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**Mental Health Spillovers from Serious Family Illness: Doubly
Robust Estimation Using EQ-5D-5L Population Normative Data**

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ABSTRACT

People are interconnected and ill-health is rarely experienced in isolation. However, while there has been extensive research on health spillovers related to informal caregiving, there is comparatively little evidence on how ill-health may impact upon non-caregiving family members. This paper analyses EQ-5D-5L normative data from a nationally representative sample of adult residents of Ireland to estimate the independent relationship between serious family illness and five distinct dimensions of health. The empirical strategy combines inverse probability weighting and multivariate ordered probit regression in a doubly robust estimation. We find that experience of serious family illness is associated with large mental health decrements that are independent of caring responsibilities, while similar results are not evident for the four other health dimensions. Furthermore, stratified sub-sample analyses indicate considerable heterogeneity by sex and by income. In particular, we find evidence consistent with larger mental health spillovers for females than for males, as well as for low and medium income households relative to high income households. The latter suggests that such spillovers may be substantially worse for those with fewer resources. Overall, the findings have a range of potential implications, including for the provision of mental health supports and services, for equity of health outcomes, as well as for health economic evaluation. For example, we calculate that our estimates of health spillovers are consistent with a 1.3% reduction in health utility for non-caregiving family members.

KEYWORDS

Health Spillovers; Mental Health; Inverse Probability Weighting; Multivariate Ordered Probit Model; Doubly Robust Estimation; EQ-5D-5L.

1. INTRODUCTION

People are interconnected and ill-health is rarely experienced in isolation (Smith and Christakis, 2008; Wittenberg and Prosser, 2013). For example, it has been suggested that the physical and mental strain of ‘caring for’ an ill or disabled relative imposes a health- and quality of life-related burden (Bhadhuri et al., 2017; Brouwer, 2006). In addition, the illness experience of an individual is also thought to ‘spillover’ and exert a psychic or emotional toll on both caregiving and non-caregiving family members, and this is a result of ‘caring about’ the person (Al-Janabi et al., 2016; Bhadhuri et al., 2017; Bobinac et al., 2011; Wittenberg, Ritter, et al., 2013). Taken together, this suggests that the conceptualization of health effects should extend beyond the individual to those physically present and/or emotionally connected (Wittenberg, Saada, et al., 2013). Thus, in this paper, we consider the relationship between serious family illness and the mental health of non-caregiving family members.

In a health economics context, how an individual’s health may impact upon family members, and consequently health care demand, has been extensively discussed (Basu et al., 2010; Jones-Lee, 1992). Much of the early dialogue in relation to spillovers focussed on impacts on wider welfare, as opposed to health *per se* (Al-Janabi et al., 2016). For example, Lees (1967) described these externalities as “the disutility felt by an individual at the thought that others are not getting adequate medical care”. However, in keeping with the prevailing view of the period, the author also suggested that they were less than “minimally relevant” to the political economy of health services (Lees, 1967). In contrast, subsequent work from Culyer (Culyer, 1971; Culyer and Simpson, 1980; Culyer, 1989) showed how, through ‘interdependent utility functions’ or ‘caring externalities’, health care consumption might generate welfare gains in others.

In an effort to provide theoretical support for the interpersonal value of health, Jacobson (2000) extended the individualistic Grossman model of demand for health care (Grossman, 1972) to

show how other family members' health is important for an individual's own health stock and for health care utilisation. In particular, she considered each family member to be a producer of other family members' health, as well as their own. As a result, they receive investment and consumption benefits from investing in the health of other family members. The family, therefore, invest in health "until the rate of marginal consumption benefits equals the rate of marginal net effective costs of health capital" (Jacobson, 2000).

As highlighted by Basu and Meltzer (2005), the Jacobson model is not without limitation. In particular, they suggest it does not take transitions between family structures into account or provide a guide for treatment choice while making an investment in health, thus restricting the relevance of the model in informing cost-effectiveness analysis (CEA). They build upon the work of Jacobson and others to establish a conceptual framework of utility maximisation which corresponds to family well-being. The paper, first to employ the term 'spillover effects' in the context of CEA (Grosse et al., 2019), adopts a welfarist approach to spillovers, and shows how the appropriate benefits for CEA from a societal perspective consist of effects extending beyond those accrued by the patient alone (Basu and Meltzer, 2005). Nevertheless, others have argued that applied economic evaluations generally require a narrower interpretation of health spillovers. Thus, most attempts to quantify and incorporate health spillovers into CEA focus solely on a measure of health output, i.e., quality-adjusted life years (Al-Janabi et al., 2016). Such efforts have gained increasing attention in recent years and guidelines specifying how these economic evaluations should be conducted now acknowledge the need to incorporate spillovers (Brown et al., 2019).

For example, while the first iteration of guidelines by the US Panel on Cost-effectiveness in Health and Medicine recognised that spillover effects could 'ripple out' from every intervention (or program), they recommended only for inclusion of 'important' spillovers in sensitivity analysis, where possible. In the main, this recommendation reflected the limited data

on family health-related quality of life at the time (Weinstein et al., 1996). In contrast, the Second Panel on Cost-Effectiveness in Health and Medicine, convened in 2012, advocated for the inclusion of family spillover effects in reference case analyses for CEA conducted from either a health care or societal perspective (Neumann et al., 2016). The Second Panel did, however, continue to acknowledge the methodological and data-related constraints applicable to the incorporation of these spillovers.

Multiple regulatory agencies have echoed the recommendations of the Second US Panel in their own guidelines. For example, in 2013, the UK's National Institute for Health and Care Excellence (NICE) advocated for the inclusion of "all direct health effects, whether for patients or, when relevant, carers" (NICE, 2013). Brouwer (2019) suggests that a contemporaneous focus on informal caregivers in the literature likely prompted their specific reference to carer health effects. Citing subsequent empirical evidence, he suggests that consideration of the broader family network is more in keeping with the goal of health optimisation aimed for by decision-making bodies such as NICE. Guidelines for economic evaluation from Canada and the Netherlands provide further prominent examples of explicit recommendation for consideration of 'potential spillover impacts' or 'societal benefits' respectively (CADTH, 2018; Zorginstituut Nederland, 2016). These approaches concur with a widely-held view within the literature that "the health effects in family members and caregivers are directly relevant for the decision rule that underlies the analysis" in economic evaluation of health care interventions (Brouwer, 2019). Nonetheless, health spillovers are still often overlooked in CEA (Al-Janabi et al., 2016).

In this context, a burgeoning literature describes the varied scope of situations in which health spillovers might occur, as well as their possible manifestations, which range from somatic illness and deleterious effects on physical health to psychological symptomatology and broader declines in well-being (Al-Janabi et al., 2016; Francetic et al., 2020; Lavelle et al., 2014;

Wittenberg and Prosser, 2013; Wittenberg et al., 2019). The complexity of the potential consequences of serious family illness should not be understated. Indeed, beneficial impacts related to gratification, interdependence, and joy have also been described (Wittenberg, Saada, et al., 2013). Notwithstanding these potential benefits, the emerging evidence generally implies a considerable component of disease burden may be unaccounted for (Wittenberg and Prosser, 2013). Of particular note is the potential impact of health spillovers on the common mental disorders. With the World Health Organisation (WHO) estimating that depression and anxiety account for 7.5% and 3.4% of all years lived with disability respectively, the consequence of these disorders, in terms of lost health and economic costs, is substantial (WHO, 2017).

Given all of this, this paper uses nationally representative data on adults resident in Ireland to examine the independent association between experience of serious family illness and various self-reported dimensions of health-related quality of life, including anxiety and depression. In particular, it combines inverse probability weighting (IPW) and multivariate ordered probit (MVOP) regression in a doubly robust estimation of this relationship. The analysis is motivated by discernible gaps within the extant literature. For instance, empirical research on health spillovers continues to mainly focus on caring spillovers within specific population sub-groups, with little research on spillovers for non-caregivers at a population level, or on differences across groups (Al-Janabi et al., 2016). Concern has also developed as to the representativeness of spillover effects obtained from these analyses, with critics suggesting a preponderance of evidence relates to spillovers resulting from cancers and rare diseases (McCabe, 2019). In addressing these gaps, our paper makes a number of specific contributions: first, it presents nationally representative evidence that experience of serious family illness is strongly associated with mental health decrements that are independent of caring responsibilities and a range of other factors; second, it shows that similar results are not evident for other dimensions of health; third, it finds considerable heterogeneity by sex and by income in the relationship

between mental health and serious family illness; and fourth, it estimates the reduction in health utility from serious family illness for both caregiving and non-caregiving family members.

2. DATA AND METHODS

2.1. Data

We use data from the Irish EQ-5D-5L Survey, 2015-16 (O'Neill, 2018). EQ-5D is an instrument used to describe and value health and is commonly employed in clinical trials, health surveys, and health outcome measurement (Forbes et al., 2017; Pickard et al., 2007). The EQ-5D questionnaire measures health-related quality of life across 5 dimensions: mobility; self-care; usual activities; pain/discomfort; and, anxiety/depression (Brooks, 1996). The most recent iteration, the EQ-5D-5L, categorises each dimension into 5 severity levels: no problems; slight problems; moderate problems; severe problems; and, extreme problems/unable to (Herdman et al., 2011). It describes 3,125 distinct health states and, for each, an index score anchored at 1 (full health) and 0 (dead) is calculated using preference data (Drummond et al., 2015).

The EQ-5D-5L descriptive system was recently used to capture the self-reported health of a representative sample of 1,131 adult residents in Ireland by means of a computer-assisted-personal-interview survey (Hobbins, Barry, Kelleher, and O'Neill, 2018). In addition to the EQ-5D-5L questions, information was collected on a range of socio-demographic variables for each respondent, as well as on their experience of serious illness in themselves, their family, and in caring for others. The precise wording of the EQ-5D-5L and serious illness questions are presented in Appendix A.

Definitions and sample descriptive statistics for the variables used in our analysis are presented in Table 1. For our five dependent variables, which relate to the EQ-5D dimensions, we

aggregate the moderate, severe and extreme/unable to categories, due to relatively small numbers of observations in some cells. Table 1 shows that, for example, 13.8% of respondents indicated they were slightly anxious or depressed, while 8.2% indicated they were moderately, severely, or extremely anxious or depressed. In terms of the serious illness variables, 33.2% of respondents indicated that they had experienced serious illness in themselves, 69.8% that they had experienced serious illness in their family, and 51.6% that they had experienced serious illness in caring for others. The congruence of the proportion of respondents indicating ever having experienced any serious illness in themselves (33.2%) with the 26.6% of respondents residing in Ireland who reported currently having a long-standing illness or health problem in the 2016 wave of the EU Statistics on Income and Living Conditions (EU-SILC) survey speaks to the veracity of these figures (Eurostat, 2020).

It is important to note, however, that these serious illness questions do not put a timeframe on when such experiences occurred, nor on their nature. Nonetheless, the inclusion of questions relating to respondents' experience of serious illness in themselves or in caring for others allows us to control for two key contextual factors. Controlling for an individual's own health status is important since it has been suggested that people with chronic or serious illness may cluster together in households (Wittenberg, Ritter, et al., 2013). In addition, by controlling for experience of serious illness in caring for others, we can differentiate between health decrements related to 'caring for' and 'caring about' the individual with serious illness.

In terms of other explanatory variables, the number of people in the respondent's household is included since the health of both the family member with serious illness and the respondent may be affected by common social support networks (Al-Janabi et al., 2016). We also control for additional personal, household, and socioeconomic characteristics including age, sex, marital status, children in the household, living environment (urban/rural), level of education,

employment status, and annual household income in our econometric models. Details of these variables are also presented in Table 1.

2.2. Empirical Approach

Tubeuf et al. (2019) describe three distinct methods of measuring spillovers: (1) direct measurement of disutility among family members; (2) relative assessment of family members' utility by comparison to a control group; and (3) family member utility estimation in a hypothetical scenario in which the patient is healthy and/or does not require caregiving. Insofar as the approach employed here seeks to econometrically model the self-reported health of respondents as a function of their experience of serious family illness, it aligns most closely with the second of these categories. Nonetheless, while the term 'spillover' is generally construed causally, here we employ it as a label of decrement or disutility associated with serious family illness, given our empirical approach. This is in keeping with previous literature on the topic (Bobinac et al., 2011; Wittenberg, Ritter, et al., 2013).

To examine the evidence of health spillovers from serious illness, we estimate MVOP models of the EQ-5D health dimensions. In the case of q outcomes, the MVOP model can be specified in a q -equation seemingly unrelated regressions (SUR) system, where for each individual i and outcome n , the continuous latent variable $Health_{i,n}^*$ denotes underlying health in that particular dimension. Our model consists of $q = 5$ outcomes and each latent health variable is expressed as a function of a vector of the three serious illness variables (**SI**), a vector of personal, household, and socioeconomic characteristics (**X**) as listed in Table 1, sets of parameters γ_n and β_n (which differ across equations), and an equation-specific error term $\varepsilon_{i,n}$. Formally, we have:

$$\begin{aligned}
Mobility_i^* &= \mathbf{S}\mathbf{I}_i\gamma_1 + \mathbf{X}_i\beta_1 + \varepsilon_{i,1} \\
SelfCare_i^* &= \mathbf{S}\mathbf{I}_i\gamma_2 + \mathbf{X}_i\beta_2 + \varepsilon_{i,2} \\
UsualAct_i^* &= \mathbf{S}\mathbf{I}_i\gamma_3 + \mathbf{X}_i\beta_3 + \varepsilon_{i,3} \\
Pain/Dis_i^* &= \mathbf{S}\mathbf{I}_i\gamma_4 + \mathbf{X}_i\beta_4 + \varepsilon_{i,4} \\
Anx/Dep_i^* &= \mathbf{S}\mathbf{I}_i\gamma_5 + \mathbf{X}_i\beta_5 + \varepsilon_{i,5}
\end{aligned} \tag{1}$$

In the MVOP model, $\varepsilon_{i,n}$ is assumed to have a standard normal distribution, while importantly, given the SUR nature of the model, the multivariate distribution of the error term is multivariate normal with mean 0 and correlation matrix Ω i.e., $\{\varepsilon_{i,1}, \dots, \varepsilon_{i,5}\} \sim N(0, \Omega)$ where:

$$\Omega = \begin{pmatrix} 1 & \rho_{12} & \dots & \rho_{15} \\ \rho_{21} & 1 & \dots & \rho_{25} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{51} & \rho_{52} & \dots & 1 \end{pmatrix} \tag{2}$$

and ρ_{jk} represents the correlation between $\varepsilon_{i,j}$ and $\varepsilon_{i,k}$. This set-up allows for unobserved heterogeneity through potentially non-zero values of the off-diagonal elements of the symmetric matrix Ω , by capturing the effects of common unobserved factors influencing the underlying latent propensities.

In our main model, the relationship between each latent variable $Health_{i,n}^*$ and corresponding observed ordered variable $Health_{i,n}$, which takes values equal to $j_n = \{1,2,3\}$, is given by:

$$Health_{i,n} = j_n \text{ if } \delta_{j_n-1,n} < Health_{i,n}^* < \delta_{j_n,n} \tag{3}$$

where δ denotes ‘cutpoints’ in the distribution of $Health_{i,n}^*$ and $\delta_{0,n}$ and $\delta_{3,n}$ are normalized to $-\infty$ and $+\infty$ respectively.

In estimating MVOP models that include a range of control variables, the aim is to reduce the likelihood that differences in the self-reported health of those with and without experience of

serious family illness reflect differences in other characteristics across groups. That being said, to further reduce the impact of any systematic differences between respondents in each group, we employ a doubly robust estimator by combining the aforementioned MVOP models with inverse probability weights based on propensity scores to increase the observational equivalence of those who have, and have not, experienced serious family illness (Neelsen and O'Donnell, 2017). The advantage of this approach is that it guards against misspecification more effectively than the IPW or regression alone, with the estimator being consistent as long as either the propensity score or MVOP model is correctly specified (Kaiser and Schmid, 2016). Inverse-probability weighted estimators have previously been employed in conjunction with non-linear models by Jones et al. (2006).

To calculate and apply inverse probability weights, the propensity score is first estimated using a probit model, such that:

$$\hat{p}_i = \Pr(T_i = 1|\mathbf{X}_i) \quad [4]$$

where T denotes experience of serious family illness (1/0) and \mathbf{X} is a vector of covariates included in the propensity score model. Estimated weights (\hat{w}) that are applied to the MVOP model are then calculated as the inverse of the predicted probability of experiencing (or not experiencing) serious family illness, such that:

$$\hat{w}_i = \frac{T_i}{\hat{p}_i} + \frac{1 - T_i}{1 - \hat{p}_i} \quad [5]$$

which implies that $\hat{w}_i = \frac{1}{\hat{p}_i}$ if an individual has experienced serious family illness and $\hat{w}_i = \frac{1}{1 - \hat{p}_i}$ if not.

Curtis et al. (2007) state that, in general, candidate covariates for the propensity score model may include those which might confound the relationship between treatment and outcome.

Others, however, advise that only those variables which are unaffected by the treatment, or anticipation of treatment, should be used (Jones, 2007). As a result, our weights are estimated on the basis of a propensity score model that includes all MVOP model covariates, apart from the other serious illness variables. Nonetheless, to test the sensitivity of our findings, we also apply weights derived from a range of propensity score models that include varying subsets of controls. To assess balance between treatment and control groups before and after fitting the propensity score model and applying corresponding inverse probability weights, we estimate the standardised difference in covariates across each group. In keeping with previous literature, absolute standardised differences of below 0.10 are assumed to reflect good overlap (Kelleher et al., 2020; Normand et al., 2001). All analyses presented were conducted using Stata/SE 16.1 (Stata Corp, College Station, TX). In particular, we used Roodman's (2011) `cmp` command applying inverse probability weights to estimate γ , β , ρ and δ in the MVOP models, which allows us to calculate relevant partial effects.

In addition to the main MVOP model, we also consider a number of extensions to the analysis. For instance, it has been suggested that following application of inverse probability weights, restricting the analysis to subjects with better overlap of covariate distributions can also help to balance the groups being compared and, thus, improve validity (Glynn et al., 2019). Therefore, following the methods of Stürmer et al. (2010), prior to estimating the weighted MVOP model, we asymmetrically trim the sample by dropping any observation in the group reporting serious illness in their family with a propensity score at or below the 5th percentile of the propensity score or any observation from the group not reporting any experience of serious family illness with a propensity score at or above the 95th percentile of the propensity score.

In addition, we also consider a number of sub-sample analyses. This is because previous studies have found evidence of potential differences in the magnitudes of spillovers by sex (Barzallo, 2018), while others have suggested that they may also differ by socioeconomic status (McCabe,

2019). In particular, we perform sub-sample analysis following stratification of the full sample by sex (female and male) and by household income (low, medium, and high income households).

Based on personal correspondence with a member of the team of surveyors who gathered the Irish EQ-5D-5L population normative data used in this paper, we believe that the full sample likely includes a number of health care, social care, and other professionals, who may perform caring or related roles outside of their family. Accordingly, in a further extension to the main analysis, we estimate our models excluding respondents who reported no experience of serious illness in their family but experience of serious illness in caring for others. The sample excluding these ‘formal carers’ (broadly defined) is also employed in a five-level MVOP model, the partial effect estimates of which are combined with health utility decrements from the five-level value set for Ireland (Hobbins, Barry, Kelleher, Shah, et al., 2018). This allows us to calculate utility decrements associated with experience of serious illness in the family and in caring for a family member. Finally, we also conduct a range of additional sensitivity and robustness checks – see Appendix D.

3. RESULTS

3.1 Main Analysis

The standardised difference in mean propensity score between ‘treatment’ (serious illness in family) and ‘control’ (no serious illness in family) groups, before and after application of weights, was 0.461 and 0.009 respectively, indicating good balance between the two groups after weighting – see Table 2. The propensity score distribution in the treatment and control groups also suggests of good overlap – see Figure B1 in Appendix B. Details of other observed

weighting characteristics and standardised differences in covariate means are presented in Table 2.

Table 3 presents estimated average partial effects for the three serious illness variables from the main inverse probability weighted MVOP model. In terms of our key finding, we estimate that respondents who indicated experience of serious family illness were 12.2 percentage points (ppts) less likely to report not being anxious or depressed, 6.6 ppts more likely to report being slightly anxious or depressed, and 5.6 ppts more likely to report being moderately, severely or extremely anxious or depressed (see Table 3 and Figure 1). Interestingly, similar independent associations were not found for the other four dimensions of health, where all partial effects were practically and statistically insignificant. Indeed, a key advantage of our weighted MVOP approach is that it allows us to show that potential health spillovers are evident where they might be expected (e.g., serious family illness is independently related to increased anxiety/depression), but not where we might not anticipate finding them (e.g., between serious family illness and an individual's self-care or pain/discomfort). This can be considered as a type of falsification test in support of the presence of mental health spillovers. It is, however, important to note that a similar pattern was not observed in relation to the serious illness in caring variable, contrary to what might be expected. We return to this issue below.

Full results for this model are presented in Appendix C for information. All values of $\hat{\rho}_{jk}$ are positive and statistically significant. This supports the use of an MVOP model and implies that respondents with a higher propensity to report a problem in health dimension j also have a higher propensity to report a problem in dimension k .

3.2. Extensions

In the first extension to our analysis, the sample was trimmed to further augment the observational equivalence of the treatment and control groups. The estimated partial effects of serious family illness from the trimmed weighted MVOP model differ only slightly from those from the main inverse probability weighted model (Table 4). In addition, it is also interesting to note that the estimated partial effects from the weighted and unweighted MVOP models are broadly consistent. As shown in Appendix D, all other estimated partial effects for the three serious illness variables obtained from unweighted and trimmed inverse probability weighted models were similar to those from the main model.

We also estimated models using sub-samples relating to sex and to household income – results for anxiety/depression are presented in Table 5. For serious illness in the family, the estimated partial effects are larger for females than males, suggesting larger mental health spillovers for females from family illness. However, the opposite pattern is found for serious illness in caring. For income, there are marked differences in partial effects for family and the individual's own serious illness by income group. Most notably, anxiety/depression spillovers from serious family illness are much larger for respondents in low and medium income households, suggesting that mental health spillovers may be substantially worse for those with fewer resources.

We also conducted sub-sample analyses by sex and by income group for the four other health dimensions (results presented in Appendix D). While there were some anomalous findings, in general these results do not suggest differences by sex or by income for serious family illness. This is not surprising, since Table 3 suggests no impact of serious illness in the family on these dimensions in the full sample.

Overall, 92 of the 1,131 respondents (8.1%) reported experience of serious illness in caring for others, but not in their family. Sub-sample analysis conducted excluding this group (a high proportion of which are likely to be ‘formal’ carers) indicates that the estimated partial effects relating to experience of serious illness in family and in caring for others are now similar in magnitude – see Table 6. Indeed, it may well be that the likely inclusion of (unidentifiable) formal carers in the full sample analysis resulted in the null finding for caring in Table 3 and that the results in Table 6 are more representative of the overall population of non-formal carers. In addition, considering that experience of serious illness in family and in caring are both independently associated with anxiety/depression, but not with the other four dimensions of health, the estimates in Table 6 further corroborate the falsification test interpretation of our findings.

Finally, we also estimated a model employing five level versions of the dependent variables and the sample excluding ‘formal’ carers. Combining the estimated partial effects from this model with health utility decrements from the EQ-5D-5L value set for Ireland (Hobbins, Barry, Kelleher, Shah, et al., 2018) allows us to estimate the average utility decrement associated with experience of serious illness in the family and in caring for others (Table 7). For example, we assume that serious family illness increases the probability of slight, moderate, severe, and extreme anxiety/depression by 3.6 ppts, 2.5 ppts, 0.6 ppts, and 0.2 ppts respectively. Based on Table 2 in Hobbins, Barry, Kelleher, Shah, et al. (2018), these health states result in reductions in health utility of -0.08, -0.20, -0.54, and -0.65 respectively. Weighting these reductions by the applicable predicted changes in anxiety/depression levels from serious family illness, and then summing, results in a predicted overall reduction in health utility of -0.012. The predicted reduction in health utility associated with experience of serious illness in caring for others sums to -0.014. With a mean health utility of 0.91 for those reporting no serious family illness in the O'Neill (2018) data, this implies a percentage reduction of about 1.3%. Similarly, a mean utility

of 0.91 among those reporting no experience of serious illness in caring for others implies a percentage reduction of approximately 1.5% associated with health spillovers related to caregiving.

4. DISCUSSION

We present an analysis of the independent relationship between five separate dimensions of health and serious illness. Our doubly robust estimation strategy finds evidence consistent with results from Al-Janabi et al. (2016), in that we observe decrements associated with serious family illness that relate primarily to the dimension of anxiety/depression and extend to individuals in the broader family network. In differentiating between spillovers that arise from ‘caring for’ and ‘caring about’ a family member with a serious illness, our results also concur with those of Bobinac et al. (2011). Moreover, the estimated magnitude of spillover disutility related to caring for a family member with serious illness, -0.014, is remarkably similar to an estimated utility loss of -0.015 reported by Davidson et al. (2008). The observed consistency lends support to our modelling approach and estimates.

In addition to these overall findings, we also find evidence of heterogeneity by sex and by household income. The finding that our estimated spillovers are considerably lower in high income households is particularly noteworthy. Although we cannot speak to the potential mechanisms behind this, our results would appear to provide empirical support for the suggestion by McCabe (2019) that those who can afford respite care may carry a smaller burden in terms of health-related quality of life. Other possible explanations include better access to health care and support services, an increased capacity to navigate such services, and a greater ability to absorb labour market shocks arising from serious illness.

A number of limitations to this analysis should be borne in mind. First, our data is cross-sectional and our model, as a result, descriptive. Therefore, our estimates should be considered as independent associations rather than causal effects. Indeed, there may be reasons to doubt that these observed associations are, in fact, true spillover effects. For example, they could also reflect direct effects of a common environmental, economic, or genetic factor. It is, however, important to note that we do not find evidence of such common influences in the other EQ-5D health dimensions, as one might expect if this were the case. Nonetheless, future research should look, where possible, to employ research designs such as difference-in-differences, regression discontinuity design, or instrumental variable estimation, to aid casual inference.

In addition, the potential for inconsistencies in the interpretation of the serious illness questions might also be cause for concern. For example, respondents could possibly consider their own serious illness when asked about experience of serious illness in their family or in caring for others. With that said, by enquiring about the individual's own serious illness experience immediately prior to the other serious illness questions, item ordering is likely to mitigate the risk of such misinterpretation. Other limitations relate to the data we analyse. For example, our outcome measures and main independent variables of interest are self-reported and subjective. The analysis was also constrained by the independent variables available for inclusion in our control set. Moreover, we have very limited information on the extent, nature, and timing of the serious illness. For instance, we don't know when the illness occurred, how long it lasted for, nor the degree of closeness in the family relationship. As such, future iterations of the EQ-5D-5L Survey might inquire about serious illness experience with a greater degree of dimensionality. Additionally, it would be beneficial to assess the face validity of the wording of these questions prior to implementation. It should also be noted that certain spillover impacts may evade the dimensions of the EQ-5D instrument (Wittenberg, Ritter, et al., 2013). The E-QALY project measure (Extending the QALY Project, 2017) aims to capture quality of life

more broadly, explicitly including aspects of life considered important to carers. A direct comparison of the EQ-5D-5L with this novel generic quality of life measure, assessing the ability of each to detect and quantify spillovers, may be warranted as another avenue for future research.

Nonetheless, if the independent associations observed in this analysis were to reflect a causal relationship, they would suggest that serious family illness increases anxiety/depression experience among non-caregiving family members. This is relevant in many contexts, including increasing morbidity within aging populations, as well as the current coronavirus pandemic, as it suggests the provision of mental health services and supports may not be sufficient unless the increased demand related to spillovers is accounted for.

Furthermore, our finding that spillovers may be moderated by household resources has equity implications. For example, it suggests the possibility of a ‘vicious cycle’ whereby poorer households, which tend to have poorer health outcomes, are more impacted by health spillovers than richer households, potentially leading to more adverse economic outcomes. Finally, there are also likely implications for CEA, especially in Ireland. To our knowledge, this paper is the first to present spillover disutility estimates in a sample of the population of Ireland. Fitzgerald et al. (2018) had previously reported the caregiver utility of Irish parents to young children with cystic fibrosis but employed the CarerQoL-7D instrument which includes non-health domains, making such findings incompatible with CEA (Wittenberg et al., 2019). In keeping with other regulatory agencies, the most recently published version of the “Guidelines for the Economic Evaluation of Health Technologies in Ireland” from the Health Information and Quality Authority (HIQA) recommends for inclusion of “all health benefits accruing to individuals” in the reference case analysis (HIQA, 2020). This recommendation brings the applicability of our findings into even sharper focus.

It should lastly be noted that spillover inclusion in CEA is the subject of a continued normative debate (Dixon and Round, 2019; Wittenberg et al., 2019). Some advocate for inclusion on the basis that omission would be at odds with the goal of health optimisation espoused by decision-making bodies (Brouwer, 2019). Others believe that their incorporation warrants caution owing to the potential for unintended impacts on the distribution of health, equity in decision making, and procedural justice, among others (Dixon and Round, 2019; McCabe, 2019; Wittenberg et al., 2019). While the findings of this analysis add to the evidence base informing the expansion of CEA to include spillovers, they do not inform questions as to the appropriateness of such expansions. Consensus on whether these impacts are “normatively justifiable” remains elusive, providing a further important focus for future research (Wittenberg et al., 2019).

5. CONCLUSION

Our estimates of spillover disutility are consistent with serious family illness leading to an average reduction of 1.3% in health utility for non-caregiving family members and implies deteriorations in population health beyond those more overtly attributable to serious illness. Thus, evaluation of disease burden, or the effectiveness of interventions aimed at ameliorating such diseases, may be incomplete without consideration of the full spectrum of effects on the individual and those around them.

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TABLES

Table 1: Variable Definitions and Sample Descriptive Statistics

Variable	Categories/Definition	%
Dependent Variables: EQ-5D Health Dimensions		
<i>Mobility</i>	= No problems in walking about	78.3
	= Slight problems in walking about	12.6
	= Moderate, severe or extreme problems in walking about	9.0
<i>Self-care</i>	= No problems washing or dressing myself	93.7
	= Slight problems washing or dressing myself	4.8
	= Moderate, severe or extreme problems washing or dressing myself	1.5
<i>Usual Activities</i>	= No problems doing my usual activities	80.8
	= Slight problems doing my usual activities	11.2
	= Moderate, severe or extreme problems doing my usual activities	8.0
<i>Pain/Discomfort</i>	= No pain or discomfort	59.5
	= Slight pain or discomfort	23.9
	= Moderate, severe or extreme pain or discomfort	16.6
<i>Anxiety/Depression</i>	= Not anxious or depressed	78.0
	= Slightly anxious or depressed	13.8
	= Moderately, severely or extremely anxious or depressed	8.2
Independent Variables: Serious Illness		
<i>Serious Illness Individual</i>	= 1 if you have experienced serious illness in you yourself; 0 else	33.2
<i>Serious Illness Family</i>	= 1 if you have experienced serious illness in your family; 0 else	69.8
<i>Serious Illness Caring</i>	= 1 if you have experienced serious illness in caring for others; 0 else	51.6
Independent Variables: Personal and Household Characteristics		
<i>Age</i>	= 18-44 years	41.9
	= 45-64 years	36.3
	= 65+ years	21.8
<i>Female</i>	= 1 if female; 0 else	62.3
<i>Marital Status</i>	= Married/living as married	60.1
	= Never married	23.6
	= Divorced/separated/widowed	16.3
<i>Number in Household</i>	= 1	17.8
	= 2	28.4
	= 3	17.7
	= 4	19.5
	= 5	11.5
	= 6+	5.1
<i>Children</i>	= 1 if children in household; 0 else	39.3
<i>Urban</i>	= 1 if living in urban area; 0 else	58.0
Independent Variables: Socioeconomic Characteristics		
<i>Third Level</i>	= 1 if individual has a third level education; 0 else	55.8
<i>Employment Status</i>	= Full-time employed/self-employed	34.0
	= Part-time employed/self-employed	14.9
	= Home duties	11.0
	= Retired	22.6
	= Student	6.2
	= Unemployed / long-term sickness / other	11.5
<i>Annual Household Income</i>	= Low (< €30,000)	33.6
	= Medium (€30,000 to €60,000)	32.6
	= High (> €60,000)	33.8
Observations		1,131

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table 2: Observed Weighting Characteristics and Standardised Differences in Covariate Means

Variable	Categories	Before IPW			After IPW		
		Serious Illness Family - No	Serious Illness Family - Yes	Std. Diff.	Serious Illness Family - No	Serious Illness Family - Yes	Std. Diff.
		Mean/% (SD)	Mean/% (SD)		Mean/% (SD)	Mean/% (SD)	
Propensity Score		0.667 (±0.095)	0.711 (±0.094)	0.461	0.697 (±0.094)	0.697 (±0.097)	0.009
Personal and Household Characteristics							
Age	= 18-44 years	47.4%	39.5%	-0.158	41.8%	41.9%	0.002
	= 45-64 years	28.1%	39.9%	0.252	36.2%	36.4%	0.003
	= 65+ years	24.6%	20.5%	-0.096	22.0%	21.8%	-0.006
Female	= 1 if female	53.5%	66.2%	0.260	62.0%	62.3%	0.006
	= 0	46.5%	33.8%		38.0%	37.7%	
Marital Status	= Married/living as married	64.9%	58.0%	-0.141	60.0%	60.0%	0.001
	= Never married	20.5%	25.0%	0.107	22.7%	23.5%	0.017
	= Divorced/separated/widowed	14.6%	17.0%	0.065	17.3%	16.5%	-0.021
No. in Household	= 1	15.5%	18.8%	0.087	17.6%	17.8%	0.006
	= 2	28.7%	28.3%	-0.009	27.6%	28.2%	0.013
	= 3	18.1%	17.5%	-0.017	18.0%	17.7%	-0.010
	= 4	20.5%	19.1%	-0.033	19.5%	19.5%	-0.001
	= 5	12.3%	11.2%	-0.035	12.0%	11.7%	-0.010
	= 6+	5.0%	5.2%	0.010	5.3%	5.2%	-0.005
Children	= 1 if children in household	41.2%	38.4%	-0.058	39.2%	39.3%	0.001
	= 0	58.8%	61.6%		60.8%	60.7%	
Urban	= 1 if living in urban area	57.9%	58.0%	0.003	58.2%	58.0%	-0.003
	= 0 if living in rural area	42.1%	42.0%		41.8%	42.0%	
Socioeconomic Characteristics							
Third Level	= 1 if individual has a third level education	54.7%	56.3%	0.032	54.9%	55.5%	0.011
	= 0	45.3%	43.7%		45.1%	44.5%	
Employment Status	= Full-time	40.1%	31.3%	-0.183	33.5%	33.7%	0.005
	= Part-time	11.1%	16.5%	0.156	14.7%	14.8%	0.003
	= Home duties	9.4%	11.7%	0.075	11.6%	11.1%	-0.016
	= Retired	22.2%	22.7%	0.011	22.4%	22.6%	0.005
	= Student	6.4%	6.1%	-0.014	6.6%	6.3%	-0.013
	= Unemployed/long-term sickness/other	10.8%	11.8%	0.031	11.2%	11.5%	0.009
Annual Household Income	= Low (< €30,000)	30.4%	35.0%	0.097	33.9%	33.8%	-0.002
	= Medium (€30,000 to €60,000)	32.7%	32.6%	-0.004	32.8%	32.6%	-0.004
	= High (> €60,000)	36.8%	32.4%	-0.092	33.3%	33.6%	0.006
Observations		342	789				

Notes: Balance of respondent characteristics before and after applying inverse probability weights assessed using *tebalance summarize*. An absolute standardised difference of <0.1 was considered consistent with reasonable similarity between groups. IPW, inverse probability weighting; Std. Diff., standardised difference.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table 3: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.161*** (0.029)	-0.087*** (0.016)	-0.188*** (0.026)	-0.171*** (0.033)	-0.077*** (0.027)
<i>Slight problems</i>	0.077*** (0.014)	0.064*** (0.013)	0.089*** (0.014)	0.062*** (0.012)	0.040*** (0.014)
<i>Moderate+ problems</i>	0.084*** (0.017)	0.022*** (0.006)	0.100*** (0.016)	0.109*** (0.023)	0.037*** (0.014)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.021 (0.024)	-0.007 (0.012)	-0.034 (0.022)	-0.032 (0.030)	-0.122*** (0.022)
<i>Slight problems</i>	0.010 (0.011)	0.005 (0.008)	0.016 (0.010)	0.012 (0.012)	0.066*** (0.013)
<i>Moderate+ problems</i>	0.011 (0.013)	0.002 (0.003)	0.018 (0.012)	0.020 (0.018)	0.056*** (0.010)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.016 (0.024)	-0.009 (0.012)	-0.012 (0.021)	-0.027 (0.030)	-0.029 (0.023)
<i>Slight problems</i>	-0.007 (0.011)	0.006 (0.009)	0.006 (0.010)	0.010 (0.011)	0.015 (0.012)
<i>Moderate+ problems</i>	-0.008 (0.013)	0.003 (0.004)	0.006 (0.011)	0.017 (0.018)	0.014 (0.011)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table 4: Multivariate Ordered Probit and Inverse Probability Weighted Multivariate Ordered Probit Estimated Partial Effects of Serious Family Illness on *Anxiety/Depression*

	MVOP		
	Unweighted	IP Weighted	Trimmed IP Weighted
<i>Serious Illness Family</i>			
<i>No problems</i>	-0.111*** (0.025)	-0.122*** (0.022)	-0.114*** (0.024)
<i>Slight problems</i>	0.059*** (0.015)	0.066*** (0.013)	0.061*** (0.014)
<i>Moderate+ problems</i>	0.052*** (0.011)	0.056*** (0.010)	0.053*** (0.011)
Observations	1,131	1,131	1,056

Notes: The table presents estimated average partial effects for *Serious Illness Family* on *Anxiety/Depression* from multivariate ordered probit models of the EQ-5D health dimensions. The presented estimated partial effects are from unweighted, inverse probability weighted and asymmetrically trimmed inverse probability weighted samples. The control variables included in the models are *Age, Female, Marital Status, No. in Household, Children, Urban, Third Level, Employment Status, and Annual Household Income*. MVOP, multivariate ordered probit; IP, inverse probability. Delta-method standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table 5: Estimated Partial Effects of Serious Illness Variables on *Anxiety/Depression* by Sex and by Income

	Female	Male	Low Income	Med. Income	High Income
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.070** (0.033)	-0.101** (0.042)	-0.111** (0.052)	-0.089** (0.037)	-0.020 (0.048)
<i>Slight problems</i>	0.038** (0.018)	0.049** (0.020)	0.044** (0.021)	0.046** (0.020)	0.013 (0.032)
<i>Moderate+ problems</i>	0.033** (0.016)	0.052** (0.023)	0.067** (0.032)	0.043** (0.020)	0.006 (0.016)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.157*** (0.028)	-0.073** (0.034)	-0.162*** (0.047)	-0.143*** (0.032)	-0.056 (0.039)
<i>Slight problems</i>	0.089*** (0.017)	0.037* (0.019)	0.068*** (0.023)	0.080*** (0.023)	0.039 (0.028)
<i>Moderate+ problems</i>	0.068*** (0.013)	0.036** (0.017)	0.094*** (0.027)	0.063*** (0.014)	0.017 (0.012)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.000 (0.028)	-0.083** (0.037)	-0.035 (0.046)	-0.032 (0.033)	-0.055 (0.039)
<i>Slight problems</i>	-0.000 (0.015)	0.041** (0.019)	0.014 (0.019)	0.017 (0.017)	0.037 (0.027)
<i>Moderate+ problems</i>	-0.000 (0.013)	0.042** (0.019)	0.021 (0.027)	0.015 (0.016)	0.017 (0.013)
Observations	705	426	380	369	382

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* on *Anxiety/Depression* from five separate sub-sample multivariate ordered probit models of the EQ-5D health dimensions. The sub-samples include females, males, low income, medium income, and high income respondents. All models were weighted as per the main model of the analysis except in the case of the high income sub-sample, which is unweighted to allow for model convergence. The control variables included in all five models are *Age*, *Marital Status*, *Children*, *Urban*, *Third Level* and *Employment Status*. The sex-specific models also control for *Annual Household Income* and *No. in Household*, while the income-specific models also control for *Female*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table 6: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions: Sub-Sample Analysis Excluding Formal/Non-Family Carers

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.177*** (0.033)	-0.096*** (0.018)	-0.190*** (0.029)	-0.196*** (0.037)	-0.084*** (0.032)
<i>Slight problems</i>	0.084*** (0.017)	0.072*** (0.015)	0.088*** (0.015)	0.068*** (0.013)	0.042*** (0.016)
<i>Moderate+ problems</i>	0.093*** (0.019)	0.024*** (0.006)	0.102*** (0.018)	0.128*** (0.026)	0.042** (0.016)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.004 (0.030)	-0.004 (0.016)	-0.033 (0.028)	-0.032 (0.037)	-0.073** (0.030)
<i>Slight problems</i>	0.002 (0.014)	0.003 (0.011)	0.015 (0.013)	0.012 (0.014)	0.038** (0.017)
<i>Moderate+ problems</i>	0.002 (0.016)	0.001 (0.005)	0.018 (0.015)	0.020 (0.023)	0.035** (0.014)
<i>Serious Illness Caring</i>					
<i>No problems</i>	-0.000 (0.027)	-0.010 (0.015)	-0.014 (0.025)	-0.022 (0.034)	-0.076*** (0.028)
<i>Slight problems</i>	0.000 (0.012)	0.007 (0.010)	0.007 (0.011)	0.008 (0.012)	0.039*** (0.014)
<i>Moderate+ problems</i>	0.000 (0.014)	0.003 (0.004)	0.008 (0.014)	0.014 (0.021)	0.038*** (0.014)
Observations	1,039	1,039	1,039	1,039	1,039

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. Respondents reporting no experience of serious illness in their family but experience of serious illness in caring for others are excluded from this sub-sample analysis. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

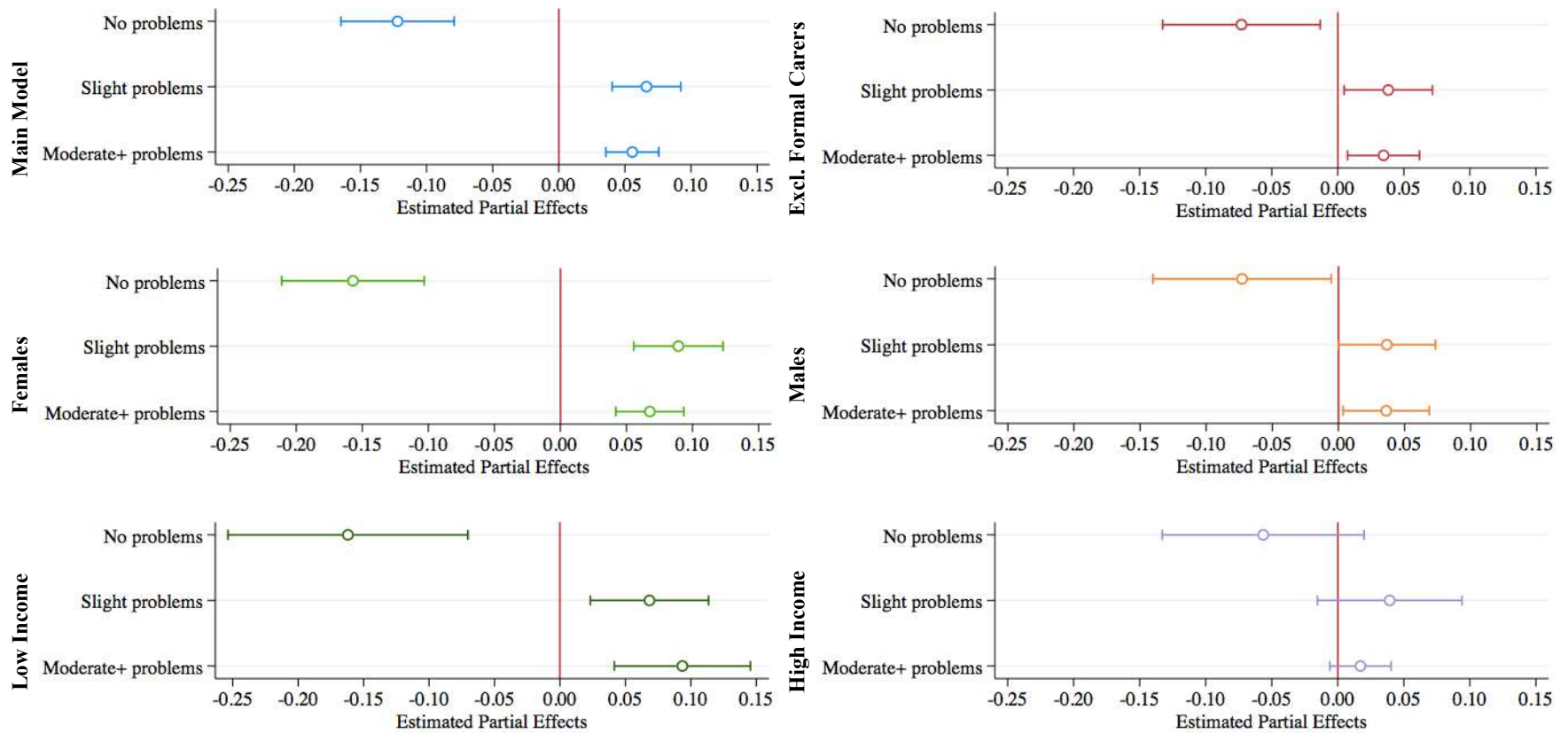
Table 7: Calculation of Health Utility Decrement from Serious Family Illness

	Anxiety/Depression Spillover Estimate (1)	Anxiety/Depression Related Reductions in Health Utility (2)	(1)*(2)	95% CI
<i>Serious Illness Family</i>				
<i>Anxiety/Depression</i>				
<i>Slight</i>	0.036	-0.080	-0.003	[-0.006, 0.000]
<i>Moderate</i>	0.025	-0.202	-0.005	[-0.010, -0.001]
<i>Severe</i>	0.006	-0.535	-0.003	[-0.006, 0.000]
<i>Extreme</i>	0.002	-0.646	-0.001	[-0.003, 0.001]
Estimated health utility decrement			-0.012	
<i>Serious Illness Caring</i>				
<i>Anxiety/Depression</i>				
<i>Slight</i>	0.038	-0.080	-0.003	[-0.005, -0.001]
<i>Moderate</i>	0.028	-0.202	-0.006	[-0.010, -0.002]
<i>Severe</i>	0.007	-0.535	-0.004	[-0.007, 0.000]
<i>Extreme</i>	0.002	-0.646	-0.001	[-0.003, 0.001]
Estimated health utility decrement			-0.014	

Notes: Sub-sample excluding formal/non-family carers employed in calculations. Individual level confidence intervals calculated on the basis of multiplicands resulting from 1000 random draws from the probability distributions of utility values from the Irish country tariff and the applicable 5L partial effect estimate.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018) and from Hobbins, Barry, Kelleher, Shah, et al. (2018).

Figure 1: Estimated Partial Effects of Serious Family Illness on *Anxiety/Depression*



Notes: The figure presents a visual summary of the estimated average partial effects for Serious Illness Family on Anxiety/Depression from multivariate ordered probit models of Mobility, Self-care, Usual Activities, Pain/Discomfort, and Anxiety/Depression employed in the main analysis and selected extensions. 95% confidence intervals are also included.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

APPENDIX A: Health Dimension and Serious Illness Questions

Health Dimension Questions

Under each heading, please tick the ONE box that best describes your health TODAY.

MOBILITY

- I have no problems in walking about
- I have slight problems in walking about
- I have moderate problems in walking about
- I have severe problems in walking about
- I am unable to walk about

SELF-CARE

- I have no problems washing or dressing myself
- I have slight problems washing or dressing myself
- I have moderate problems washing or dressing myself
- I have severe problems washing or dressing myself
- I am unable to wash or dress myself

USUAL ACTIVITIES (e.g. work, study, housework, family or leisure activities)

- I have no problems doing my usual activities
- I have slight problems doing my usual activities
- I have moderate problems doing my usual activities
- I have severe problems doing my usual activities
- I am unable to do my usual activities

PAIN / DISCOMFORT

- I have no pain or discomfort
- I have slight pain or discomfort
- I have moderate pain or discomfort
- I have severe pain or discomfort
- I have extreme pain or discomfort

ANXIETY / DEPRESSION

- I am not anxious or depressed
- I am slightly anxious or depressed
- I am moderately anxious or depressed
- I am severely anxious or depressed
- I am extremely anxious or depressed

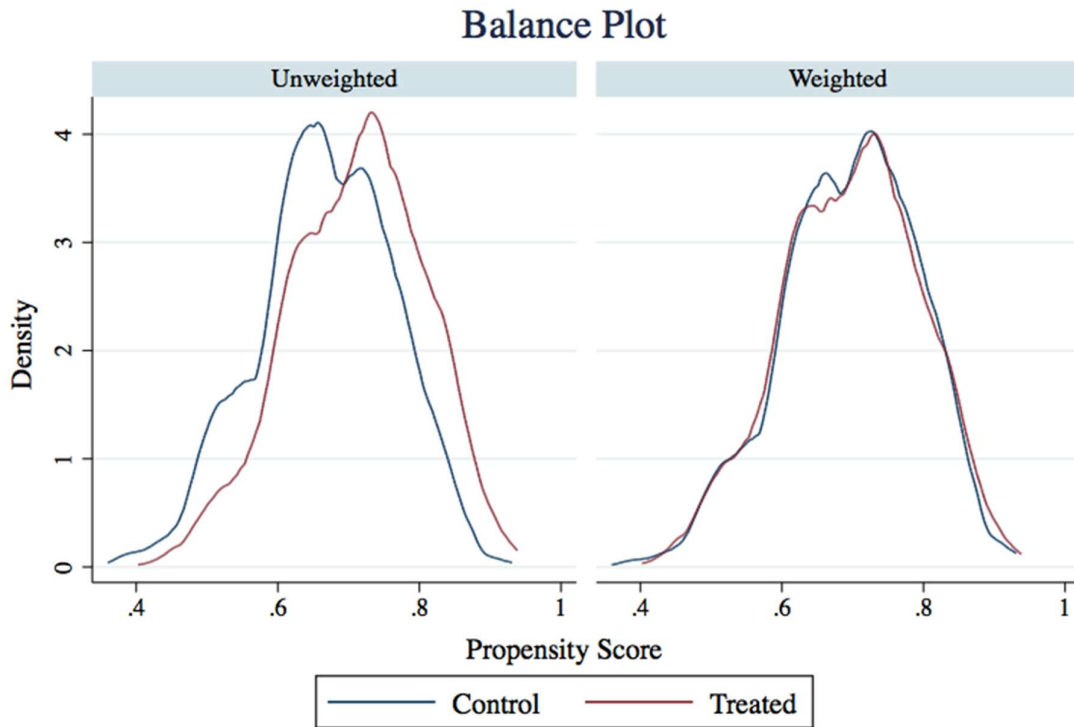
Serious Illness Questions

Have you experienced serious illness?

- | | | |
|----------------------|------------------------------|-----------------------------|
| In you yourself | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| In your family | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| In caring for others | <input type="checkbox"/> Yes | <input type="checkbox"/> No |

APPENDIX B: Propensity Score Distribution

Figure B1: Propensity Score Balance Across Treatment and Control Groups Before and After Weighting



Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

APPENDIX C: Full Results for Main Model

Table C1: Estimated Coefficients from Weighted Multivariate Ordered Probit Model

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Family</i>	0.089 (0.103)	0.073 (0.131)	0.154 (0.102)	0.092 (0.086)	0.499*** (0.098)
<i>Serious Illness Caring</i>	-0.067 (0.101)	0.094 (0.132)	0.054 (0.097)	0.077 (0.085)	0.119 (0.092)
<i>Serious Illness Individual</i>	0.613*** (0.102)	0.840*** (0.134)	0.751*** (0.096)	0.468*** (0.090)	0.300*** (0.102)
<i>45-64 years</i>	0.327** (0.139)	-0.000 (0.183)	0.013 (0.132)	0.267** (0.109)	-0.140 (0.131)
<i>65+ years</i>	0.543*** (0.208)	-0.140 (0.267)	-0.014 (0.186)	0.182 (0.180)	-0.485** (0.209)
<i>Female</i>	0.012 (0.099)	0.233 (0.144)	0.054 (0.100)	-0.012 (0.089)	0.015 (0.110)
<i>Never married</i>	-0.217 (0.171)	-0.213 (0.212)	-0.395** (0.155)	-0.300** (0.129)	0.150 (0.140)
<i>Divorced etc.</i>	-0.109 (0.161)	0.018 (0.196)	-0.146 (0.155)	-0.088 (0.138)	0.171 (0.160)
<i>2 in Household</i>	-0.092 (0.173)	0.107 (0.203)	-0.087 (0.163)	0.208 (0.153)	0.006 (0.165)
<i>3 in Household</i>	-0.054 (0.204)	-0.197 (0.283)	-0.165 (0.200)	0.041 (0.187)	-0.109 (0.186)
<i>4 in Household</i>	0.196 (0.242)	-0.058 (0.321)	0.081 (0.231)	0.184 (0.197)	0.026 (0.210)
<i>5 in Household</i>	-0.195 (0.276)	-0.141 (0.417)	-0.104 (0.277)	0.198 (0.239)	-0.061 (0.245)
<i>6+ in Household</i>	-0.529 (0.350)	-0.721 (0.512)	-0.793** (0.371)	0.067 (0.262)	-0.476* (0.275)
<i>Children</i>	-0.271* (0.156)	0.050 (0.209)	-0.261* (0.156)	-0.083 (0.132)	0.188 (0.156)
<i>Urban</i>	-0.124 (0.096)	-0.288** (0.131)	-0.178* (0.095)	-0.118 (0.083)	0.250** (0.098)
<i>Third level</i>	-0.101 (0.108)	-0.041 (0.145)	-0.151 (0.102)	-0.055 (0.094)	-0.090 (0.101)
<i>Part-time</i>	0.161 (0.191)	0.612** (0.272)	0.226 (0.180)	0.189 (0.156)	0.059 (0.184)
<i>Home duties</i>	0.018 (0.180)	0.147 (0.259)	0.140 (0.181)	-0.170 (0.155)	0.118 (0.167)
<i>Retired</i>	0.447** (0.176)	0.688*** (0.257)	0.447*** (0.159)	0.302* (0.161)	0.174 (0.181)
<i>Student</i>	0.454* (0.239)	0.104 (0.312)	0.726*** (0.235)	0.239 (0.184)	0.030 (0.219)
<i>Unemployed etc.</i>	0.264 (0.174)	0.184 (0.235)	0.369** (0.163)	0.171 (0.147)	0.512*** (0.160)
<i>Medium Income</i>	-0.256** (0.124)	-0.409** (0.161)	-0.328*** (0.124)	-0.161 (0.108)	-0.354*** (0.119)
<i>High Income</i>	-0.298** (0.152)	-0.690*** (0.222)	-0.221 (0.153)	-0.322** (0.127)	-0.342*** (0.133)
$\hat{\delta}_1$	1.059*** (0.276)	1.992*** (0.387)	1.003*** (0.259)	0.498** (0.226)	1.292*** (0.262)
$\hat{\delta}_2$	1.776*** (0.285)	2.815*** (0.399)	1.628*** (0.265)	1.335*** (0.231)	1.998*** (0.263)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated coefficients from a multivariate ordered probit model of *Mobility*, *Self-care*, *Usual Activities*, *Pain/Discomfort*, and *Anxiety/Depression*. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table C2: Estimated Correlation Matrix

	ε_1	ε_2	ε_3	ε_4	ε_5
ε_1	1				
ε_2	0.667*** (0.049)	1			
ε_3	0.746*** (0.034)	0.830*** (0.034)	1		
ε_4	0.617*** (0.038)	0.452*** (0.057)	0.654*** (0.035)	1	
ε_5	0.279*** (0.055)	0.223*** (0.071)	0.317*** (0.056)	0.313*** (0.053)	1

Note: The table presents the estimated correlation matrix Ω from Equation 2, where $\hat{\rho}_{jk}$ represents the estimated correlation between error term ε_j and ε_k . Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

APPENDIX D: Robustness and Sensitivity Checks

We undertook a wide range of robustness and sensitivity checks. In relation to the full sample analysis, we estimated an unweighted MVOP model (Table D1), models with inverse probability weights derived from a range of propensity score models that include varying subsets of control (Table D2 & D3), weighted models with different subsets of controls (Tables D4 & D5), a multivariate probit model (Table D6), and models using four and five level versions of the dependent variables (Tables D7 & D8). In general, we found our main estimates and conclusions to be robust across these alternative models.

In addition, Table D9 presents the results of a weighted model estimated after asymmetrically trimming the sample by dropping any observation in the group reporting serious illness in their family with a propensity score at or below the 5th percentile of the propensity score or any observation from the group not reporting any experience of serious family illness with a propensity score at or above the 95th percentile of the propensity score. We also conducted subsample analyses by sex and income group for the four other health dimensions (Tables D10-D13). While there were some anomalous findings, in general these results do not suggest differences by sex or by income for serious family illness. This is not surprising, since Table 2 suggests no impact of serious illness in the family on these dimensions in the full sample.

Table D1: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions (Unweighted Multivariate Ordered Probit Model)

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.163*** (0.026)	-0.097*** (0.017)	-0.193*** (0.026)	-0.171*** (0.030)	-0.104*** (0.027)
<i>Slight problems</i>	0.074*** (0.013)	0.071*** (0.013)	0.090*** (0.014)	0.057*** (0.010)	0.051*** (0.013)
<i>Moderate+ problems</i>	0.089*** (0.015)	0.026*** (0.007)	0.104*** (0.016)	0.114*** (0.021)	0.054*** (0.015)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.018 (0.024)	0.000 (0.015)	-0.024 (0.023)	-0.025 (0.030)	-0.111*** (0.025)
<i>Slight problems</i>	0.008 (0.011)	-0.000 (0.010)	0.011 (0.011)	0.009 (0.011)	0.059*** (0.015)
<i>Moderate+ problems</i>	0.010 (0.013)	-0.000 (0.005)	0.013 (0.013)	0.016 (0.019)	0.052*** (0.011)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.017 (0.022)	-0.007 (0.013)	-0.009 (0.022)	-0.021 (0.028)	-0.047* (0.024)
<i>Slight problems</i>	-0.007 (0.010)	0.004 (0.009)	0.004 (0.010)	0.008 (0.010)	0.024* (0.012)
<i>Moderate+ problems</i>	-0.010 (0.013)	0.002 (0.004)	0.005 (0.012)	0.014 (0.018)	0.024* (0.012)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from a multivariate ordered probit model of the EQ-5D health dimensions conducted using the unweighted sample. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D2: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions
(Weights Based on All Covariates of the Main Model)

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.147*** (0.032)	-0.086*** (0.017)	-0.190*** (0.029)	-0.165*** (0.037)	-0.058** (0.024)
<i>Slight problems</i>	0.069*** (0.014)	0.067*** (0.015)	0.091*** (0.016)	0.060*** (0.013)	0.032** (0.013)
<i>Moderate+ problems</i>	0.079*** (0.019)	0.019*** (0.005)	0.098*** (0.017)	0.105*** (0.025)	0.026** (0.012)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.025 (0.025)	-0.011 (0.012)	-0.033 (0.022)	-0.033 (0.031)	-0.136*** (0.021)
<i>Slight problems</i>	0.011 (0.012)	0.008 (0.009)	0.016 (0.011)	0.013 (0.012)	0.078*** (0.013)
<i>Moderate+ problems</i>	0.013 (0.014)	0.003 (0.003)	0.018 (0.012)	0.020 (0.019)	0.057*** (0.010)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.024 (0.024)	-0.006 (0.012)	-0.009 (0.023)	-0.023 (0.030)	-0.020 (0.022)
<i>Slight problems</i>	-0.011 (0.011)	0.005 (0.009)	0.004 (0.011)	0.009 (0.012)	0.011 (0.012)
<i>Moderate+ problems</i>	-0.013 (0.013)	0.002 (0.003)	0.005 (0.012)	0.014 (0.018)	0.009 (0.010)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D3: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions (Weights Based on Personal and Household Characteristics)

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.157*** (0.028)	-0.086*** (0.015)	-0.188*** (0.026)	-0.176*** (0.033)	-0.082*** (0.026)
<i>Slight problems</i>	0.075*** (0.014)	0.065*** (0.013)	0.088*** (0.013)	0.064*** (0.012)	0.042*** (0.013)
<i>Moderate+ problems</i>	0.081*** (0.016)	0.022*** (0.005)	0.100*** (0.016)	0.112*** (0.022)	0.040*** (0.014)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.023 (0.024)	-0.007 (0.012)	-0.034 (0.021)	-0.033 (0.030)	-0.122*** (0.022)
<i>Slight problems</i>	0.011 (0.011)	0.005 (0.008)	0.016 (0.010)	0.013 (0.012)	0.066*** (0.013)
<i>Moderate+ problems</i>	0.012 (0.012)	0.002 (0.003)	0.018 (0.011)	0.020 (0.018)	0.056*** (0.010)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.015 (0.023)	-0.009 (0.012)	-0.012 (0.021)	-0.027 (0.029)	-0.028 (0.022)
<i>Slight problems</i>	-0.007 (0.011)	0.006 (0.008)	0.006 (0.010)	0.011 (0.011)	0.015 (0.012)
<i>Moderate+ problems</i>	-0.008 (0.012)	0.002 (0.003)	0.007 (0.011)	0.017 (0.018)	0.013 (0.010)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D4: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions Based a Weighted Model with No Controls (Weights Based on All Covariates of the Main Model Excluding Serious Illness Variables)

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.258*** (0.031)	-0.122*** (0.019)	-0.243*** (0.029)	-0.236*** (0.033)	-0.091*** (0.026)
<i>Slight problems</i>	0.118*** (0.015)	0.091*** (0.017)	0.113*** (0.015)	0.081*** (0.011)	0.046*** (0.013)
<i>Moderate+ problems</i>	0.140*** (0.020)	0.031*** (0.008)	0.130*** (0.019)	0.155*** (0.025)	0.044*** (0.014)
<i>Serious Illness Family</i>					
<i>No problems</i>	0.000 (0.027)	0.005 (0.015)	-0.019 (0.023)	-0.010 (0.032)	-0.121*** (0.024)
<i>Slight problems</i>	-0.000 (0.013)	-0.004 (0.011)	0.009 (0.011)	0.004 (0.013)	0.065*** (0.014)
<i>Moderate+ problems</i>	-0.000 (0.014)	-0.001 (0.004)	0.010 (0.012)	0.006 (0.020)	0.056*** (0.011)
<i>Serious Illness Caring</i>					
<i>No problems</i>	-0.009 (0.026)	-0.014 (0.015)	-0.021 (0.023)	-0.053* (0.032)	-0.025 (0.024)
<i>Slight problems</i>	0.004 (0.012)	0.010 (0.011)	0.010 (0.011)	0.021* (0.012)	0.013 (0.013)
<i>Moderate+ problems</i>	0.005 (0.014)	0.004 (0.004)	0.011 (0.012)	0.033* (0.020)	0.012 (0.011)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Individual*, *Serious Illness Family*, and *Serious Illness Caring* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D5: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions Based a Weighted Model with Personal and Household Controls (Weights Based on All Covariates of the Main Model Excluding Serious Illness Variables)

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.169*** (0.030)	-0.095*** (0.018)	-0.196*** (0.028)	-0.180*** (0.034)	-0.097*** (0.028)
<i>Slight problems</i>	0.081*** (0.015)	0.071*** (0.014)	0.094*** (0.014)	0.065*** (0.012)	0.049*** (0.014)
<i>Moderate+ problems</i>	0.088*** (0.018)	0.024*** (0.006)	0.103*** (0.017)	0.115*** (0.023)	0.048*** (0.015)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.018 (0.025)	-0.001 (0.014)	-0.031 (0.022)	-0.027 (0.031)	-0.121*** (0.023)
<i>Slight problems</i>	0.008 (0.012)	0.000 (0.010)	0.015 (0.011)	0.011 (0.012)	0.065*** (0.014)
<i>Moderate+ problems</i>	0.009 (0.013)	0.000 (0.004)	0.016 (0.012)	0.017 (0.019)	0.056*** (0.011)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.014 (0.025)	-0.009 (0.014)	-0.012 (0.022)	-0.028 (0.031)	-0.030 (0.024)
<i>Slight problems</i>	-0.007 (0.012)	0.006 (0.010)	0.006 (0.010)	0.011 (0.012)	0.016 (0.013)
<i>Moderate+ problems</i>	-0.008 (0.013)	0.002 (0.004)	0.006 (0.012)	0.017 (0.019)	0.014 (0.011)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Individual*, *Serious Illness Family*, and *Serious Illness Caring* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D6: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions – Weighted Multivariate Probit Model

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>Any problems</i>	0.148*** (0.029)	0.087*** (0.017)	0.197*** (0.029)	0.163*** (0.037)	0.062** (0.027)
<i>Serious Illness Family</i>					
<i>Any problems</i>	0.015 (0.025)	0.004 (0.013)	0.038* (0.023)	0.007 (0.033)	0.122*** (0.024)
<i>Serious Illness Caring</i>					
<i>Any problems</i>	-0.010 (0.026)	0.005 (0.013)	0.012 (0.022)	0.047 (0.033)	0.026 (0.024)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D7: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions – Weighted 4L Model

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.154*** (0.028)	-0.087*** (0.016)	-0.182*** (0.026)	-0.177*** (0.033)	-0.075*** (0.027)
<i>Slight problems</i>	0.075*** (0.014)	0.064*** (0.013)	0.087*** (0.014)	0.064*** (0.012)	0.039*** (0.014)
<i>Moderate problems</i>	0.056*** (0.012)	0.017*** (0.005)	0.056*** (0.011)	0.080*** (0.016)	0.027** (0.011)
<i>Severe+ problems</i>	0.024*** (0.006)	0.006** (0.003)	0.039*** (0.008)	0.033*** (0.008)	0.009** (0.004)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.026 (0.023)	-0.008 (0.012)	-0.030 (0.022)	-0.021 (0.030)	-0.117*** (0.022)
<i>Slight problems</i>	0.012 (0.011)	0.006 (0.008)	0.014 (0.011)	0.008 (0.012)	0.064*** (0.013)
<i>Moderate problems</i>	0.009 (0.008)	0.002 (0.002)	0.009 (0.007)	0.009 (0.013)	0.041*** (0.009)
<i>Severe+ problems</i>	0.004 (0.004)	0.001 (0.001)	0.007 (0.005)	0.004 (0.005)	0.012*** (0.003)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.020 (0.023)	-0.009 (0.012)	-0.006 (0.021)	-0.029 (0.030)	-0.030 (0.023)
<i>Slight problems</i>	-0.010 (0.011)	0.007 (0.009)	0.003 (0.010)	0.011 (0.011)	0.016 (0.012)
<i>Moderate problems</i>	-0.007 (0.008)	0.002 (0.003)	0.002 (0.006)	0.013 (0.013)	0.011 (0.008)
<i>Severe+ problems</i>	-0.003 (0.004)	0.001 (0.001)	0.001 (0.005)	0.005 (0.006)	0.003 (0.003)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D8: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions – Weighted 5L Model

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.153*** (0.028)	-0.086*** (0.015)	-0.178*** (0.027)	-0.175*** (0.033)	-0.076*** (0.027)
<i>Slight problems</i>	0.075*** (0.014)	0.062*** (0.012)	0.087*** (0.014)	0.064*** (0.012)	0.040*** (0.014)
<i>Moderate problems</i>	0.055*** (0.012)	0.016*** (0.005)	0.056*** (0.011)	0.079*** (0.016)	0.028** (0.011)
<i>Severe problems</i>	0.016*** (0.005)	0.005** (0.002)	0.022*** (0.006)	0.026*** (0.007)	0.007** (0.003)
<i>Extreme problems</i>	0.007** (0.003)	0.002 (0.002)	0.013*** (0.004)	0.007** (0.003)	0.002 (0.001)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.025 (0.023)	-0.007 (0.012)	-0.029 (0.022)	-0.020 (0.030)	-0.117*** (0.022)
<i>Slight problems</i>	0.012 (0.011)	0.005 (0.008)	0.014 (0.011)	0.008 (0.012)	0.064*** (0.013)
<i>Moderate problems</i>	0.009 (0.008)	0.001 (0.002)	0.009 (0.007)	0.009 (0.013)	0.041*** (0.009)
<i>Severe problems</i>	0.003 (0.003)	0.001 (0.001)	0.004 (0.003)	0.003 (0.004)	0.010*** (0.003)
<i>Extreme problems</i>	0.001 (0.001)	0.000 (0.000)	0.002 (0.002)	0.001 (0.001)	0.002 (0.001)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.021 (0.023)	-0.009 (0.012)	-0.006 (0.021)	-0.028 (0.029)	-0.029 (0.023)
<i>Slight problems</i>	-0.010 (0.011)	0.006 (0.008)	0.003 (0.010)	0.011 (0.011)	0.015 (0.012)
<i>Moderate problems</i>	-0.007 (0.008)	0.002 (0.002)	0.002 (0.006)	0.012 (0.013)	0.010 (0.008)
<i>Severe problems</i>	-0.002 (0.003)	0.001 (0.001)	0.001 (0.003)	0.004 (0.004)	0.003 (0.002)
<i>Extreme problems</i>	-0.001 (0.001)	0.000 (0.000)	0.001 (0.002)	0.001 (0.001)	0.001 (0.001)
Observations	1,131	1,131	1,131	1,131	1,131

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. The control variables included in the model are *Age*, *Female*, *Marital Status*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D9: Estimated Partial Effects of Serious Illness Variables on EQ-5D Health Dimensions (Asymmetrically Trimmed Weighted Model with Weights Based on All Covariates of the Main Model Excluding Serious Illness Variables)

	Mobility	Self-care	Usual Activities	Pain/ Discomfort	Anxiety/ Depression
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.171*** (0.029)	-0.109*** (0.017)	-0.212*** (0.027)	-0.178*** (0.033)	-0.102*** (0.027)
<i>Slight problems</i>	0.078*** (0.014)	0.082*** (0.015)	0.094*** (0.014)	0.063*** (0.012)	0.051*** (0.013)
<i>Moderate+ problems</i>	0.093*** (0.017)	0.027*** (0.007)	0.118*** (0.017)	0.115*** (0.023)	0.051*** (0.014)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.020 (0.027)	-0.009 (0.013)	-0.020 (0.023)	-0.025 (0.032)	-0.114*** (0.024)
<i>Slight problems</i>	0.009 (0.012)	0.007 (0.009)	0.009 (0.010)	0.009 (0.012)	0.061*** (0.014)
<i>Moderate+ problems</i>	0.011 (0.015)	0.003 (0.004)	0.011 (0.013)	0.015 (0.020)	0.053*** (0.011)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.027 (0.024)	-0.006 (0.012)	-0.017 (0.022)	-0.037 (0.030)	-0.037 (0.023)
<i>Slight problems</i>	-0.012 (0.011)	0.005 (0.009)	0.007 (0.009)	0.014 (0.011)	0.019 (0.012)
<i>Moderate+ problems</i>	-0.015 (0.014)	0.002 (0.004)	0.009 (0.012)	0.023 (0.019)	0.018 (0.011)
Observations	1,056	1,056	1,056	1,056	1,056

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* from an asymmetrically trimmed, inverse probability weighted multivariate ordered probit model of the EQ-5D health dimensions. Asymmetric trimming of the sample performed by dropping any observation with a propensity score at or below the 5th percentile of the propensity score in the group reporting experience of serious illness in their family or any observation with a propensity score at or above the 95th percentile of the propensity score in the group not reporting any experience of serious family illness. The control variables included in the model are *Age*, *Female*, *Marital Status*, *No. in Household*, *Children*, *Urban*, *Third Level*, *Employment Status*, and *Annual Household Income*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D10: Estimated Partial Effects of Serious Illness Variables on *Mobility* by Sex and by Income

	Female	Male	Low Income	Med. Income	High Income
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.185*** (0.038)	-0.114*** (0.040)	-0.218*** (0.055)	-0.148*** (0.044)	-0.096*** (0.035)
<i>Slight problems</i>	0.082*** (0.018)	0.057*** (0.021)	0.080*** (0.021)	0.074*** (0.025)	0.057** (0.023)
<i>Moderate+ problems</i>	0.102*** (0.024)	0.057*** (0.021)	0.138*** (0.038)	0.074*** (0.022)	0.039*** (0.015)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.029 (0.032)	0.003 (0.033)	-0.013 (0.052)	-0.058 (0.040)	0.023 (0.030)
<i>Slight problems</i>	0.013 (0.014)	-0.002 (0.016)	0.005 (0.019)	0.029 (0.020)	-0.013 (0.017)
<i>Moderate+ problems</i>	0.016 (0.018)	-0.002 (0.017)	0.008 (0.033)	0.030 (0.020)	-0.010 (0.013)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.015 (0.031)	0.013 (0.032)	0.022 (0.049)	0.020 (0.039)	-0.010 (0.026)
<i>Slight problems</i>	-0.006 (0.014)	-0.006 (0.015)	-0.008 (0.018)	-0.010 (0.019)	0.006 (0.015)
<i>Moderate+ problems</i>	-0.008 (0.017)	-0.007 (0.016)	-0.014 (0.031)	-0.010 (0.020)	0.004 (0.011)
Observations	705	426	380	369	382

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* on *Mobility* from five separate sub-sample multivariate ordered probit models of the EQ-5D health dimensions. The sub-samples include females, males, low income, medium income, and high income respondents. All models were weighted as per the main model of the analysis except in the case of the high income sub-sample, which is unweighted to allow for model convergence. The control variables included in all five models are *Age*, *Marital Status*, *Children*, *Urban*, *Third Level* and *Employment Status*. The sex-specific models also control for *Annual Household Income* and *No. in Household*, while the income-specific models also control for *Female*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D11: Estimated Partial Effects of Serious Illness Variables on *Self-care* by Sex and by Income

	Female	Male	Low Income	Med. Income	High Income
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.111*** (0.022)	-0.037** (0.019)	-0.168*** (0.030)	-0.052*** (0.019)	-0.042 -
<i>Slight problems</i>	0.086*** (0.019)	0.026* (0.014)	0.117*** (0.025)	0.036*** (0.014)	0.033 (0.006)
<i>Moderate+ problems</i>	0.026*** (0.009)	0.011* (0.006)	0.051*** (0.015)	0.016** (0.007)	0.009 (0.006)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.016 (0.014)	0.006 (0.017)	0.033 (0.029)	-0.057*** (0.015)	0.018 -
<i>Slight problems</i>	0.012 (0.010)	-0.004 (0.012)	-0.022 (0.020)	0.039*** (0.012)	-0.013 (0.003)
<i>Moderate+ problems</i>	0.004 (0.004)	-0.002 (0.006)	-0.011 (0.010)	0.018*** (0.007)	-0.005 (0.003)
<i>Serious Illness Caring</i>					
<i>No problems</i>	0.002 (0.014)	-0.011 (0.018)	-0.066** (0.029)	0.017 (0.015)	0.023 -
<i>Slight problems</i>	-0.002 (0.011)	0.007 (0.012)	0.043** (0.020)	-0.011 (0.011)	-0.018 (0.003)
<i>Moderate+ problems</i>	-0.001 (0.004)	0.004 (0.006)	0.022** (0.011)	-0.006 (0.005)	-0.005 (0.003)
Observations	705	426	380	369	382

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* on *Self-care* from five separate sub-sample multivariate ordered probit models of the EQ-5D health dimensions. The sub-samples include females, males, low income, medium income, and high income respondents. All models were weighted as per the main model of the analysis except in the case of the high income sub-sample, which is unweighted to allow for model convergence. The control variables included in all five models are *Age*, *Marital Status*, *Children*, *Urban*, *Third Level* and *Employment Status*. The sex-specific models also control for *Annual Household Income* and *No. in Household*, while the income-specific models also control for *Female*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D12: Estimated Partial Effects of Serious Illness Variables on *Usual Activities* by Sex and by Income

	Female	Male	Low Income	Med. Income	High Income
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.219*** (0.034)	-0.136*** (0.041)	-0.263*** (0.047)	-0.167*** (0.038)	-0.152*** (0.047)
<i>Slight problems</i>	0.098*** (0.018)	0.069*** (0.021)	0.110*** (0.022)	0.070*** (0.019)	0.098*** (0.032)
<i>Moderate+ problems</i>	0.120*** (0.021)	0.066*** (0.022)	0.154*** (0.030)	0.097*** (0.024)	0.054*** (0.021)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.066** (0.026)	0.026 (0.036)	-0.043 (0.046)	-0.078** (0.033)	0.033 (0.035)
<i>Slight problems</i>	0.029** (0.012)	-0.013 (0.018)	0.018 (0.019)	0.033** (0.015)	-0.021 (0.022)
<i>Moderate+ problems</i>	0.036** (0.014)	-0.013 (0.018)	0.026 (0.027)	0.045** (0.019)	-0.012 (0.013)
<i>Serious Illness Caring</i>					
<i>No problems</i>	-0.015 (0.026)	-0.017 (0.036)	-0.031 (0.044)	0.006 (0.032)	-0.011 (0.029)
<i>Slight problems</i>	0.007 (0.011)	0.008 (0.018)	0.012 (0.018)	-0.003 (0.013)	0.007 (0.019)
<i>Moderate+ problems</i>	0.008 (0.014)	0.008 (0.018)	0.018 (0.026)	-0.004 (0.019)	0.004 (0.010)
Observations	705	426	380	369	382

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* on *Usual Activities* from five separate sub-sample multivariate ordered probit models of the EQ-5D health dimensions. The sub-samples include females, males, low income, medium income, and high income respondents. All models were weighted as per the main model of the analysis except in the case of the high income sub-sample, which is unweighted to allow for model convergence. The control variables included in all five models are *Age*, *Marital Status*, *Children*, *Urban*, *Third Level* and *Employment Status*. The sex-specific models also control for *Annual Household Income* and *No. in Household*, while the income-specific models also control for *Female*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).

Table D13: Estimated Partial Effects of Serious Illness Variables on *Pain/Discomfort* by Sex and by Income

	Female	Male	Low Income	Med. Income	High Income
<i>Serious Illness Individual</i>					
<i>No problems</i>	-0.158*** (0.042)	-0.205*** (0.054)	-0.186*** (0.056)	-0.167*** (0.056)	-0.184*** (0.057)
<i>Slight problems</i>	0.051*** (0.013)	0.086*** (0.023)	0.043*** (0.014)	0.054*** (0.018)	0.108*** (0.032)
<i>Moderate+ problems</i>	0.107*** (0.030)	0.119*** (0.034)	0.143*** (0.044)	0.113*** (0.040)	0.076*** (0.027)
<i>Serious Illness Family</i>					
<i>No problems</i>	-0.059 (0.039)	0.014 (0.043)	0.027 (0.055)	-0.119** (0.049)	-0.003 (0.049)
<i>Slight problems</i>	0.021 (0.014)	-0.006 (0.019)	-0.007 (0.013)	0.042** (0.018)	0.002 (0.031)
<i>Moderate+ problems</i>	0.038 (0.025)	-0.008 (0.024)	-0.020 (0.042)	0.077** (0.032)	0.001 (0.019)
<i>Serious Illness Caring</i>					
<i>No problems</i>	-0.017 (0.038)	-0.049 (0.045)	-0.071 (0.055)	0.020 (0.050)	-0.048 (0.046)
<i>Slight problems</i>	0.006 (0.013)	0.021 (0.020)	0.017 (0.014)	-0.007 (0.017)	0.030 (0.029)
<i>Moderate+ problems</i>	0.011 (0.025)	0.028 (0.025)	0.054 (0.041)	-0.013 (0.032)	0.018 (0.017)
Observations	705	426	380	369	382

Notes: The table presents estimated average partial effects for *Serious Illness Family*, *Serious Illness Caring*, and *Serious Illness Individual* on *Pain/Discomfort* from five separate sub-sample multivariate ordered probit models of the EQ-5D health dimensions. The sub-samples include females, males, low income, medium income, and high income respondents. All models were weighted as per the main model of the analysis except in the case of the high income sub-sample, which is unweighted to allow for model convergence. The control variables included in all five models are *Age*, *Marital Status*, *Children*, *Urban*, *Third Level* and *Employment Status*. The sex-specific models also control for *Annual Household Income* and *No. in Household*, while the income-specific models also control for *Female*. Delta-method standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Source: Analysis of data from the Irish EQ-5D-5L Survey, 2015/16 (O'Neill, 2018).