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## **Less money or better health? Evaluating individual's willingness to make trade-offs using life satisfaction data**

**Abstract:** *Health care practitioners are increasingly required to make more efficient decisions when it comes to allocating health care expenditure. This requires not only information relating to the costs of medical interventions, but also the benefits of such interventions on individual's overall well-being. In order to calculate the well-being losses associated with health conditions, this study uses the compensating income variation approach (CIV), to calculate the amount of extra equivalent household income to make someone who suffers from one of 15 health conditions, as well off in terms of life satisfaction as someone who does not have these health conditions. To help put these findings into perspective, this study also calculates CIVs for many other factors commonly found to be significantly associated with subjective well-being (e.g. unemployment, widowhood, separation and indicators of social capital). This paper builds on previous work using CIVs in health by addressing the issue of income endogeneity in life satisfaction and also testing how robust the derived CIVs are to the inclusion of personality measures, namely the Big Five personality traits. The analysis suggests that health conditions significantly affect individual's quality of life and that the amount needed to make someone with a health condition as well off as someone without those health conditions can be substantive, albeit less than is commonly reported in the literature using the CIV approach to date.*

*Keywords: medical conditions; self-reported quality of life; compensating income variation; instrumental variables; health*

### **1. Introduction**

Faced with ever increasing costs, policymakers need to make informed decisions about which types of health care interventions should be prioritised over others. In addition to considering the costs of such interventions, decision making about the allocation of resources in the health domain requires information about the value attached to health improvements (Groot and van den Brink, 2006). When it comes to assessing the value of health care interventions, there are a number of different economic methodologies used. The simplest method commonly employed is cost-effectiveness analysis as the benefits are measured as a single unidimensional outcome, e.g. cases prevented, conditions diagnosed or life years gained. An important limitation is that this unidimensional approach may mean that other potentially important outcomes are ignored. In comparison to cost effectiveness analysis (CEA), cost utility analysis (CUA) considers a broader measure of health related outcomes such as quality adjusted life years (QALYs). QALYs are a generic measure of disease burden which reflects both the quality as well as quantity of life saved. It assumes that living a year in perfect health is worth

one QALY and living a year with less than perfect health is worth somewhere between 0 and 1, depending on the severity of the health condition.

A variety of procedures have been developed to determine preferences for health states that are less than perfect (i.e. less than one), by eliciting hypothetical choices (Dolan and Kahneman 2008). The most common being the visual analogue scale (VAS), the standard gamble (SG) and the time tradeoff (TTO) (see Dolan 2000 for a useful review of these methods). The VAS requires respondents to rate health states on a scale (typically represented by a vertical "thermometer-type" line) with "worst" and "best" endpoints, usually represented by 0 and 100, respectively (Dolan, 1999). While simple to use, it is subject to a number of biases such as context and spreading bias, and end-point aversion (Dolan, 2000). As valuations derived from the VAS are elicited in a choiceless context, i.e. don't require individuals' to make trade-offs, health economists generally prefer the choice based SG and TTO methods (Dolan, 2000; Tolley, 2009). For the SG approach, respondents choose between a health state that is certain (for example, frequent asthma attacks) and a gamble with one better (e.g. full health) and one worse (e.g. death) outcome possible. With the TTO, respondents choose between living for a defined period of time in a specified poorer health state or living for a shorter period of time in full health (Dolan, 1999). Some recent studies have sought to elicit more 'informed' preferences when using SG and TTO methods. For example, Dolan et al. (2013) elicited preferences for health states via a TTO that incorporated various levels of satisfaction with life alongside the standard health state descriptors.

An alternative preference based approach which more directly monetises the benefits of health care states is through contingent valuation (CV). With SG and TTO methods the unit of the scale is a quality adjusted life year, whereas with CV respondents are asked how much they

would be willing to pay for a hypothetical change from one health state to another or simply their WTP for the elimination of specified health risks. One advantage of this approach is that it more easily allows a direct comparison of the benefits of a health care intervention with its costs than other choice based methods. Second, by determining an individuals' willingness to pay (WTP) we can also measure potential benefits of health care other than just health gain. An additional advantage of this method is that it allows preferences for health to be considered alongside other non-health attributes, that the individual values, i.e. allow a comparison between the value individuals place on improvements in health relative to other arguments in their utility function (Dolan, 2000). The validity and reliability of the contingent valuation method is, however, the subject of heated controversy, as it is argued that the methodology is susceptible to hypothetical bias and framing problems (Carson et al., 2001; Murphy et al., 2005; Lusk and Norwood, 2009). More specifically, respondents are usually presented with hypothetical choice tasks - choices they may have no personal experience with - meaning that they may find it difficult to fully understand and comprehend the actual scenario they are being asked to assess. A further criticism of all stated preference approaches is that people will typically underestimate the extent to which they and others will adapt to changed circumstances, and as such, elicited choices under these methods may not accurately reflect the utility associated with different health states (Dolan and Kahneman, 2008). Further common criticisms of some of these choice based methods are that they can be relatively time-consuming and cognitively challenging for respondents (Dolan, 2000; Tolley, 2009).

Another widely used approach for obtaining WTP for health outcomes is through using revealed preferences (RP), where people's preferences for health conditions are 'revealed' from observed behavior in the market (Mark and Swait, 2008; Romley and Goldman, 2011). The hedonic pricing approach, using wages, is an example of such an approach where the

amount that individuals need to be compensated for risks to health is ascertained by determining how wages differ in response to changing on the job health risks (Viscusi and Aldi, 2004). One limitation with this approach arises from the issue of self-selection as, for example, workers who choose a certain occupation with high health risks are likely to be a select group for whom health risks weigh less heavily than the general population (Cropper et al., 2011). One further pervasive problem with all revealed preference methods is that consumer decisions are based on perceived rather than objective perceptions. If adequate information on occupational risks is missing, then people's subjective assessment and objective measures may not correspond with each other very well, thus leading to biased estimates of individuals' willingness to pay (Frey et al., 2010).

More recently, the compensating income variation (CIV) approach (also commonly referred to as the subjective well-being valuation approach) has been proposed as an alternative to preference based measures (e.g. stated and revealed preferences) for determining how much individuals value improvements in health (Groot and van den Brink, 2006; Ferrer-i-Carbonell and van Praag, 2002; Powdthavee and van den Berg, 2011). The CIV method involves regressing a measure of life satisfaction on different health conditions, controlling for other personal characteristics such as income. The output from such a regression analysis can then be used to calculate how much individuals are willing to trade off income for better health, by estimating how much extra income an individual would require, to offset a given loss in life satisfaction arising from a health condition. In this paper, we use this approach to calculate the level of compensation that is required to make an individual indifferent between having and not having 15 different health conditions, using a large nationally representative survey in the UK. Since this approach does not rely on stated valuations, it is less prone to bias than CV, and

since it involves a randomly selected representative sample of individuals it is not subject to problems of self-selection, commonly associated with revealed preferences.

In calculating CIVs for health conditions, this paper addresses major issues in the existing literature in this area. First, to the best of our knowledge no study has accounted for endogeneity in income when it comes to calculating compensating income variations of health conditions. Failure to account for endogeneity in income means that the effect of income on life satisfaction is likely to be significantly understated and consequently derived CIVs which reflect health-income trade-offs will be biased upwards. Second, through the inclusion of measures of individuals' personality traits, commonly not available in large scale surveys, I account for any personality induced bias in in the regression estimates. Personality induced bias may have affected previous estimates of CIVs in health as people with different personality traits may be more/less affected by differences in health conditions and personality traits have also been shown to significantly affect life satisfaction (see Steel et al., 2008). One final advantage of this work is that I calculate CIVs for many other widely studied determinants of subjective well-being (e.g. unemployment, relationship status and social capital). In this way we can compare the CIVs for the health conditions under examination with that from many other factors commonly found to be significantly associated with life satisfaction. Our derived CIVs for health conditions range from a low of £6,177 for asthma to a high of £33,502 for congestive heart failure.

## **2. Life satisfaction and health**

One of the central assumptions underpinning neo-classical economics is that utility is formed based on the consumption of goods. In keeping with this conceptualisation of well-being, economists have commonly focused on determining how best we can increase the choices

available to people through, for example, raising incomes so that individuals can satisfy their preferences (Harsanyi, 1982; Dolan and White, 2007). Recently, however, there has been a resurgence of interest among economists in subjective indicators of well-being, as money and economic growth are increasingly recognised as an inadequate indicator of progress, especially in developed countries (Constanza et al., 2014). For example, while consumers are becoming increasingly satiated with products, this is often not matched by increases in how they rate their quality of life. This in turn has led to greater efforts aimed at understanding the nature of people's well-being beyond consumption opportunities (Forgeard et al., 2011; Hirschauer et al., 2015)

In particular, there is increasing interest in using direct reports of subjective well-being in the measurement of consumer preferences and social welfare. Emerging interdisciplinary research has begun to address concerns regarding the reliability of using these measures of well-being as an approximation for individually experienced welfare or utility and they have been shown to have a high scientific standard in terms of internal consistency, reliability and validity (Dolan and White 2007; Frey et al., 2010). For example, responses to life satisfaction questions is highly sensitive to factors we would expect to affect welfare and in the 'right' direction (see Fujiwara and Dolan, 2016). Direct reports of subjective well-being are also correlated with physical reactions that can be thought of as describing true, internal happiness (Alesina et al., 2004). For instance, individuals reporting to have a high degree of well-being tend to smile more (Pavot, 1991) and satisfied individuals are less likely to suffer from hypertension (Blanchflower and Oswald, 2008). Furthermore, research in psychology has shown that responses to questions about life satisfaction correspond with external reports on respondents by others (e.g. friends and partners) and life satisfaction ratings have also been shown to be

highly correlated with actual behaviour, e.g. suicide (Di Tella et al, 2003; Bray and Gunnell, 2006).

Once we accept that subjective measures of well-being (e.g. self-reported life satisfaction) can be a valid approximation for individually experienced welfare or utility, then we can value health conditions by estimating a micro-econometric life satisfaction function with the health conditions of interest and income included as explanatory variables. Not only will this provide a direct measure of the relationship between health conditions and individuals' reported well-being, but by using the point estimates for income and health conditions we can calculate constant trade-off ratios (Frey et al., 2010). In other words, how much extra income an individual would need to be compensated for a deterioration in their health. These trade-off ratios between income and health can inform on the benefits of health care interventions and, as such, assist policymaking decisions when it comes to cost-benefit analysis, which is the primary evaluation tool for health care expenditure in most developed countries (Dolan and Fujiwara, 2016).

This approach avoids some of the difficulties inherent with stated and revealed preferences. For example, it does not require that respondents evaluate hypothetical situations as in stated preference methods (e.g. contingent valuation). It is also less cognitively demanding for respondents and there is no reason to expect answers to be affected by strategic behaviour. Furthermore, in contrast to revealed preferences it does not presume rational agents and that markets are in equilibrium (Welsch, 2006). There is growing acceptance and subsequent use of this compensating income variation approach in the economics literature. It has been used, for example, to place a monetary value on airport noise (van Praag and Baarsma, 2005), flood



disasters (Luechinger and Raschky, 2009), terrorism (Frey et al., 2009), weather and climate (Maddison and Rehdanz, 2011) and air pollution (Luechinger, 2009; Levinson, 2012).

An important normative issue surrounds the question as to whether the measure of subjective well-being used in calculating values for health can be seen simply as a substitute for preferences (Adler, 2013; Dolan and Fujiwara, 2016). If subjective indicators of well-being reflect the degree to which an individual's preferences are satisfied, then CIVs can be interpreted as equivalent to willingness to pay and willingness to accept figures. Dolan and Kahneman (2008) and Fujiwara and Dolan (2016), among others, argue that subjective well-being measures provide an indication of experience as opposed to preference utility. In other words, subjective well-being measures record the intensity with which an individual is experiencing a positive or a negative state and the factors impacting how intense that state is (Adler, 2013). When subjective well-being is viewed in experience utility terms, the CIVs cannot be seen as comparable with values derived from other preference based approaches such as revealed and stated preference methods (Fujiwara and Dolan, 2016). Subjective well-being measures indicate the quality of an individual's mental state, and importantly for the purposes of policy formulation, still present legitimate estimates of compensating and equivalent measures of welfare change<sup>1</sup> (Fujiwara and Dolan, 2016).

Rather than calling the values derived from our subjective well-being model as willingness to pay estimates we refer to these figures as compensating income variations, i.e. the amount of extra equivalent household income<sup>2</sup> to be given to someone with a health condition to leave

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<sup>1</sup> Legitimate in the sense that they can be derived mathematically from subjective well-being functions (see Fujiwara and Dolan, 2016)

<sup>2</sup> Equivalent household income is calculated by dividing household income by the square root of the household size. This implies that, for instance, a household of four persons has needs twice as large as one composed of a single person. This scale is often used by the OECD and other organisations for comparing income inequality and poverty across areas (e.g. OECD 2011, OECD 2008))

them with the same levels of life satisfaction as someone without that health condition. A further question arises in relation to which subjective well-being measures such be used to value health conditions. In this study we focus on life satisfaction which can be seen as being made up of a balance of affect (emotions and feelings) together with a cognitive evaluation of how satisfied they are with their life overall, i.e. how well their quality of life measures up to aspirations and goals (Dolan and Fujiwara, 2016). This can be seen as the most common measure of subjective well-being used to derive compensating income variations in the literature to date. We do recognise, however, that there are other dimensions of well-being that are better captured by other indicators such as happiness questions or the degree to which an individual has a strong sense of purpose or meaning in life (eudaimonic dimension).

Looking specifically at research relating to health conditions, a number of recent studies have made an important contribution to the field of health care evaluation by also applying this technique in estimating how much extra income an individual would need to be ‘compensated’ for cardiovascular disease (Groot et al., 2004a; Groot and van den Brink, 2006; Latif, 2012), headaches/migraines (Groot and van den Brink, 2004b) and chronic pain (McNamee and Mendolia, 2014). A smaller number of studies have also used this approach in valuing a range of different health conditions (Ferrer-i-Carbonell and van Praag, 2002; Groot and van den Brink, 2008; Mentzakis, 2011; Powdthavee and van den Berg, 2011; Graham et al., 2011). Our study offers a number of advantages relative to this pre-existing research. First we account for endogeneity in income in calculating our derived CIVs. Second, by taking advantage of the Big Five personality traits recorded in the household survey used in this study, we are able to add in measures of individual’s personality traits as control variables to the analysis. To help

put these findings into perspective we also calculate CIVs for a wide range of other determinants of life satisfaction.

### **3. Data**

The dataset used in this analysis is Understanding Society: the UK household longitudinal study (UKLS). This is a comprehensive household survey that started in 2009 with a nationally-representative stratified, clustered sample of around 50,000 adults (16+) living in the United Kingdom. It uses an overlapping panel design with data collection for a single wave conducted across 24 months. Interviews are typically carried out face-to-face in respondents' homes by trained interviewers. Our measure of life satisfaction is based on respondents answer to the following question: Please choose the number which you feel best describes how dissatisfied or satisfied you are with your life overall. Respondents are given a 7 point scale ranging from 1 completely dissatisfied to 7 completely satisfied. The key explanatory variables of interest are derived from participant's response to a question about whether they have been diagnosed with certain health conditions asked in wave 1 (2009 – 2011) of the survey. Participants were presented with a card listing 17 health conditions and asked 'Has a doctor or other health professional ever told you that you have any of the conditions listed on this card'. Participants who reported that they had been diagnosed with one of these conditions were then asked if they still had that health condition<sup>3</sup>.

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<sup>3</sup> As noted by one of our referees, there could be various sources of measurement error at play when relying on respondent's own self-reports when it comes to diagnosing medical conditions. For example, respondents might have the condition, but haven't been diagnosed or simply may have forgotten the fact of diagnosis. If this measurement error is significant then this could lead us to underestimate the effect of health conditions on life satisfaction. Due to data constraints it is not possible to test for this source of bias but is worth highlighting as a useful avenue for future research, i.e. to what extent is relying on self-reported evaluations of health conditions biasing estimates of the relationship between health and life satisfaction?

Using this information, we derive dummy variables indicating if a survey participant is currently suffering from a specified health condition. This is important as much of the literature in this area is based on responses where participants are asked to recall if they have ever suffered from a specified health condition. The effect of health conditions on life satisfaction will likely be understated when the measures used capture both those who currently suffer with a health condition and those who suffered in the past, but now free of that condition.

A further advantage of this survey dataset is that it allows for a relatively detailed classification, in comparison to many prior studies of health conditions. For example, respondents are asked to report whether they suffer from a number of specific cardiovascular diseases (e.g. angina, high blood pressure, congestive heart failure, coronary heart disease, stroke) as opposed to just a broad classification of heart or cardiovascular issues. Similarly, respondents are asked to indicate if they have a current diagnosis of a number of respiratory conditions (e.g. asthma, chronic bronchitis, emphysema). Other conditions examined are cancer or malignancy, liver conditions, epilepsy, diabetes, arthritis, hyperthyroidism and hypothyroidism. Dummy variables reflecting whether a respondent has a current diagnosis of one of 15 different health conditions along with equivalent household income were then entered as the main explanatory variables of interest in a regression analysis of life satisfaction (see table 1)<sup>4</sup>.

Based on prior research, we include a rich set of commonly observed predictors of life satisfaction (see Dolan, 2008 for a review of this literature). These include socio-economic

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<sup>4</sup> Two of the 17 health conditions were excluded from the analysis for various reasons. While a number of individuals reported that they had a heart attack, as one would expect in a survey such as this none of the respondents reported that they were actually suffering from a heart attack. Therefore if we included this measure we would be estimating the effect of being diagnosed at some point with a heart attack on life satisfaction as opposed to the effect of suffering from a heart attack on life satisfaction. Depression was left out from the analysis given the close correspondence between indicators of psychological health and general life satisfaction. i.e. to some extent they can be regarded as alternative metrics of welfare. For interested readers the derived CIV for depression comes to £206,261.

variables such as age, gender, relationship status, number of children, education and labour force status. We add variables reflecting the extent to which individuals talk with their neighbors and participate in religious activities as overall proxy variables for social capital. We also added a variable reflecting whether respondents care for someone that is sick, disabled or elderly as this has recently been found to be negatively related with life satisfaction (van den Berg et al., 2014). Regional dummy variables were included to capture regional differences in access to medical care. We include household income in its natural logarithm which reflects the diminishing marginal utility of income (see Layard et al., 2008). We also controlled for the square root of household size to make a real equivalent household income variable, i.e. make household income comparable across different household compositions (see footnote 1).

Unfortunately large scale surveys that collect detailed information in relation to health conditions are cross sectional in nature, or like this survey longitudinal, but do not collect information on health conditions in enough waves to enable longitudinal data analysis (e.g. fixed effects). This leaves the regression estimates from using such a dataset open to bias from unobserved sources of heterogeneity. One potentially important source of unobserved heterogeneity may arise from personality traits. Personality differences may lead to biased estimates of the effect of health conditions on life satisfaction, as personality traits are correlated with both life satisfaction (see Steel et al. 2008 for a review), as well as the likelihood of acquiring a wide range of mental and physical disorders (see Goodwin and Friedman 2006). Neglecting this unobserved heterogeneity may result in what psychologists call a ‘personality bias’ on the obtained estimates. An advantage of this work is that we are able to include measures of personality traits (namely the Big Five personality traits) as additional controls in the regression analysis of life satisfaction, to control for any potential personality induced bias in the coefficient estimates. To obtain a measure of the Big Five

personality traits, participants in wave 3 (conducted between 2011 and 2013) were asked to what extent they agree/disagree with 25 statements beginning with the quote “I see myself as someone who”. Each statement is classed in one of five categories: extraversion, agreeableness, conscientiousness, neuroticism and openness. A composite score for each personality trait is then derived by summing the scores for each of the individual categories.

One potentially problematic issue in using these personality traits as control variables in our analysis is that individuals’ personality traits are recorded in wave 3 of the survey, whereas the health conditions are only recorded in wave 1. Given that the Understanding Society survey employs a longitudinal study design (mostly the same respondents are re-interviewed in each wave) we can, however, match individuals with diagnosed health conditions recorded in wave 1 (2009-2011) to their personality traits recorded in wave 3 (2011-2013). The predominant view in the literature is that personality traits are relatively stable over time (at least among adults – see Borghans et al. 2008). However, some recent longitudinal research suggests that personality change does occur over an individuals’ life cycle (Boyce et al., 2013). Notwithstanding this possibility, it seems likely that if any personality changes do occur then they will be relatively minor given the short time that would have elapsed between when respondents were interviewed as part of wave 1 of Understanding Society and then as part of wave 3.

This matching could still potentially be problematic given that individuals with relatively more serious health conditions are perhaps more likely to drop out of the survey between wave 1 and 3 than an average survey participant. This could give rise to a selection bias if we are relying on this data to test the relationship between personality traits and health conditions. In this study, however, personality traits function merely as additional controls in helping us to

correctly identify the relationship between health and life satisfaction, and in the absence of better data, testing the sensitivity of our health coefficients to the inclusion of the Big Five personality traits does at least give us a useful indication of the likelihood of ‘personality induced bias’ affecting the regression estimates.

#### 4. Analysis

The analysis begins by assuming that the life satisfaction measure (LS) is a function of equivalent household income (Y), the particular health condition of interest (h), a vector of other health conditions (H) and the individual’s other characteristics (X):

$$LS = LS(Y, h, H, X)$$

Assuming a linear functional form and a constant marginal utility of income yields:

$$LS = \beta_0 + \beta_1 Y + \beta_2 h + H' \beta_3 + X' \beta_4 + \varepsilon$$

The premise of the life satisfaction approach for valuation is that we can calculate compensating and equivalent measures<sup>5</sup> of welfare change from data on individuals self-reported well-being (Fujiwara, and Dolan, 2016). The compensating income variation (CIV) for condition h can be determined as the level of equivalent household income required to equate life satisfaction in the presence of the condition (e.g. having congestive heart failure) (h=1) to the level that would exist in the absence of the condition (h=0):

The CIV can be calculated as:

$$CIV = \frac{-\beta_2}{\beta_1} \quad [1]$$

In this study, in order to capture the decreasing marginal utility of income, life satisfaction is assumed to be a function of the log of equivalent household income. Under this specification

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<sup>5</sup> The compensating version “is the amount of money, to be hypothetically deducted or provided, that would leave the agent in his initial SWB position following a change in the good, and the equivalent version of the SWB value is the amount of money, to be hypothetically deducted or provided, that would leave the agent in his subsequent SWB position in absence of a change in the good” (see Fujiwara and Dolan, 2016 on p.14).

the CIV can be derived as (see Powdthavee and van den Berg, 2011; Asgeirsdottir et al., 2015 and O Neill, 2016 for a more detailed exposition):

$$CIV = Y_i * \left( \exp\left(\frac{-b_2}{b_1}\right) - 1 \right) \quad [2]$$

where  $Y_i$  = average annual equivalent household income of the survey sample

Life satisfaction scores are reported on an ordinal scale. However, in keeping with prior research (see Ferrer-i-Carbonell and Frijters 2004) assuming cardinality of life satisfaction scores had little influence on findings and for ease of reading, I assumed cardinality in life satisfaction.

## 5. Results

### 5.1. Basic specification

Table 2 reports the basic life satisfaction regression including the full set of control variables. The results relating to the control variables are all along expected lines and correspond with the results widely documented in previous literature (see Dolan et al., 2008). For example, we observe a negative relationship between age and life satisfaction, but a positive relationship between age squared and life satisfaction. This would be in keeping with previous work which suggests a U-shaped relationship with higher levels of life satisfaction for the relatively younger and older groups, with the lowest levels in middle age<sup>6</sup>. As expected, unemployment was negatively related, whereas education and being in a relationship was found to be positively related with life satisfaction. The proxy variables relating to social capital (talk to neighbours and participate in religious activities) were both positively related with life

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<sup>6</sup> Recent work by Frijters and Beaton (2012) suggests that this commonly observed U-shaped relationship could be due to selection effects, i.e. household surveys typically over-sample older happier individuals and under-sample relatively unhappy middle aged individuals



satisfaction. Finally, in keeping with recent research by van den Berg et al. (2014), individuals who care for someone who is sick, disabled or the elderly is likely to have a significantly lower level of life satisfaction.

The key variables of interest are the log of equivalent household income and our dummy variables indicating whether a respondent has a current diagnosis of one of the 15 specified health conditions. The findings in relation to health conditions are all along expected lines. All the health conditions are statistically significant and negatively related with life satisfaction with the exception of hypothyroidism, which although of the expected sign is not statistically significantly different from zero. It is a relatively common disorder of the endocrine system in adults and causes a number of symptoms such as poor ability to tolerate cold, a feeling of tiredness, and weight gain. It would, however, typically be a relatively benign condition (at least in the majority of cases) and this perhaps explains its lack of statistical significance in our baseline specification. Turning to the other health conditions, in addition to being statistically significant, the relative magnitude of their effects are also along expected lines in that health conditions such as asthma and high blood pressure are associated with a smaller change in life satisfaction than what are generally regarded as more serious health conditions such as congestive heart failure and epilepsy. For example, having congestive heart failure is associated with a half point decrease in our seven point life satisfaction scale. On the other hand, having high blood pressure is associated with a 0.13 point decrease in the life satisfaction scale.

The log of equivalent household income also has the expected positive sign and is statistically significant suggesting that higher household incomes is associated with higher life satisfaction scores. There are, however, a number of reasons to expect that the effect of income on life satisfaction is substantially downward biased due to endogeneity and this would lead to

erroneously large CIVs. One such source of endogeneity bias likely arises through measurement error in income, which can bias the estimated effect towards zero. In addition, neglecting unobserved heterogeneity which may be correlated with both income and life satisfaction can also result in biased estimates. For instance, incomes are likely to be highly positively correlated with factors such as working hours, time spent away from family and loved ones, time spent commuting and stress, all of which are potentially strongly negatively correlated with life satisfaction, thus leading to downward biased estimates (Powdthavee, 2010).

The solution to these endogeneity problems is to find an instrument for household income, i.e. something that is correlated with income but does not have an independent effect on life satisfaction, after conditioning on the other included variables. Within our data we have two possible instrumental variables, namely the educational status of respondents' parents. These are suitable instrumental variables as there is much research to suggest that parental education (both mothers and fathers) can influence children's achievements such as their income levels in later life (Blanden and Gregg, 2004; Tomul and Celik, 2009; Dahl and Lochner, 2012; Erola et al., 2016). Children from highly educated parents are relatively more likely to derive benefits when it comes to household income from financial endowments (Musick and Mare, 2006, Erola et al., 2016). In addition to a direct transfer of economic and material resources, there are a number of other indirect pathways in which parental education would be expected to affect their adult children's income level. For example, parental education may be a signal of social status or prestige that may be helpful for their children in the labour market (Erola et al., 2016). One would also expect that children of relatively more educated parents would be more likely to have at their disposal advantageous parental social networks that would assist them in the labour market (Jager, 2007).

While there are strong grounds to suggest that parental education levels affect their children's outcomes such as income in later life, we argue that there is unlikely to be a direct effect of parental education on their adult children's life satisfaction. Even respondents own education level is typically found to be only weakly related to life satisfaction - in fact in many studies it is found to have no effect once confounding factors such as income and health are adequately controlled for (see Dolan et al., 2008). Perhaps one could argue that there could be indirect effects in that children of more highly educated parents are endowed with a variety of skills that could lead to better labour market outcomes, health, marriage and education, all of which can lead to higher levels of life satisfaction. However, we control for these indirect channels through which one could argue that parental education could plausibly affect their adult children's life satisfaction, e.g. income, health, family and occupational status and even personality traits are all control variables in the regression analysis. The question then becomes whether, after conditioning on these control variables, is it reasonable to expect that parental education will still affect their adult children's life satisfaction? This paper argues that it is not. This argument is supported by a recent cohort study by Frijters et al. (2014), which examined the relationship between childhood characteristics and life satisfaction. Using the National Child Development Study which contains detailed information about participant's lives from birth to age 50, they found that children with more highly educated parents were not found to have higher life satisfaction scores than children with relatively less educated parents<sup>7</sup>.

Knight et al. (2009), also recently used parental education to instrument for respondent's income in a study of the determinants of happiness in rural China and found that the instrumented income coefficient was over four times larger than that estimated when using

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<sup>7</sup> The authors are careful to point out that they are not able to make strong causal statements given the method of analysis.

conventional ordinary least squares (OLS). As outlined below, our results using this UK sample are very similar to that reported by Knight et al. (2009). Encouragingly our results are also similar to other recent research using different sets of instrumental variables to identify the effect of income on life satisfaction (Luttmer, 2005; Luechinger, 2009; Powdthavee, 2010). Luttmer (2005), and Luechinger (2009), for example, both used predicted household earnings to instrument for income when examining the role of relative earnings on happiness and estimating compensating income variations for air pollution respectively, and found that instrumenting income resulted in an estimated effect that was three times larger than what was estimated in their baseline OLS specification. Powdthavee (2010) used variables relating to the proportion of household members who showed the interviewer their payslip to instrument for log of real household income and found that after instrumenting, the estimated effect of income on happiness doubled as compared to that estimated using OLS.

The estimated effect of income on life satisfaction in our analysis more than trebles (increases from 0.14 to 0.49) once we instrument income (two stage least squares (2SLS)) as compared to the OLS estimates. All the instruments have the expected significant relationship with the log of equivalent household income. In all cases, the statistical tests suggest that the instruments are relevant. The Anderson canonical correlations likelihood ratio test rejects the null of underidentification. The obtained F statistic at 15.3 exceeds the conventional minimum standard of power of  $F = 10$  (Stock et al., 2002). We can test the validity of the instruments, conditioning on the assumption that a subset of instrument is valid, by implementing the standard overidentification test. The resulting Sargan's test statistic was statistically insignificant with a p value of 0.79 and therefore we can be reasonably satisfied that our instruments are consistent in producing robust estimates of the effect of the log of equivalent household income on life satisfaction.

Another important way to assess the validity of the instrumental variables is to test how robust the coefficients are to the selection of different combinations of instruments. We examined the effect of either just using mother's education level or father's education level as instruments, and the results were robust to these different combinations. For instance, our estimated coefficient for the log of equivalent household income when we just used the two dummy variables reflecting the education level of the participant's mother as instruments was 0.50, whereas when father's education levels was used, the estimated coefficient was 0.47. This compares to a coefficient of 0.49 when both mother's and fathers' education level are used as instruments.

## 5.2. Compensating income variation

Using the coefficients representing the effect of health conditions on life satisfaction, as well as our instrumented log of equivalent household income coefficient, we next derive an estimate of the extra equivalent household income (compensation) an individual with a health condition would require in order to experience the same level of life satisfaction, as an otherwise identical individual without that health condition. We do this for all 15 health conditions examined in the life satisfaction equation. To calculate the CIVs, we need to estimate equation 2 described earlier. Taking congestive heart failure as an illustrative example, the extra equivalent household income required to leave someone with congestive heart failure as well off in life satisfaction terms as someone without the condition amounts to £33,502 per annum. At the other end of the scale, the extra equivalent household income needed when it comes to asthma amounts to £6,177 per annum. For cancer or malignancy, a liver condition and a stroke the compensating income variation amounts to £18,169, £16,103 and £15,385 respectively. The results relating to the remaining health conditions are presented in table 3.

One important point to note is that these monetary values would have been grossly overstated if we had not instrumented our income measure. Specifically, failure to control for endogeneity in income will understate the effect of income on life satisfaction which means that the amount of extra income needed to ‘compensate’ individuals for losses in health (or indeed other arguments in their utility function) will be significantly overstated using conventional OLS estimates. Comparing the monetary estimates obtained in this study with derived estimates from other studies which have not taken account of endogeneity bias is challenging, given the variability in health conditions examined (most often just one) and the different income measures and time spans of the survey’s used. Notwithstanding these difficulties, we can see a general pattern whereby the compensating income variations obtained in this study, while substantive, are generally much lower than that reported in previous work which have used the CIV approach (see section 2).

In order to help put these findings into perspective, I next derive CIVs for many other factors commonly found to be significantly related with life satisfaction. These results can also be seen in table 3. In keeping with findings reported by Graham et al. (2011) who calculated life satisfaction equivalents for various health conditions in Latin American countries, we find that disutility losses associated with health conditions are high relative to that of many other factors commonly reported as significantly affecting life satisfaction. For example, marital separation and divorce are factors commonly associated with life satisfaction losses, and we find that the amount of extra income needed to compensate someone who is separated or a widow, to leave them as well off in life satisfaction terms, as someone who is single amounts to £3,641 and £6,941 respectively. The CIVs for all the health conditions examined with the exception of asthma and hyperthyroidism exceed these values. The derived CIV to compensate someone who cares for someone that is sick, disabled or the elderly is £17,089 and again the CIVs for

many of the health conditions exceed this value. Other than health, unemployment is the factor commonly associated with the largest life satisfaction losses in the literature and we also find the non-pecuniary losses associated with unemployment to be substantive, with a compensating income variation of £29,367. The derived CIVs for congestive heart failure and chronic bronchitis exceed that of unemployment and epilepsy is only marginally behind at £27,785. Given that our health coefficients capture average effects, and that many of these conditions have varying degrees of severity, it is likely that a significant number of individuals with other health conditions reported in table 3 also experience larger disutility losses from a health condition than they would from unemployment. Looking at table 3, we can also see that the CIVs for health are also high relative to our indicators of social capital (regular attendance at religious services and events and neighbourly interaction).

### 5.3. Sensitivity to personality controls

One potential threat to the validity of these results is due to ‘personality induced bias’ as personality traits are significantly correlated with both life satisfaction and certain health conditions. One way to test the likely importance of personality caused bias in the coefficient estimates is to test how robust they are to the inclusion of variables reflecting personality traits. In this study, we are able to test the sensitivity of the results relating to the effect of health conditions on life satisfaction to the inclusion of the Big Five personality traits. In keeping with the findings outlined in Steel et al. (2008), neuroticism, extraversion, agreeableness and conscientiousness were all significantly related to life satisfaction, whereas openness had no statistically significant relationship (see column 6 in table 2). One limitation with the approach used here is that by matching personality traits collected in wave 3 (2011-2013) with diagnosed health conditions collected in wave 1 (2009-2011), the results relating to the relationship between health conditions and life satisfaction reported in this specification could be affected

by attrition bias, which might impact on the extent to which the results can be generalised to the wider cohort. Still in the absence of better data, all we can do is to remain cognisant of this limitation, and remind readers of this potential shortcoming when it comes to assessing the likelihood of personality induced bias in the coefficient estimates.

The coefficients relating to key explanatory variables of interest, namely the log of equivalent household income and health conditions (with some exceptions) were largely unaffected by the inclusion of the Big five personality traits (see column 6 of table 2). The exception is whether a respondent has a current diagnosis of a liver condition or a stroke, as while of the expected sign, these variables were no longer statistically significant and the coefficient size were much smaller. One potential explanation for this difference is due to attrition bias as many of the respondents with a current diagnosis of a stroke or liver condition recorded in wave 1 were not re-interviewed in wave 3. Given the serious nature of many liver and stroke conditions, it is possible that individuals who were not re-interviewed are systematically different than those who were. Notwithstanding the possibility for attrition bias when it comes to estimating the sensitivity of our health coefficients to the inclusion of personality traits, the fact that, for the most part, our coefficients reflecting health conditions were robust to the inclusion of personality controls should support the argument that unobserved heterogeneity arising from the omission of personality variables are not significantly biasing our derived CIVs, although some caution is required when using the figures for stroke and liver conditions.

## **6. Conclusion**

A rapid increase in expenditures has fostered the need to quantify the value of health benefits obtained by health care interventions (Groot and van den Brink 2008). While one can rely on an assessment by the medical doctor or clinician to value a health gain or loss, many consider



that it is most appropriate to elicit valuations from those people who are currently experiencing the health states for which values are sought (Dolan, 1999). One commonly used method for monetising the benefits of health care interventions is to ascertain how much individuals are willing to pay for one health state relative to another. The two most commonly used approaches for eliciting willingness to pay are revealed preferences and contingent valuation. Revealed preferences involve deducing willingness to pay from observed behaviour (e.g. hedonic wages), whereas the contingent valuation method asks individuals to directly state their willingness to pay for a hypothetical change in health. An alternative approach that has been increasingly suggested by economists as a useful mechanism for eliciting valuations for health care interventions (and indeed a wide variety of other public goods) is the compensating income variation (CIV) approach. This involves estimating a micro-econometric life satisfaction equation, with various health conditions and income included as explanatory variables. By calculating the marginal rate of substitution between income and health, we can calculate how much extra income an individual would require to compensate them for each of the health conditions examined.

While not without its own set of limitations (see Levinson (2012) for a more detailed overview), this approach does have a number of advantages over revealed and stated preference methods. Relative to stated preference methods (e.g. contingent valuation), for example, the scope for framing effects, strategic behaviour and hypothetical bias is reduced. It is also less cognitively demanding for individual's as they are not asked to value health conditions directly, rather to evaluate their own life satisfaction. Furthermore, it uses information on the entire population, thereby avoiding problems of self-selection associated with revealed preferences (e.g. the hedonic wage approach).

Using the compensating income variation (CIV) approach, we calculated the amount of income needed to make someone with a current diagnosis of one of 15 specified health conditions as well off as someone without these health conditions. The compensating equivalent household income variations ranged from £6,177 (asthma) to £33,502 (congestive heart failure) depending on the health conditions examined. Therefore we can see that health conditions significantly affect individuals' quality of life and that the amount needed to make someone with a health condition as well off as someone without those health conditions can be substantive. By putting what amounts to a price tag on various health conditions, health policy makers can make direct comparisons between the relative benefits and costs of different treatment options or ideally measures aimed at reducing the numbers of people acquiring these health conditions (Pownthavee and van den Berg, 2011). This, in turn, can make decision making about which health care interventions to prioritise more straightforward than would otherwise be the case. It can also allow us to compare the benefits of good health with other factors found to affect individual's life satisfaction.

One important limitation of this analysis concerns the validity of the instruments used to address income endogeneity. Our identifying assumption is that parental education level is correlated with individuals' income but not directly related to their adult children's life satisfaction. Our instruments pass the usual validity checks, i.e. test of overidentifying restrictions and are also robust to different combinations of instruments. Despite these validity checks one could still argue that parental education level could affect their adult children's life satisfaction indirectly through an association with other individual outcomes such as income, health, family status, occupation and even personality traits. While these are variables we control for in our analysis we acknowledge that there may still be other indirect channels unaccounted for in our model specification through which parental education could affect

individual's life satisfaction. Having said that, the validity of our instruments is supported by recent cohort studies which have found that children with more highly educated parents were not more satisfied adults (Frijters, et al., 2014).

Our instrumental variable (IV) estimates are also similar to that obtained in other recent studies which have used different sets of instruments (e.g. predicted earnings and whether the respondent shows interviewers their payslip) and this should also help to alleviate concerns relating to the validity of the instruments used in this analysis. In keeping with our own results these studies have reported that IV estimates are between 2 and 5 times larger than conventional OLS estimates. One further limitation with this analysis is that due to data limitations pertaining to measures of health conditions contained in this dataset, and indeed other commonly used health datasets, we are only able to calculate a single value for each particular health condition. Many of these health conditions can, however, have varying degrees of severity and as such it would be useful for future work to examine to what extent these average values vary depending on the severity of the health condition under examination.

Despite this note of caution, this work had a number of advantages over previous research using the CIV approach for valuing health conditions. For example, one advantage of the dataset used in this analysis is that it allowed a comparison of a wide range of health conditions. Furthermore, to the best of our knowledge, this study provides the first estimates of the amount of income that is needed to 'compensate' for different health conditions which correct for endogeneity in income<sup>8</sup>. Results suggest that estimates of the effect of income on life satisfaction in previous studies using the 'compensating income variation' approach are likely

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<sup>8</sup> Powdthavee (2009) touched on this issue by estimating the CIV for self-reported disability status as opposed to specific diagnosed medical conditions. Similar to our analysis of medical conditions he also found that conventional regression estimates will lead to an upward bias when estimating the CIV for disability.

to be downward biased due to endogeneity. This means that they will typically overestimate the amount of extra income needed to leave the life satisfaction of someone with a specified health condition the same, as someone without that condition. Of course it is not just in health where the life satisfaction approach has been used to value public goods and the same point applies. Without correcting for endogeneity bias, the amounts needed to compensate individuals for losses in health or other arguments in their utility function, is likely to be significantly overestimated.

An additional advantage of this work is that we were able to examine the sensitivity of the results to the inclusion of variables designed to measure personality traits. The results were generally robust to the inclusion of the Big Five personality traits which suggest that ‘personality induced bias’ is not significantly affecting the reliability of the CIV estimates and also should be of some comfort to other researchers who do not have measures of personality available as control variables. This is also in keeping with research by Helliwell (2008), who found that his estimated coefficient reflecting the relationship between individual’s own subjective evaluation of their health status and life satisfaction, was also largely unaffected by the inclusion of personality related variables<sup>9</sup>. To put these findings into perspective, we also calculated CIVs for many other factors associated with life satisfaction losses. For example, the CIVs for unemployment, separation, widowhood and caring for someone that is sick, disabled or the elderly amounted to £29,367, £3,641, £6,971 and £17,089 respectively. To conclude, the analysis suggests that health conditions significantly affect individuals’ quality of life and that the amount needed to make someone with a health condition as well off as

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<sup>9</sup> Of course personality is not just related to health but also to many of the other explanatory variables. Personality, for example, may affect the likelihood of getting married, employment and social interaction with others and these have all been found in this study (and indeed many others) to be significantly related with life satisfaction. It is, therefore, interesting to report that the coefficients relating to these variables also appear to be largely unaffected by the addition of these personality variables.

someone without those health conditions can be substantive, albeit less than is commonly reported in the literature using the CIV approach to date.

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## List of tables

**Table 1: Key summary statistics**

Health Conditions	Number with each health condition
Angina	544
Arthritis	3,862
Asthma	3,375
Cancer or a malignancy	287
Chronic bronchitis	274
Coronary heart disease	414
Congestive heart failure	96
Diabetes	1623
Emphysema	162
Epilepsy	219
High blood pressure	4,140
Hyperthyroidism (over-active thyroid)	167
Hypothyroidism (under-active thyroid)	848
Liver condition	220
Stroke condition	465
Mean equivalent annual household income	£23,352

**Table 2: Determinants of life satisfaction**

	Coef.	Std. Err.	t	Personality controls added
Equivalent household income ***	0.138	0.011	12.080	0.150 ***
Age ***	-0.035	0.003	-11.000	-0.042 ***
Age squared ***	0.000	0.000	11.530	0.000 ***
Female ***	0.041	0.016	2.590	0.092 ***
Relationship status - single is the reference category				
Married ***	0.248	0.024	10.410	0.207 ***
Separated **	-0.071	0.034	-2.100	-0.122 ***
Widowed **	-0.128	0.065	-1.980	-0.151 **
Number of children ***	-0.048	0.008	-5.890	-0.046 ***
Has a degree ***	0.057	0.017	3.440	0.065 ***
Employment status - employed is the reference category				
Self-employed	0.019	0.030	0.630	0.016
Unemployed ***	-0.399	0.033	-12.180	-0.380 ***
Retired ***	0.247	0.035	7.110	0.280 ***
Familycare *	-0.058	0.030	-1.940	0.023
Training ***	0.214	0.033	6.470	0.206 ***
Disabled ***	-1.149	0.048	-23.810	-1.035 ***
Other **	-0.557	0.253	-2.200	-0.548 *
Regularly attend religious services **	0.045	0.022	2.040	0.024 ***
Regularly talk with neighbors ***	0.255	0.019	13.410	0.201
Cares for sick, disabled or elderly in the household ***	-0.269	0.028	-9.690	-0.258 ***
Angina ***	-0.167	0.063	-2.650	-0.116
Arthritis ***	-0.155	0.026	-6.030	-0.135 ***
Asthma ***	-0.115	0.025	-4.590	-0.081 ***
Cancer or malignancy ***	-0.282	0.082	-3.460	-0.311 ***
Chronic Bronchitis ***	-0.412	0.086	-4.800	-0.397 ***
Coronary Heart Disease **	-0.162	0.072	-2.250	-0.142
Congestive Heartfailure ***	-0.436	0.143	-3.040	-0.595 ***
Diabetes ***	-0.263	0.036	-7.240	-0.291 ***
Emphysema **	-0.231	0.111	-2.090	-0.287 *
Epilepsy ***	-0.384	0.093	-4.150	-0.388 ***
High bloodpressure ***	-0.125	0.025	-4.990	-0.060 **
Hyperthyroidism ***	-0.300	0.106	-2.840	-0.379 ***
Hypothyroidism	-0.055	0.048	-1.150	-0.016
Liver condition***	-0.257	0.093	-2.770	-0.099
Stroke ***	-0.248	0.065	-3.790	-0.074
Regional controls left unreported for parsimony				
<i>Personality controls</i>				
Openness	-0.008			

Agreeableness***	0.056			
Extraversion ***	0.035			
Neuroticism***	-0.169			
Conscientiousness***	0.083			
N	34,379			21,511

**Table 3: Compensating income variations**

<i>Health condition</i>	£ (per annum)
Angina	-9,483
Arthritis	-8,689
Asthma	-6,177
Cancer or a malignancy	-18,169
Chronic bronchitis	-30,784
Coronary heart disease	-9,150
Congestive heart failure	-33,502
Diabetes	-16,590
Emphysema	-14,604
Epilepsy	-27,785
High blood pressure	-6,786
Hyperthyroidism (over-active thyroid)	-19,722
Hypothyroidism (under-active thyroid)	-2,774
Liver condition	-16,103
Stroke condition	-15,385
<i>Other correlates of life satisfaction</i>	
Married (single is the reference category)	+15,385
Separated (single is the reference category)	-3,641
Widowed (single is the reference category)	-6,971
Unemployment (employed is the reference category)	-29,367
Cares for sick, disabled or elderly in the household	-17,089
Regularly talk with neighbors: Strongly agree with the statement 'I regularly stop and talk to my neighbors' (does not strongly agree with the statement is the reference category)	+15,943
Regularly attend religious services: I attend religious services or events once a week or more (do not attend or attend less often than once a week is the reference category)	+2,246
Retired (employed is the reference category)	+15,306