0	45	0	35
Mean estimated SF-6D	0.799	0.786	0.817	0.794	0.853

hours have a lower probability of being completely satisfied with life.

3.1. Model predictions

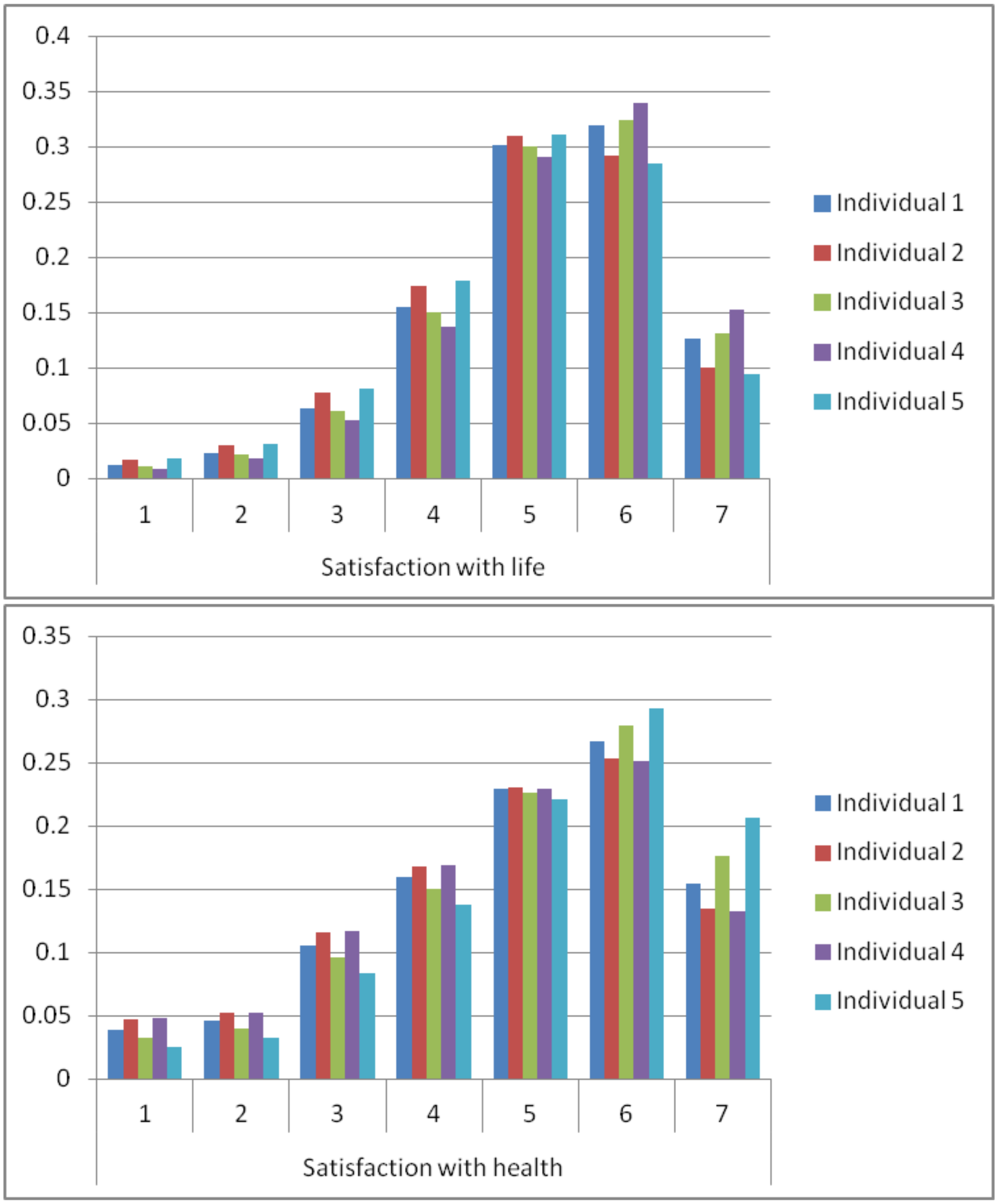
Many variables affect the different outcome measures both directly and indirectly through their effects on health. It is therefore difficult to assess the implications of the model solely by reference to the estimated parameters.

Table 5 shows the observable characteristics of 5 hypothetical individuals. Individual 1 is an individual with average characteristics (median for discrete variables) in the sample. The second individual differs from the first in that she is unemployed and has lower equivalised household income. The third individual differs from the first in that she has a degree and has higher household income but works longer hours. The last two individuals are males with characteristics as depicted in the table. The expected SF-6D indices for these individuals follow the patterns that we would expect with the second individual having a lower value than the average individual (individual 1) and the third one having a higher value. Comparing the two males (individuals 4 and 5), the younger male has a higher estimated SF-6D index. Figure 2 plots the probabilities of satisfaction with life and with health for these five hypothetical individuals. It is worth noting that while the probabilities of being satisfied with life and satisfied with health follow a similar pattern when comparing across the first three individuals, the patterns of satisfaction with life and health are very different for the last two individuals. For example, looking at the last level of satisfaction ('completely satisfied'), the younger individual has a much higher probability of being satisfied with his health (as expected given that he has the highest expected level of health) but the lowest probability of being completely satisfied with his life. This highlights how different these measures might be depending on the circumstances of the individual.

For the rest of the section, we concentrate on comparing the effects for the individual with average characteristics; Individual 1. Figure 3 shows how the predicted probabilities of being satisfied with life and with health change as the levels of the SF-6D physical functioning dimension increase (top two graphs) and as the levels of the SF-6D mental health dimension increase (bottom two panels). The probabilities at the extremes of satisfaction with health seem to be more sensitive in absolute terms than the extremes of satisfaction with life and this is common to both changes in the physical functioning levels as well as changes in the mental health levels. It is however difficult to assess the effects of these changes on a common scale as no valuation exists for satisfaction with life or satisfaction with health. As an illustrative example we present in Table 6 some calculated values of these differences when we attach equidistant values between 0 and 1 to each satisfaction label [1] and compare it with the predicted SF-6D values for that same

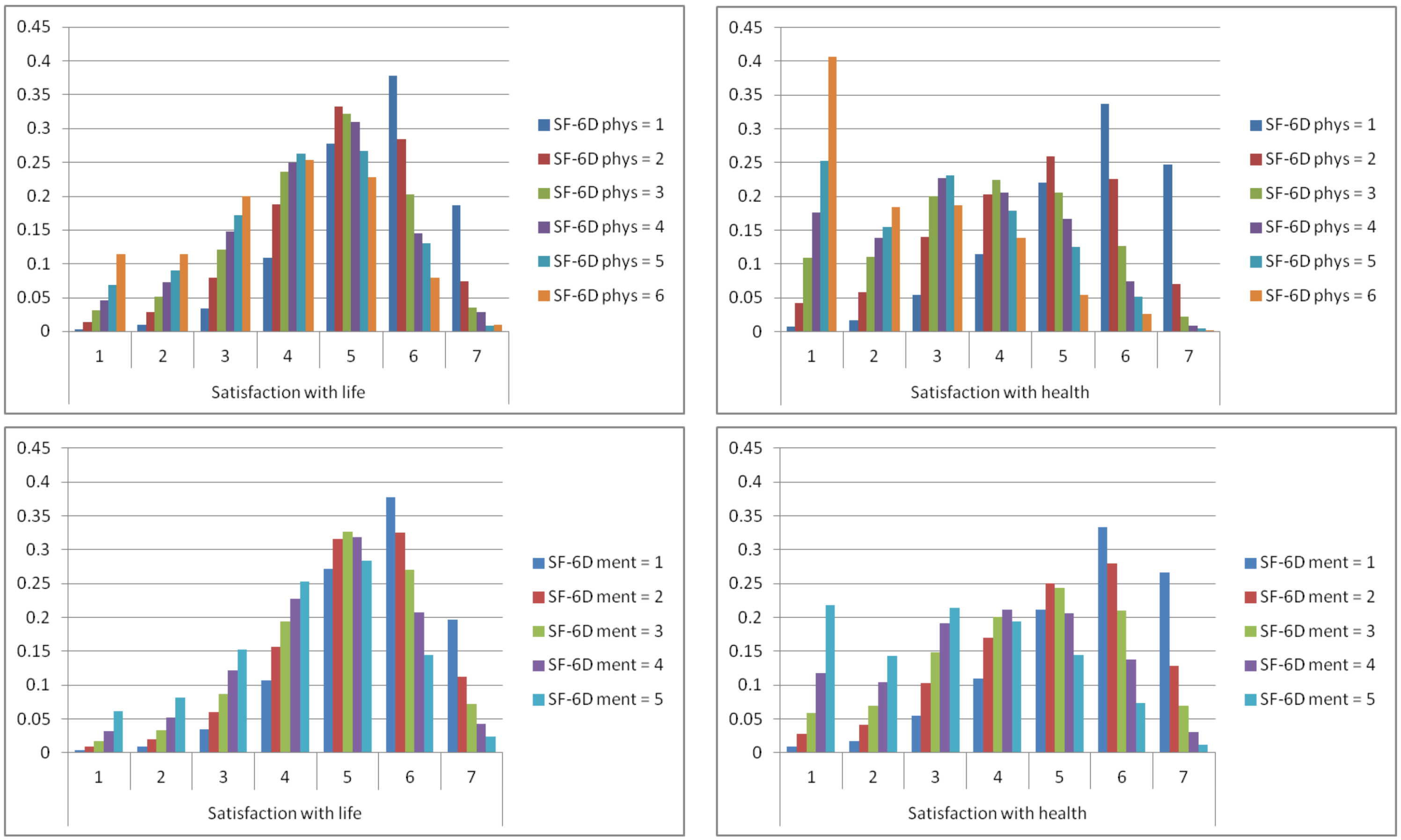
[1]This involves attaching the values 0.1429, 0.2857, 0.4286, 0.5714, 0.7143, 0.8571 and 1 to the satisfaction levels 1 to 7.

Figure 2: Probabilities of satisfaction with life and with health for five hypothetical individuals



person. Despite the obvious limitations of this approach it is included to enable comparisons with existing literature (Mukuria and Brazier, 2013; Dolan, 2011b; Dolan and Metcalfe, 2012; Dolan et al., 2012).

Figure 3: Probabilities of Satisfaction with life and with health conditional on different levels of physical functioning and mental health



Attaching weights in this way gives very similar index values for SwL and SwH for the first level of both physical functioning and mental health and these values are substantially lower than the SF-6D index. However, for the last level of both the values of SwL and SwH are markedly different. When comparing SwL to SwH, it is clear that an increase in both the physical functioning and the mental health levels from the first (mildest) to the last (most severe) translate into a much larger change in SwH than in SwL. In both cases, the difference in the SF-6D index is somewhere in between, though closer to the change in the satisfaction with health index than to the change in the life satisfaction index. This agrees with the pattern that was depicted in Table 1 using the model with only the SF-6D index and seems to apply to the dimensions. Interestingly, we do not find evidence that SwL places higher weight on mental health than physical health than SwH or SF-6D; the drop in the value of the index when moving from the mildest to the most severe level is higher for physical functioning (0.2695) than for mental health (0.2012). However, the differences between the extreme levels might not be equivalent in both dimensions. The last row of Table 6 depicts the ratios of the scores for the three outcome measures. These ratios are almost identical for SwL and SwH and higher than the same ratio for SF-6D, which indicate that in relative terms subjective measures might give a higher weight to the physical component of SF-6D. This, however, relies on the equidistant values we have attached to the SwL and SwH responses and this assumption is not harmless. Attaching a different set of values, for example with increasing rather than equidistant intervals, leads to ratios of 1.2770 and 1.2442 for SwL and SwH respectively; much closer to the ratio of SF-6D.

Figure 4 shows the predicted probabilities of each level of satisfaction with

Table 6: Expected indices of SF-6D, SwL and SwH conditional on different levels of physical functioning and mental health

	SF-6D	SwL	SwH
Physical functioning			
level 1	0.8641	0.7897	0.7894
level 2	0.7550	0.7070	0.6480
level 3	0.6909	0.6455	0.5396
level 4	0.6270	0.6077	0.4729
level 5	0.5869	0.5708	0.4209
level 6	0.4744	0.5202	0.3334
Difference 1 to 6 (a)	0.3897	0.2695	0.4560
Mental health			
level 1	0.8806	0.7931	0.7944
level 2	0.7950	0.7393	0.7044
level 3	0.7556	0.6970	0.6301
level 4	0.6252	0.6486	0.5459
level 5	0.5619	0.5919	0.4532
Difference 1 to 5 (b)	0.3187	0.2012	0.3412
Ratio of (a) to (b)	1.2228	1.3396	1.3360

life and with health for two of the reported health problems; namely, disability and anxiety, depression or bad nerves. Table 7 shows the values associated with the SF-6D, SwL and SwH for those with and without specific health conditions and calculates the differences. The table also reports the ratio of the differences for each condition relative to the difference for the presence/absence of anxiety and depression. This indicates the extent to which each measure values each condition relative to the sole category that relates solely to mental health conditions. These figures show that the model predicts that migraine has the smallest impact on all three measures. The ratios for the three outcomes are very similar across each of the 11 comparisons made. There is no discernible pattern that suggests one measure consistently values conditions higher or lower relative to anxiety or depression. The lowest ratio is associated with the SF-6D in 7/11 of the conditions and with SwL for the remaining 4/11.

4. Discussion

This paper presents an integrated framework for the consideration of measures of satisfaction with life, satisfaction with health and a generic preference based measure of health in a consistent manner. It overcomes the problems of endogeneity and measurement error and enables us to compare the measures on the same scale, which has not previously been done. Our model is based on the concept that there is an unobserved latent health, which is measured to some degree by all three of the outcomes and by self-reported health condition indicators. Importantly, these observable outcomes might be subject to measurement error, for which our model accounts. This overcomes some of the fundamental restrictions in previous studies, in which generic health measures have been treated as

Figure 4: Probabilities of satisfaction with life and with health for the presence or absence of two health problems

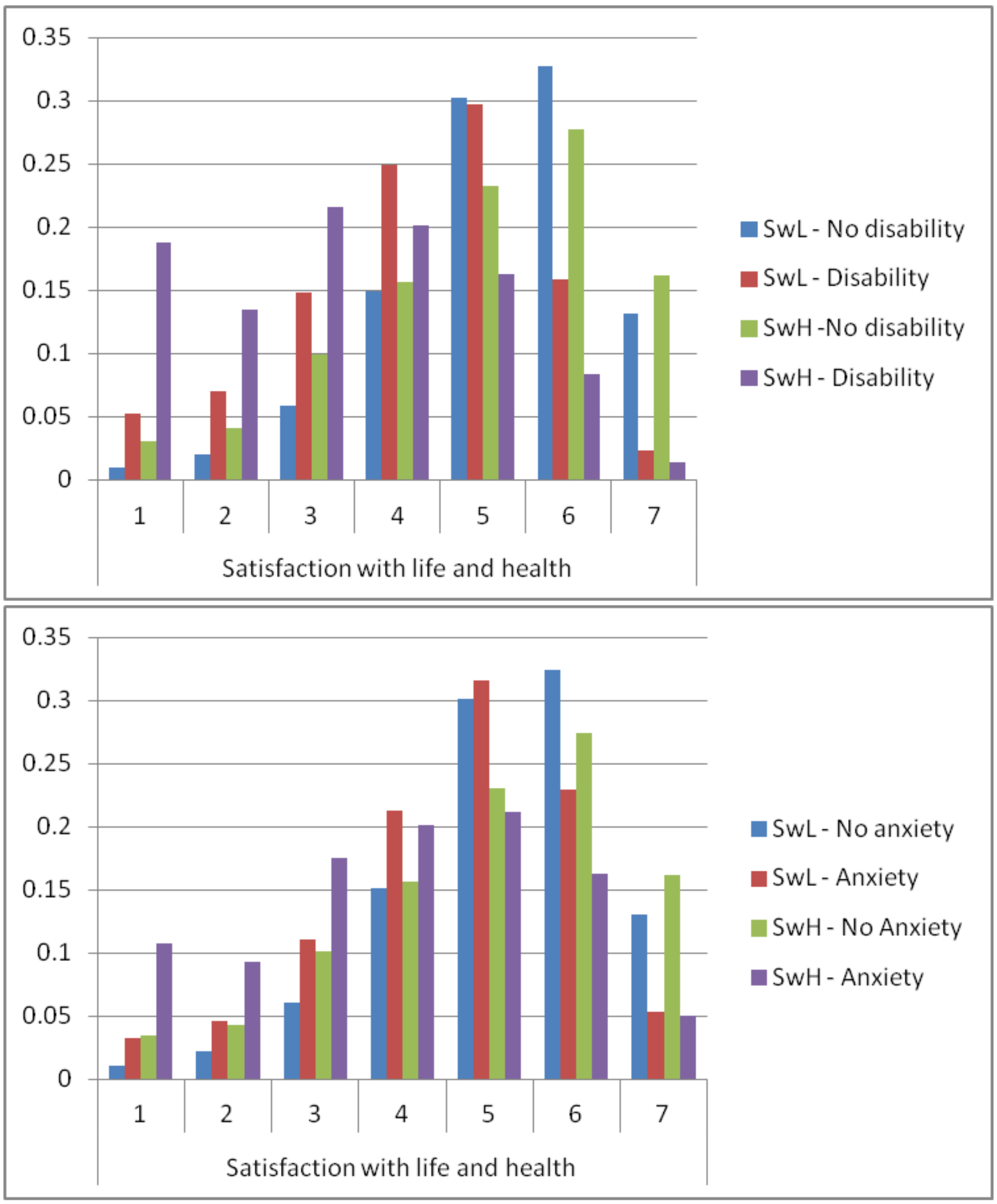


Table 7: Expected indices of SF-6D, SwL and SwH conditional on health problems and ratios of differences relative to anxiety, depression or bad nerves

Health Problem		SF-6D	SwL	SwH
Anxiety	Absence (a)	0.804	0.744	0.710
	Presence (b)	0.716	0.662	0.572
Disability	Absence (c)	0.806	0.746	0.714
	Presence (d)	0.652	0.606	0.475
	Ratio [(c)-(d)]/[(a)-(b)]	1.761	1.716	1.730
Arms, legs, hands	Absence (c)	0.826	0.764	0.746
	Presence (d)	0.720	0.666	0.577
	Ratio [(c)-(d)]/[(a)-(b)]	1.214	1.203	1.223
Sight	Absence (c)	0.802	0.742	0.708
	Presence (d)	0.713	0.660	0.567
	Ratio [(c)-(d)]/[(a)-(b)]	1.021	1.013	1.015
Hearing	Absence (c)	0.804	0.744	0.711
	Presence (d)	0.727	0.672	0.588
	Ratio [(c)-(d)]/[(a)-(b)]	0.885	0.891	0.888
Skin	Absence (c)	0.800	0.740	0.705
	Presence (d)	0.788	0.729	0.684
	Ratio [(c)-(d)]/[(a)-(b)]	0.135	0.139	0.148
Chest	Absence (c)	0.805	0.745	0.713
	Presence (d)	0.749	0.692	0.623
	Ratio [(c)-(d)]/[(a)-(b)]	0.640	0.653	0.649
Heart	Absence (c)	0.813	0.752	0.725
	Presence (d)	0.719	0.666	0.576
	Ratio [(c)-(d)]/[(a)-(b)]	1.072	1.060	1.070
Stomach	Absence (c)	0.803	0.743	0.709
	Presence (d)	0.728	0.672	0.588
	Ratio [(c)-(d)]/[(a)-(b)]	0.854	0.878	0.877
Diabetes	Absence (c)	0.801	0.741	0.706
	Presence (d)	0.727	0.672	0.587
	Ratio [(c)-(d)]/[(a)-(b)]	0.845	0.848	0.858
Migraine	Absence (c)	0.801	0.741	0.705
	Presence (d)	0.777	0.718	0.667
	Ratio [(c)-(d)]/[(a)-(b)]	0.271	0.280	0.275
Other	Absence (c)	0.801	0.741	0.706
	Presence (d)	0.751	0.694	0.626
	Ratio [(c)-(d)]/[(a)-(b)]	0.568	0.570	0.573

exogenous. Results reported in the existing literature are not based on a common scale meaning that, to make comparisons, it is necessary to make strong assumptions about values for the ordinal satisfaction responses. We find that SF-6D and satisfaction with health appear to respond to changes in underlying health to a similar degree. These outcome measures are conceptually different: the latter is based on reports by individuals that have experience of the health state in question (experienced utility), while the former is valued by the general public who have not experienced the condition (decision utility). SF-6D is based on a conception of health defined by six specific dimensions, whereas SwH has no restriction imposed on the definition of health. Yet the results suggest that these conceptual differences might not amount to substantial differences in practice. We also find that satisfaction with life changes in a similar direction to health-specific outcome measures when latent health changes, but when this is measured on a scale that allows comparisons to be drawn the outcome is less responsive than both SF-6D and SwH. Presumably this is because SwL clearly addresses a broader concept than simply health factors and therefore the impact of changes in health are diluted when using such an instrument. In contrast to previous studies (Dolan et al., 2012; Mukuria and Brazier, 2013), our results show that the relative effects of changes in mental health versus physical health are not significantly different across the three outcome measures. Therefore, claims of fundamental differences between utility for experienced events versus those that have not been experienced may be premature in this setting.

Inevitably, our study and its findings have a number of caveats. We employ a single data source, using only two waves of the BHPS and one generic outcome measure; the SF-6D. Replication of the findings in other datasets, other populations and using different outcome measures would be valuable. In particular, the conception of health given by the widely used EQ-5D instrument warrants inclusion in this type of analysis. EQ-5D and SF-6D are substantially different both in terms of their descriptive systems and valuation methods. The relationship between wellbeing and generic preference based outcome measures may not be consistent across different measures. It would be both interesting and valuable to separate the concept of latent health out into mental and physical components. However, the existing dataset and the dimensions of SF-6D are quite limiting in this regard and we were not able to estimate models given these restrictions. Alternative outcome measures, larger datasets or longer panels might allow this to be pursued in future work. Nevertheless, the data source is the same as that used by Dolan et al. (2012) and therefore provides a comparison that controls for some of these issues. It is therefore clear that the analysis methods do have an important impact on general conclusions and this at least warrants consideration by analysts working in this area.

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Appendix

Table A.1: Parameter estimates: latent health and outcome variables SwL, SwH and SF-6D

	Latent Health		SwL		SwH		SF-6D	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
latent health			0.364***	0.012	0.633***	0.021	0.045***	0.001
(Age/10)	-0.973***	0.114	0.163***	0.055	0.410***	0.071	0.049***	0.005
$(Age/10)^2$	-0.009	0.011	0.025***	0.005	0.016**	0.006	-0.002***	0.000
Female	-0.158**	0.074	0.041	0.033	0.038	0.042	-0.025***	0.003
Mixed background	-0.191	0.520	0.100	0.195	0.268	0.237		
Other background	-0.882***	0.215	-0.071	0.092	-0.021	0.113		
Black	-0.242	0.487	-0.381	0.260	-0.355	0.266		
Couple	0.089	0.066	0.317***	0.034				
Separated/divorced	-0.257**	0.100	-0.092*	0.049				
Widow	-0.077	0.111	0.066	0.057				
Number of children	0.059**	0.024	-0.103***	0.012				
Higher education	0.235***	0.049	-0.148***	0.024	-0.110***	0.028		
log of income	0.307***	0.037	0.021	0.021	-0.094***	0.024		
Unemployed	-0.140	0.112	-0.355***	0.069				
(Hours of work/10)			-0.135***	0.018				
$(Hours\ of\ work/10)^2$			0.014***	0.004				
Weekly religious services	0.235***	0.076	0.182***	0.041	0.148***	0.044		
Intercept							0.745***	0.014
Γ_0			-2.286***	0.172	-2.892***	0.205		
Γ_1			-1.723***	0.168	-2.232***	0.202		
Γ_2			-1.060***	0.166	-1.392***	0.200		
Γ_3			-0.274*	0.166	-0.569***	0.200		
Γ_4			0.732***	0.166	0.399**	0.199		
Γ_5			1.988***	0.167	1.737***	0.201		
Variance	3.341***				0.007***	0.000		

Table A.2: Parameter estimates: outcome variables self reported health conditions

		Coefficient	SE
Disabled	latent health	-0.356 ***	0.014
	Gamma0	2.871 ***	0.154
Arms, legs and hands	latent health	-0.323 ***	0.010
	Gamma0	1.517 ***	0.124
Sight	latent health	-0.185 ***	0.009
	Gamma0	2.291 ***	0.080
Hearing	latent health	-0.18 ***	0.008
	Gamma0	1.962 ***	0.074
Skin	latent health	-0.028 ***	0.006
	Gamma0	1.236 ***	0.025
Chest	latent health	-0.135 ***	0.007
	Gamma0	1.539 ***	0.056
Heart	latent health	-0.26 ***	0.008
	Gamma0	1.774 ***	0.103
Stomach	latent health	-0.165 ***	0.008
	Gamma0	2.016 ***	0.069
Diabetes	latent health	-0.149 ***	0.009
	Gamma0	2.315 ***	0.072
Anxiety	latent health	-0.187 ***	0.009
	Gamma0	2.106 ***	0.077
Migraine	latent health	-0.050 ***	0.007
	Gamma0	1.519 ***	0.031
Other	latent health	-0.100 ***	0.007
	Gamma0	1.961 ***	0.048

Table A.3: Estimated thresholds of the outcomes equations: self reported health conditions

	Coefficient	SE
Disabled	2.998***	0.159
Arms, legs and hands	1.621***	0.127
Sight	2.299***	0.078
Hearing	1.966***	0.072
Skin	1.240***	0.025
Chest	1.563***	0.056
Heart	1.780***	0.099
Stomach	2.040***	0.068
Diabetes	2.312***	0.070
Anxiety	2.152***	0.078
Migraine	1.534***	0.032
Other	1.976***	0.048