Valuing Morbidity Risk:
Willingness to Pay per Quality-Adjusted Life Year

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Abstract

We estimate willingness to pay for small reductions in the risk of suffering a range of morbid health conditions using a stated-preference survey fielded to an internet panel that is representative of the US population. The adverse health conditions are described using a generic health utility system (EQ-5D). Estimated WTP is significantly associated with the reduction in probability of illness and with the severity and duration of the health condition. The variation of WTP with severity and duration is much smaller than proportionate, which implies that WTP to reduce risk is not equal to the expected loss in quality adjusted life years (QALYs) multiplied by a constant monetary value per QALY. WTP to reduce risk to another person in the household is significantly larger than to oneself, approximately 70 percent larger for an adult and 190 percent larger for a child.

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1. Introduction

Humans face risks of a wide range of adverse health effects induced by environmental and other factors. Although there is a large literature that addresses the monetary value of mortality risks (e.g., Viscusi and Aldy 2003, Kochi et al. 2006), there are few estimates of the value of reducing risks of nonfatal illness. Policymakers need a widely applicable method for estimating the value of morbidity risk in order to quantify the health benefits of improvements in environmental quality.

One approach is to combine preference-based measures of the severity and duration of illness, such as the quality-adjusted life year (QALY), with monetary estimates of the value of reduced morbidity and mortality. For example, the US Food and Drug Administration (FDA) estimates the benefits of averted morbidity by multiplying the expected QALY gain by a constant monetary value and adding expected medical costs (Robinson, 2007). Johnson et al. (1997), Van Houtven et al. (2006), and others have proposed developing a non-linear transfer function to estimate monetary values from QALYs. An advantage of this approach is its ability to draw on the wealth of existing information about preferences for health conditions in the cost-utility literature. A review of the literature published through 2001 found 533 original studies that used cost per QALY to evaluate health and medical interventions (Bell et al. 2001, Neumann et al. 2005). The review has been extended through July 2010, yielding more than 2,500 original studies including more than 9,000 health-state values (Neumann, personal communication).

To help assess the prospect of using existing QALY estimates to value morbidity risk, we conducted a stated-preference survey to examine the following questions:

- Can changes in health-related quality of life (HRQL) measured by a generic index of health status be used to estimate WTP to reduce specific morbidity risks?
- What is the relationship between WTP and QALY values for health risks that vary in duration, severity of symptoms, and the attributes of health that are impaired?
- Does WTP depend on characteristics of the health condition in addition to those captured by QALYs, such as information conveyed by the name of the condition?

- How does the value of reducing morbidity risks to children compare with the value of reducing similar risks to adults?
- Does WTP depend on current health or other characteristics of the individual at risk?
- How does the value of reducing morbidity risk depend on respondent characteristics such as age, education, and income?

In the remainder of this section, we describe the theoretical and empirical background for the study. First, we briefly review the literature on WTP to reduce morbidity risk, focusing on studies that are relevant to QALY measures of health. Second, we characterize the specifications of the lifetime utility function for health, longevity, and wealth that are consistent with the assumption that preferences over health and longevity can be represented by QALYs and examine the implications for WTP to increase health and longevity. This theoretical model serves as a baseline for developing empirical models that describe how WTP to reduce risk depends on the severity and duration of the health effect. Third, we justify the use of household WTP for valuing health. We describe the research design and methods in Section 2, present empirical results in Section 3, and draw conclusions in Section 4.

Prior Work on Valuing Morbidity

There are several approaches to valuing morbidity risk. Cost-of-illness methods (COI, Rice 1966) measure direct and indirect costs of morbidity, such as medical expenditures and lost productivity, but do not capture the non-monetary costs of illness, such as pain and suffering. As a result, COI estimates are generally considered to be inferior to estimates derived from theoretically correct measures of economic benefit, such as WTP. COI information concerning the external costs of impaired health (e.g., insured medical expenses, sick pay) may provide a useful supplement to WTP information that captures only the private benefits of better health.

Preliminary efforts to explore the relationship between WTP and QALYs include work by O'Brien and Viramontes (1994), Cutler and Richardson (1997), Krabbe et al. (1997), and Bala et al. (1998). Similar to current FDA practice, Tolley et al. (1994) place monetary values on alleviation of a wide range of health conditions by assuming that WTP is proportional to QALYs gained. In direct elicitations, they observe that WTP is less than proportional to duration of improved health.

Jones-Lee et al. (1995) elicit WTP to reduce the probabilities of fatality and of six injuries of varying severity from motor-vehicle crashes and elicit probabilities of fatality for a standard gamble between fatality and complete recovery that respondents view as indifferent to the specified injury. They find that the ratio of WTP to prevent injury to WTP to prevent fatality is much larger than the complement of the standard gamble probability for the corresponding injury, which implies WTP is less than proportional to severity as measured by standard gamble.

In a meta-analysis of studies that estimate WTP to alleviate a total of 53 short-term health conditions described by duration and HRQL (measured by the Quality of Well-Being Scale or QWB, Kaplan et al. 1993), Johnson et al. (1997) find a nonlinear relationship between WTP and QALYs. Estimated WTP increases at a decreasing rate with duration and severity. Van Houtven et al. (2006) expand on this work by including 236 estimates of WTP to prevent acute health impairments. They find that WTP increases less than proportionately with duration and more than proportionately with the severity of illness. They also find that WTP and the QWB respond differently to health attributes: WTP is significantly associated with QWB scores for mobility and physical activity but not for symptoms and social activity.

Johnson et al. (2000) and Gyrd-Hansen (2003) apply discrete-choice modeling to value changes in hypothetical acute respiratory and cardiovascular illness and chronic health states, respectively. Both studies find evidence of a nonlinear relationship between WTP and QALYs as well as variation in WTP for different attributes of health.

Byrne et al. (2005) and King et al. (2005) assess current health and elicit WTP for hypothetical treatments that would yield perfect health in various populations suffering chronic health conditions (Byrne et al. also assessed health and WTP for two hypothetical health states). Mean WTP was on the order of $10,000 (Byrne et al., 2005) and $100,000 (King et al., 2005), much larger than conventionally assessed in stated-preference studies and implying non-marginal changes in disposable income.

Hammitt and Haninger (2007) elicited WTP to reduce the risk of acute illness (1, 3, or 7 days) from foodborne pathogens. They found that WTP varied significantly with the reduction in probability of harm, severity, and duration of illness. Using the same data, Haninger and Hammitt (2011) estimated the elasticities of WTP with respect to duration and severity as about 0.1 and 0.2, respectively, much smaller than

the elasticity with respect to risk reduction (0.5) and the value of one required if WTP is proportional to expected gain in QALYs.

Pinto-Prades et al. (2009) elicited WTP per month for improved treatment of a temporary health impairment (that would shorten its duration or reduce its severity) and to halve or eliminate a 1 percent risk of developing a chronic (lifetime) impairment. The impairment was characterized solely by EQ-5D profile. They found that WTP increased with duration and severity of the impairment but much less than proportionately. A factor causing concern about their results is that monthly WTP, which averaged 50-100€, was insensitive to whether the respondent would be required to pay for 12 or 24 months.

Theoretical Background

WTP and QALYs represent alternative methods of assigning values to health risks. WTP is the amount of money available for consumption that an individual views as providing the same utility as the specified change in health risk. WTP is defined as the compensating variation, i.e., the maximum amount of money an individual would exchange for the reduction in health risk. A closely related measure, WTA (willingness to accept compensation) is defined as the equivalent variation, i.e., the minimum amount of money an individual would accept to forego the reduction in health risk. For small changes in risk, WTP and WTA should be nearly equal, although differences can arise for large changes in risk or when the risk change has no close substitutes (Hanemann 1991). Standard economic theory places little constraint on how WTP varies with health risk, except that WTP should increase with the severity of the harm avoided and, for small reductions in the probability of harm, WTP should be nearly proportional to the change in probability (Hammitt 2000, Corso et al. 2001).

QALYs are an alternative measure of individual utility for health that impose more structure on preferences. If an individual's preferences for health are consistent with QALYs, they must satisfy several conditions including mutual utility independence between health and longevity and constant proportional tradeoff of longevity for health (Pliskin et al. 1980), or risk neutrality over longevity for any health state and indifference to health quality for periods of zero duration (Bleichrodt et al. 1997). In addition, preferences for health and longevity are assumed to be independent of income (Hammitt 2002a).

If an individual's preferences for future health and longevity can be represented by QALYs, then his utility function for his remaining lifetime with health *h*, longevity *T*, and wealth *w* must be a positive linear function of future QALYs and can be represented as

$$U(h,T,w) = Qa(w) + b(w) \quad (1)$$

where *Q* is future QALYs and $a(w)$ and $b(w)$ are functions of wealth.[1] Since utility is increasing in QALYs, $a(w) > 0$. Under the standard assumption that the individual never prefers to die with less wealth, $b'(w) \geq 0$. If the marginal utility of wealth is non-decreasing in health and longevity, then $a'(w) \geq 0$. Assuming the marginal utility of wealth while living is positive requires $a'(w) > 0$ or $b'(w) > 0$ (Hammitt 2002b).

Individual WTP per QALY can be characterized by differentiating equation (1) to obtain the marginal rate of substitution between wealth and future QALYs,

$$V = -\frac{dw}{dQ} = \frac{a(w)}{Qa'(w)+b'(w)} + \frac{\partial w}{\partial Q}. \quad (2)$$

The marginal rate of substitution *V* depends on two terms. The second term is the "indirect" effect of health and longevity on wealth, which includes any changes in income and private medical expenditures that result from better health and longevity. The first term represents the "direct" effect of health and longevity on utility and depends on wealth. For simplicity, assume the effect on wealth is negligible in comparison with the direct effect. The direct effect is bounded by two cases. If the marginal utility of wealth is independent of health and longevity, $a'(w) = 0$ and *V* is independent of future QALYs. If the individual is indifferent to the level of his bequest, $b'(w) = 0$ and *V* is inversely proportional to future QALYs. Otherwise, *V* declines with future QALYs but less than proportionately.

Household WTP as a Measure of the Value of Health

There are a variety of reasons why children's own WTP for health and safety initiatives are not appropriate measures of the value of these goods to children. Children differ from adults in ways that present problems for the standard economic assumptions of informed and rational behavior (Harbaugh 1999). For example,

[1] This follows because the utility function for health and longevity conditional on any level of wealth must be strategically equivalent (i.e., imply the same preferences over lotteries on health and longevity). See Keeney and Raiffa (1976).

children have incompletely developed reasoning abilities and typically do not have income or authority over spending.

While children's own WTP may be an inappropriate measure of value, household WTP is an appropriate starting point. Understandably, parents know and care about their children's health and are accustomed to making economic decisions that will affect their children. To some extent, economists may view parental choices as altruistic behavior, but they may also regard households as unitary economic agents with preferences and behaviors that are the result of some intra-household decision-making process.

Although much of the literature on the value of health risk treats the concept as measuring an individual's rate of substitution between income and risk, in both theory and practice it seems more tenable to interpret this literature as measuring household WTP for changes in risk. In some cases, the change in risk is to a defined individual (e.g., the worker in studies of compensating wage differentials). In other cases, the risk change may benefit the entire household (e.g., studies valuing the risk of residential proximity to hazardous-waste sites; Smith and Desvousges 1987, Gayer et al. 2000, Davis 2004). In all cases, the opportunity cost of a risk reduction is less income available to the household for spending on other goods. Depending on how households allocate consumption among their members, some or all of them may have lower consumption as a result.

2. Survey instrument

We administered a stated-preference survey to a sample from a nationwide internet panel hosted by Knowledge Networks. Panel members were recruited through random digit dial and closely match the US population on measurable demographic and socioeconomic factors.

Respondents were asked to value reductions in risk of a nonfatal illness that might affect a specified "target:" themselves, a child, or another adult living in their household. (If the household includes more than one child or other adult, the target was randomly selected.) Respondents valued two risk reductions to themselves and two each to a child and to another adult if present in the household. By valuing risks to another adult in the household, we can distinguish two effects that may contribute to any difference between the value of reducing risk to oneself and to one's child: self vs. other and adult vs. child. The order of targets was randomized.

The morbid condition was described using the EQ-5D, a generic health-state classification and utility system that characterizes health states using five attributes (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression; EuroQol Group 1990). Each attribute can take one of three levels (1 = no problems, 2 = moderate problems, 3 = severe problems). The health-related quality of life (HRQL) associated with a health state is a measure that is normalized to one for perfect health and zero for health states equivalent to dead (negative values are permitted for states worse than dead). It can be calculated by applying a scoring rule to the EQ-5D health-state description. For half the respondents, the name of the disease or health condition causing each morbid condition was provided; for the other half, conditions were described by the EQ-5D profile alone. The EQ-5D profiles that were presented are typical profiles reported by individuals having the named health states as reported in the Medical Expenditure Panel Survey (MEPS) conducted by the US Agency for Healthcare Research and Quality (some illness names are associated with multiple profiles). The duration of the morbidity was varied among three values: a month, a year, and remainder of lifetime. Combinations of duration with condition name and associated EQ-5D profiles that are unrealistic were excluded.

The EQ-5D profiles, durations, and condition names included in the survey are presented in Table 1. For each profile, we report the corresponding HRQL estimated using the scoring rule developed by Shaw et al. (2005) using preferences for health states elicited from a large representative sample of the US population. The HRQL for these EQ-5D profiles ranges from a maximum of 0.827 to a minimum of 0.086. The maximum is obtained for health profile A, for which the pain/discomfort attribute is at its second level and all the other attributes are at their first (best) levels (labeled M1 S1 U1 P2 A1, see Table 1 note). This profile is associated with influenza, respiratory infection, and skin cancer. The minimum HRQL is for health profile K, which is associated with heart disease. For this profile, the mobility and pain/discomfort attributes are at their worst levels and the other three attributes are at their intermediate levels (M3 S2 U2 P3 A2). All of the attributes take on each of the three possible levels for some health profile with the exception of pain/discomfort, which is always at level 2 (moderate pain or discomfort) or level 3 (extreme pain or discomfort). Although the health conditions were described as nonfatal, some of the diseases are often fatal and respondents presented with these condition names may

incorporated this factor in their valuation. In addition, the use of fixed EQ-5D profiles oversimplifies the usual deterioration in health as some diseases progress.

The baseline risk of illness and intervention for reducing it were presented in rather abstract terms, as in some previous stated-preference studies (e.g., Krupnick et al. 2002 and subsequent studies using their survey instrument, Cameron et al. 2010). The risk was described as an annual risk resulting "from exposure to environmental contaminants" and could be reduced by participating in a US government environmental health protection program that includes an annual screening test and preventive medicine. The baseline risk was stated to be either 3 or 4 per 10,000 per year, and participation in the program would reduce it by either 1 or 2 per 10,000 per year (initial risk and risk reduction were varied randomly). The baseline risk, reduction in risk, and final risk were illustrated using grids containing 10,000 squares, in which the number of red squares corresponded to the risk after reduction (1, 2, or 3), the number of white squares to the risk reduction (1 or 2), and the total number of the red and white squares to the baseline risk (3 or 4). This approach is adapted from the best-performing of the visual aids tested by Corso et al. (2001) to help communicate small risk changes to survey respondents. Willingness to pay an annual fee for the risk reduction was elicited using double-bounded dichotomous-choice questions in which the additional cost to the respondent's household was varied (Hanemann et al. 1991); the follow-up bid was twice the initial bid for respondents who indicated they would choose the risk reduction and half the initial bid for other respondents.

To introduce the survey, respondents were asked to indicate their degree of concern about several types of health risks (air pollution, water contamination, occupational, aircraft and motor-vehicle crashes) on a five point scale. Next, they were presented with two practice valuation questions with feedback. These questions involved a choice between two types of food at a grocery store, in which the risk of illness and price varied between the two types. In the first question, one type of apple was both safer and less expensive than the other type of apple. Respondents who chose the dominant alternative were told that the type they had selected was both safer and less expensive than the other and that this was the logical choice. Respondents who chose the dominated alternative were told that the type they had selected was both less safe and more expensive than the other and invited to choose again. In the second practice question, between two types of grape, neither alternative was

dominant. Respondents were told the type they had chosen was safer and more expensive, or less safe and less expensive, as appropriate and asked to confirm that was the choice they preferred.

Following the practice questions, the respondent was asked to describe the current health of each of the targets in his or her household (i.e., the respondent, a child younger than 18 years, and another adult living in the household; in households with multiple children or other adults, one was selected at random). For each target, the respondent was asked to describe the target's current health using both EQ-5D (described above) and visual-analog scales. The visual-analog scale is a linear scale with numbers ranging from 0 to 100 that are associated with health states as bad as dead and as good as perfect health, respectively. The respondent was asked to select a number on this scale that corresponds to current health. In addition, the respondent was asked to estimate each target's life expectancy and to rate his or her current health using a time-tradeoff question that elicits the number of years in perfect health that are viewed to be equally desirable as the life expectancy if lived in current health. (Respondents who declined to estimate life expectancy were told the life expectancy for someone of the target's age and gender.)

For each risk to be valued, the respondent was first presented with the description (EQ-5D profile, duration, and, for half the respondents, condition name) then asked to rate the target's health conditional on having this condition using a visual-analog scale. To ensure that the illness never implied an improvement in health, each attribute in the EQ-5D profile presented to the respondent was set equal to the maximum (i.e., worst) of the level presented in Table 1 and the level corresponding to the target's current health. In most cases, the target's current value on each attribute was no worse than the level specified in the profile in Table 1 and no substitution was required.

The HRQL for the target's current health and for each EQ-5D profile was calculated using a scoring algorithm estimated for the US population (Shaw et al. 2005) and the loss in HRQL while ill was calculated as the difference between these values. An alternative measure of the loss in HRQL was calculated as the corresponding difference in the HRQL estimates obtained from the visual-analog-scale questions. While the measured based on the EQ-5D assumes the function linking impairments on each attribute to HRQL is common across individuals, the visual-analog-scale imposes no such restrictions and is respondent-specific.

The valuation question for each risk followed. By asking the respondent to evaluate health conditional on having the condition immediately prior to the valuation question we attempted to focus his or her attention on the characteristics of the disease risk to be reduced.

3. Results

Sample characteristics

Variables are identified in Table 2 together with their means and standard deviations for the full data set and the subsamples corresponding to questions about reducing risk to each target. As intended, randomly assigned design variables such as baseline risk and whether the illness is named have mean values of approximately one half in all subsamples. Current health-related quality of life is larger for a child than an adult, which is expected because the frequency of adverse health conditions increases with age. Consequently, the log of the loss in health-related quality of life conditional on having a specified morbidity is also larger for a child than for an adult target. The log of the duration of illness is substantially larger for a child than an adult because the lifetime illness has greater expected duration.

Of the 2,184 respondents, 727 (33 percent) have one or more children younger than 18 years living in the household and 1,668 (76 percent) have at least one other adult living in the household. The average respondent having a child in the household (38 years) is a decade younger than the average of all respondents (48 years). Household income for respondents with a child or other adult in the household ($68,000) is larger than for the average respondent ($62,000). Respondent's education is similar across subsamples (almost 14 years). Race and ethnicity are also similar, except that Hispanic respondents are more frequently included in the subsample having a child in the household than in other subsamples (13 percent compared with 9 percent).

Estimated WTP to reduce risk

Regression models describing WTP to reduce risk are estimated using maximum-likelihood methods assuming a lognormal error distribution to accommodate the interval-censored data that result from using double-bounded

dichotomous-choice questions (Alberini 1995). The models can be interpreted as describing the natural logarithm of WTP.

Table 3 reports the results of our basic model that characterizes WTP as a function of the initial risk, log risk reduction, log loss in HRQL, log duration of illness, the target's current HRQL, plus indicator variables for whether the illness is named and for whether the target individual's current health is equal to the illness presented in the survey. By including an indicator variable for cases in which HRQL loss is zero, we avoid the possibility that the estimated coefficient on the log of HRQL loss will be influenced by the arbitrary value we assign that variable in these cases.

Table 3 reports four models, estimated on the full sample of responses to valuation questions pooling across targets (Model 1) and separately for the two questions valuing risk to the same target (Models 2-4).[2] The estimated coefficients are reasonably similar across the pooled and subsample models. Only the coefficient on the baseline-risk variable (equal to 1 if the baseline risk is 4 in 10,000 per year and 0 if it is equal to 3 in 10,000 per year) does not significantly differ from zero. The insensitivity of estimated WTP to this small difference in baseline risk is consistent with economic theory.

The estimated coefficient on the log of risk reduction (approximately 0.6) is significantly different from zero, which implies that respondents are sensitive to the magnitude of the risk reduction, despite its small size, and constitutes strong evidence that respondents were attentive to the specification of the risk reduction. Economic theory implies that WTP should be nearly proportional to the reduction in probability of illness for these small reductions (Hammitt 2000, Corso et al. 2001). We can reject the hypothesis that WTP is proportional to risk reduction (i.e., that the coefficient on log risk reduction equals one) for the pooled model (Model 1; $p = 0.003$) and for the model of WTP to reduce risk to self (Model 2; $p = 0.05$) but not for the model for risk to child (Model 3; $p = 0.21$) or risk to other adult (Model 4; $p = 0.06$), perhaps because of the smaller sample sizes and larger standard errors for the last two models. In models for reducing risk to a target identical to those shown in Table 3 but estimated using only data from respondents who answered the valuation question about that target first (i.e., before answering questions about other household

[2] The numbers of observations for Models 2-4 are slightly less than twice the corresponding sample sizes shown in Table 2 because some respondents answered only one valuation question for a target.

members), the estimated coefficients on log risk reduction are between 0.86 and 1.02 suggesting that WTP is proportional to risk reduction.[3]

Estimated WTP is sensitive to the severity and duration of the potential morbidity but varies much less than in proportion to these variables. The estimated coefficient on log of the loss in HRQL can be interpreted as the elasticity of WTP with respect to an increase in the severity of the condition (measured by the loss of HRQL from current health). The estimated values are about 0.4 for risks to self or to another adult and 0.2 for risk to a child. These coefficients are significantly different from zero (except for the risk to child) and also from one. Measuring HRQL loss using visual-analog scores yields similar results, except the estimated elasticity for risk to a child increases to about 0.4 and is significantly different from zero.[4]

The estimated elasticity of WTP with respect to duration of illness is also significantly different from zero and from one and even smaller in magnitude: about 0.1 for all three targets. We tested whether using the log of duration accurately captures the relationship between duration and WTP by supplementing the models shown in Table 3 with an indicator variable for one year duration (the alternative values are one month and remaining lifetime). The estimated coefficient on this variable is small in absolute value (ranging between -0.18 and 0.05) and smaller than its standard error in all four models, which suggests that the effect of duration is adequately represented using the logarithmic specification.[5] Together, the findings that estimated WTP varies much less than in proportion to the severity and duration of

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[3] Estimated coefficients (standard errors) on log risk reduction are 0.969 (0.188) for the pooled model, 1.017 (0.243) for the model of WTP to reduce risk to self, 0.864 (0.637) for the model for risk to child, and 0.902 (0.332) for the model for risk to another adult.

[4] Estimated coefficients (standard errors) on log loss in HRQL based on the visual-analog scores assigned by respondents are 0.412 (0.065) for the pooled model, 0.433 (0.095) for the model of WTP to reduce risk to self, 0.421 (0.165) for the model for risk to child, and 0.319 (0.109) for the model for risk to another adult.

[5] Because the diseases with high mortality risk (e.g., lung cancer, liver cancer, Parkinson's disease) are always characterized as lifetime, one might expect that the estimated coefficient on duration is biased upward. Indeed, when the models in Table 3 are estimated using only the subsample that was not presented with disease names, the estimated coefficients on log duration are somewhat smaller than reported in Table 3. The estimated coefficients (standard errors) for Models 1 – 4 estimated on the subsample without disease names are 0.072 (0.024), 0.080 (0.036), 0.101 (0.056), and 0.052(0.040), respectively. These coefficients are similar to the coefficients estimated for models that include disease names, reported in Table 5 below.

the illness imply that WTP is much less than proportional to the loss in QALYs associated with an illness, and so WTP to avoid a loss of QALYs is a sharply decreasing function of the quantity of QALYs at stake.

The estimated coefficient on the variable indicating that the name of the illness was specified is highly significant and less than zero. This implies that WTP to reduce risk is substantially smaller when the illness is described by name and EQ-5D profile rather than by EQ-5D profile alone. The estimated magnitude of the effect ranges between a 30 percent reduction when the target is another adult and a 60 percent reduction when the target is a child.[6] Although one might have anticipated that naming the health condition would make it more realistic and salient, and perhaps increase WTP, we find the opposite result. One possible explanation is that many of the illnesses may be perceived as relatively mild (e.g., influenza, respiratory infection) and so supplementing the EQ-5D profile with the name may have caused respondents to believe the illness was less serious. Alternatively, naming the conditions may have made them more familiar and less dreaded than when they are described only by the EQ-5D profile (e.g., Slovic 1987).

In the pooled model (Model 1), the coefficients of the indicator variables for target are large and highly significant. These imply the respondent will pay about 70 percent more to reduce risk to another adult and 190 percent more for a child in his or her household. Comparing these values suggests that the larger WTP to reduce risk to a child than to the respondent him or herself is composed of two effects: larger WTP to reduce risk to someone else in one's household rather than to oneself (a premium of 70 percent) and larger WTP to reduce risk to a child than to another adult (also a premium of 70 percent).

Effects of respondent characteristics

Table 4 reports estimates of models similar to those in Table 3 with the addition of demographic and economic characteristics of the respondent and target. Estimated coefficients of the variables included in the basic model are virtually identical to those in Table 3.

Estimated WTP to reduce risk to one's child or to another adult in the household varies with the sex of the child and with the age and sex of the other adult.

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[6] Note: 30 percent ≈ 1 – exp(-0.396), 60 percent ≈ 1 – exp(-0.921).

The estimated coefficients imply that the respondent will pay about 4 percent more to reduce risk to a male child and 33 percent more to reduce risk to a male adult. WTP increases with the age of the other adult in the household, at a rate of approximately 1 percent for every decade of age. Estimated WTP also varies significantly with several respondent characteristics. WTP increases with respondent age, at a rate of approximately 16 percent for every decade of age in the pooled model and similar rates in the other models. Married respondents have significantly smaller WTP for all targets and male respondents are estimated to have smaller WTP for themselves, though not for others in the household, suggesting that men are stoic but no less altruistic than women. WTP is estimated to increase with respondents' education, though the effect is statistically significant only for risk to another adult and in the pooled model. The coefficient in the pooled model suggests that WTP increases about 4 percent with each year of education. The effect of household income is significantly positive for WTP to reduce risk to oneself or one's child, though not to reduce risk to another adult. The estimated income elasticity is about 0.3 for reducing risk to oneself and one's child, toward the lower end of previous estimates (Hammitt and Robinson 2011).

Effect of condition name

To examine how WTP varies with the illness named, we report in Table 5 a set of models that are identical to the basic models in Table 3 supplemented with variables indicating the specific illness named (recall that the illness is not named for half the respondents). Adding these indicator variables has no significant effect on the estimated coefficients for the log of risk reduction but the estimated coefficients on the log of HRQL loss and log duration of illness are somewhat smaller than in the corresponding models in Table 3. In the pooled model, for example, the coefficient on log HRQL loss decreases from 0.37 in Table 3 to 0.30 in Table 5 and the coefficient on log duration decreases from 0.13 to 0.07.

Of the 11 named conditions, the estimated coefficients of six are significantly different from zero in the pooled model (Model 1, Table 5). All are less than zero, implying that WTP to reduce the risk of these named diseases is smaller than WTP to reduce the risk of an unnamed disease having the same EQ-5D profile. Ranking these diseases in decreasing order of the absolute value of the estimated coefficient yields skin cancer, influenza, migraine headache, hepatitis, bronchitis, and respiratory

infection. Evidently, respondents view these diseases as mild compared with the associated EQ-5D profiles. In contrast, the estimated coefficients on the other five diseases (Parkinson's disease, heart disease, liver disease, liver cancer, and lung cancer) are not significantly different from zero, implying that WTP to reduce risk of these diseases is no smaller than to reduce the risk of an unnamed disease having the same EQ-5D profile. The larger WTP to reduce risks of these diseases (controlling for HRQL) may also reflect respondents' recognition that these diseases are often fatal.

Estimates of the models for each target reveal similar patterns of point estimates, though fewer estimates are significantly different from zero. One exception is that the estimated coefficient for lung cancer when the risk is to another adult (Model 4) is significantly different from zero. The estimated coefficient implies that WTP to reduce this risk is almost 140 percent larger than for an unnamed disease with the same EQ-5D profile.

WTP by EQ-5D attribute

In the models reported in Tables 3, 4, and 5, severity of illness is measured as the log of the loss in HRQL between a target's current health and health if he or she develops the stated illness. We examine the relationship between WTP and potential health loss using two approaches: estimate WTP using a model including information on each attribute at baseline and if ill, and estimate WTP as a function of losses on each attribute using a model that is based on the Shaw et al. (2005) scoring function.

The models reported in Table 6 supplement the basic model (Table 3) with variables characterizing the levels of each of the EQ-5D attributes for the target's current health and health if he or she suffers the specified illness (log HRQL loss is omitted).[7] The results suggest that WTP to reduce risk of illness varies with baseline levels and potential losses on the different attributes. When the target is an adult (the respondent or another adult), estimated WTP to reduce risk is larger when current health includes pain/discomfort and impairments in carrying out usual activities, and smaller for targets whose current health includes impairments in self-care. Estimated

[7] The variables for baseline impairment of each attribute are defined as the corresponding level of the EQ-5D attribute for current health minus one; i.e., 0 if the target's current health includes no impairment on that attribute, 1 for moderate impairment, and 2 for severe impairment. The variables for loss on each attribute are defined as the difference between the level of the attribute if ill and the level at current health and can take the values 0, 1, and 2.

WTP is larger when the illness produces a loss in mobility and (for another adult) a loss in usual activities or pain/discomfort. When the target is a child, WTP to reduce risk is smaller if the child has impaired mobility at baseline. Estimated WTP is more sensitive to baseline health than to the incremental impairment if ill: the absolute value of the coefficient on baseline impairment is larger than that on impairment for three or four of the five attributes in all four models.

Estimated coefficients of the other variables are similar to their values in the corresponding basic model (Table 3). The elasticity of WTP with magnitude of risk reduction is about 0.6 and that with duration is about 0.1. On average, WTP to reduce risk of a named illness is much smaller than for a corresponding unnamed illness, and WTP is larger when the target is a child or other adult.

Table 7 reports estimates of a model that is based on the model developed by Shaw et al. (2005) to calculate HRQL for each EQ-5D profile. This model can be used to examine whether WTP and HRQL bear similar functional relationships to EQ-5D profile. In addition to variables from the basic model, the independent variables include indicator variables for the loss (from current health) to level 2 or level 3 on each attribute, plus variables for the change in the number of attributes at level 2 or 3 and their squares.

The first column reports the coefficients of the Shaw et al. (2005) model. These coefficients estimate the decrement in HRQL associated with a loss from level 1 to the indicated level on each attribute. Note that the effect of loss to level 3 exceeds that of loss to level 2 for each attribute, as one would anticipate. In the pooled WTP model (Model 1), it is also true that the increase in WTP is larger when the illness would produce a loss to level 3 than a loss to level 2 on each attribute.

In contrast, the relative effect of losses on different attributes differs between the HRQL value function and the WTP models. For both the HRQL value function and the pooled WTP model, the attribute for which a loss to level 3 has the largest effect is mobility. In contrast, the attribute with the second largest effect in the HRQL value model is pain/discomfort, though this attribute has the least effect in the WTP model. The attribute with the second largest effect in the WTP model is anxiety/depression, though this attribute has only the fourth largest effect in the HRQL value function.

Overall, the results of Tables 6 and 7 suggest that WTP to reduce risk of a health loss described by the change in EQ-5D profile is not adequately captured by

the loss in the summary measure of HRQL calculated using the Shaw et al. (2005) scoring function. Adding a variable for log of HRQL loss to the models reported in Table 7 confirms this result, as doing so has little effect on the estimated coefficients reported in Table 7. WTP depends on the baseline levels and losses on each attribute in a pattern that differs from the difference in calculated HRQL.

4. Conclusions

We have examined the relationship between two alternative metrics for valuing health risk, WTP and QALYs, in the context of acute and chronic morbidity. A practical motivation is to determine whether it is possible to estimate WTP to reduce risk of a morbid health condition by transferring from an estimate of the expected QALY loss. Such an approach would be valuable because there are few direct estimates of WTP to reduce morbidity risk and many estimates of the QALY loss associated with adverse health conditions. Moreover, it is comparatively easy to estimate the QALY loss associated with an adverse health condition because the HRQL can be estimated using generic health-state classification and utility systems (such as the EQ-5D) and combined with an estimate of the duration of the health state. For example, Lawrence et al. (2006) estimated the QALY loss associated with several conditions by asking a small sample of physicians and others familiar with these conditions to classify them using the EQ-5D and analogous systems, from which the HRQL could be calculated.

In a large stated-preference survey, we presented respondents with risks of nonfatal health conditions described by EQ-5D profile and duration. For half the respondents, the disease or illness was also named. We elicited WTP to reduce risk to the respondent him or herself and to a child and other adult living in the respondent's household. The risk was presented as resulting from exposure to environmental contaminants and to be reducible by participating in a government environmental health protection program that includes an annual screening test and preventive medicine. WTP was elicited using standard double-bounded dichotomous-choice questions.

As a test of respondent comprehension and quality of response, we randomly varied the reduction in probability of illness between 1/10,000 and 2/10,000 per year. In all of our regression models, WTP varies with the magnitude of risk reduction. The estimated elasticity of WTP with respect to risk reduction is about 0.6 and is

statistically significantly different from zero. Although (for some models) it is significantly smaller than the value of one implied by economic theory, this value is larger than obtained in many stated-preference surveys and indicates that the respondents were attentive to differences in risk reduction across valuation questions.[8]

We find that WTP to reduce risk is significantly related to the QALY loss from illness but the variation is less than proportionate. The elasticity of WTP with respect to the loss in HRQL (the difference between the individual's current HRQL and its value if ill) is about 0.3 and the elasticity of WTP with respect to duration of illness is about 0.1. These results imply that WTP to reduce risk is not proportional to the expected reduction in QALYs lost, and so WTP to reduce morbidity risk cannot be accurately estimated by multiplying the reduction in expected QALYs lost by a constant WTP per QALY value. One might be concerned that the elasticities of WTP with respect to severity and duration are underestimated because of some form of scope insensitivity in our survey instrument. However, it seems implausible that scope insensitivity would have a larger effect on attributes such as severity and duration that are likely to be well understood by respondents than on attributes such as the small reduction in probability of illness for which respondents may have little appreciation, and for which the estimated elasticity (0.6) is much larger.

Describing the illness by name as well as EQ-5D profile reduces the estimated WTP on average. This reduction obtains only for the milder diseases considered (influenza, respiratory infection, skin cancer), not the more severe (e.g., lung cancer, liver cancer, liver disease, heart disease). The statistically significant effect of disease name (at least for some conditions) implies that the information about health state provided by an EQ-5D profile is not sufficient; i.e., respondents are not indifferent to reducing risk of different illnesses having the same EQ-5D profile. For some diseases, this additional information may include recognition of significant mortality risk.

We find that WTP to reduce risk to another person exceeds WTP to reduce risk to oneself. WTP to reduce risk to another adult in the household is estimated to be 70 percent larger than WTP to reduce risk to oneself and WTP to reduce risk to a child living in the household is an additional 70 percent larger, yielding a combined premium relative to WTP to reduce risk to self of 190 percent.

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[8] As noted above, in models estimated using only information about the first target valued, the estimated coefficient is very nearly one.

We also evaluate WTP to reduce morbidity risk as a function of pre-existing health and the decrements associated with the stated illness on each of the five EQ-5D attributes. The results suggest that WTP to reduce risk to an adult (the respondent or other adult) is larger when current health includes pain/discomfort and impairments in carrying out usual activities and smaller for targets whose current health includes impairments in self-care. Estimated WTP is larger when the illness produces a loss in mobility and (for another adult) a loss in usual activities or pain/discomfort. When the target is a child, WTP to reduce risk is smaller if the child has impaired mobility at baseline. Comparing the effect of losses on each EQ-5D attribute on WTP and on the HRQL as calculated using a scoring function developed for the US population (Shaw et al. 2005) suggests that the functional relationships between these measures and EQ-5D profile differ: although loss of mobility is the most influential attribute for both, the relative importance of other attributes differs between the measures.

The estimated value per statistical case depends on the severity and duration of morbidity as well as the individual at risk. For illustration, consider an unnamed illness of one year duration that reduces HRQL by 0.1. Using the target-specific models reported in Table 3 (Models 2 – 4), assuming perfect current health, and averaging over the two values of risk reduction, the predicted median values per statistical case are $650,000, $2.9 million, and $780,000 for the respondent, a child, and another adult living in the household, respectively. For a very severe case of 40 year duration that reduces HRQL by 1.0 (i.e., from perfect health to a state as bad as dead), the corresponding values per statistical case are $3.6, $9.5, and $5.6 million. These values for a chronic illness as bad as dead are comparable to conventional estimates of the value per statistical life (e.g., Viscusi and Aldy 2003, Kochi et al. 2006), which supports their plausibility.

In summary, we find that it is possible to elicit internally consistent and apparently meaningful estimates of WTP to reduce risk of morbid health conditions using a generic health classification and utility system. Estimated WTP is significantly larger for conditions that are more severe (as measured by the loss in calculated HRQL) and of longer duration, but the variation of WTP with these dimensions is much less than proportionate. Estimated WTP is sensitive to supplementing the EQ-5D profile with the name of the disease. Estimated WTP is larger to reduce risk to another household member than to oneself, especially when the other is a child. Moreover, the relationships of WTP and HRQL to attributes of the

EQ-5D classification system are systematically different. These results suggest that accurate estimates of WTP to reduce risk of morbid conditions cannot be obtained by multiplying the expected reduction in QALY loss by a constant WTP per QALY value. More accurate estimates may be obtained using a concave function of the severity and duration of the illness like those estimated here, though our results suggest that economic valuation is a different function than HRQL of the EQ-5D attributes and also depends on aspects of the illness that are conveyed by supplementing the EQ-5D health profile with the name of the condition.

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Table 1. Health Profiles, Illness Names, and Durations

Health Profile	EQ-5D Attribute Levels	EQ-5D Score	Name of Illness	Possible Duration
A	M1 S1 U1 P2 A1	0.827	Influenza	1 month
A	M1 S1 U1 P2 A1	0.827	Respiratory Infection	1 month, 1 year
A	M1 S1 U1 P2 A1	0.827	Skin Cancer	1 month, 1 year
B	M1 S1 U1 P2 A2	0.800	Bronchitis	1 month, 1 year, Lifetime
B	M1 S1 U1 P2 A2	0.800	Lung Cancer	Lifetime
B	M1 S1 U1 P2 A2	0.800	Migraine Headaches	1 month, 1 year, Lifetime
B	M1 S1 U1 P2 A2	0.800	Respiratory Infection	1 month, 1 year
B	M1 S1 U1 P2 A2	0.800	Skin Cancer	1 month, 1 year
C	M1 S1 U2 P2 A2	0.768	Hepatitis	1 month, 1 year, Lifetime
C	M1 S1 U2 P2 A2	0.768	Influenza	1 month
D	M2 S1 U2 P2 A2	0.708	Heart Disease	Lifetime
D	M2 S1 U2 P2 A2	0.708	Hepatitis	1 month, 1 year, Lifetime
D	M2 S1 U2 P2 A2	0.708	Liver Cancer	Lifetime
D	M2 S1 U2 P2 A2	0.708	Liver Disease	Lifetime
E	M2 S2 U2 P2 A2	0.597	Parkinson's Disease	Lifetime
F	M2 S1 U2 P3 A2	0.397	Bronchitis	1 month, 1 year, Lifetime
F	M2 S1 U2 P3 A2	0.397	Lung Cancer	Lifetime
G	M1 S1 U2 P3 A3	0.289	Migraine Headaches	1 month, 1 year, Lifetime
H	M2 S2 U3 P3 A2	0.263	Liver Cancer	Lifetime
H	M2 S2 U3 P3 A2	0.263	Liver Disease	Lifetime
J	M3 S3 U3 P2 A1	0.145	Parkinson's Disease	Lifetime
K	M3 S2 U2 P3 A2	0.086	Heart Disease	Lifetime

Note: EQ-5D attributes: M – Mobility, S – Self Care, U – Usual Activities, P – Pain/Discomfort,
A – Anxiety/Depression. Level 1 is no problem, level 2 is a moderate problem, and level 3 is a severe problem.

Table 2. Sample Means and Standard Deviations

	Household Member at Risk			
Variable	Pooled	Self	Child	Other Adult
Baseline Risk is 4 in 10,000 per Year	0.505 (0.500)	0.510 (0.500)	0.514 (0.500)	0.495 (0.500)
Log of Risk Reduction	-8.866 (0.347)	-8.867 (0.347)	-8.872 (0.347)	-8.863 (0.347)
Log of Loss in Health-Related Quality of Life	-1.426 (1288)	-1.490 (1.346)	-1.038 (0.807)	-1.512 (1.347)
Log of Duration of Illness in Years	0.858 (2.642)	0.791 (2.562)	1.125 (2.957)	0.829 (2.594)
Named Illness	0.474 (0.499)	0.486 (0.500)	0.444 (0.497)	0.471 (0.499)
Current Health-Related Quality of Life	0.870 (0.160)	0.854 (0.161)	0.948 (0.121)	0.857 (0.164)
Current Health and Illness have same EQ-5D Profile	0.085 (0.279)	0.098 (0.297)	0.010 (0.098)	0.102 (0.303)
Risk is to Child in Household	0.159 (0.366)	0.000 (0.000)	1.000 (0.000)	0.000 (0.000)
Risk is to Other Adult in Household	0.364 (0.481)	0.000 (0.000)	0.000 (0.000)	1.000 (0.000)
Age of Other Person at Risk	41.66 (20.99)		9.786 (5.521)	47.23 (17.09)
Other Person at Risk is Male	0.497 (0.500)		0.524 (0.500)	0.494 (0.500)
Respondent's Age	47.99 (17.03)	47.99 (17.03)	37.62 (11.15)	46.39 (16.96)
Male Respondent	0.489 (0.500)	0.489 (0.500)	0.477 (0.500)	0.505 (0.500)
Household Income (in thousand US$)	62.02 (43.54)	62.02 (43.54)	67.54 (42.52)	68.13 (44.40)
Log of Household Income	10.76 (0.838)	10.76 (0.838)	10.90 (0.740)	10.89 (0.781)
Respondent's Education in Years	13.69 (2.633)	13.69 (2.633)	13.90 (2.431)	13.65 (2.600)
Black, Non-Hispanic Respondent	0.084 (0.278)	0.084 (0.278)	0.087 (0.282)	0.073 (0.260)
Hispanic Respondent	0.092 (0.289)	0.092 (0.289)	0.129 (0.336)	0.090 (0.286)
Other Race, Non-Hispanic Respondent	0.056 (0.231)	0.056 (0.231)	0.054 (0.225)	0.058 (0.233)
Sample Size	2,184	2,184	727	1,668

Note: Standard deviations are in parentheses.

Table 3. Basic WTP model

	Household Member at Risk			
	Pooled	Self	Child	Other Adult
Variable	Model 1	Model 2	Model 3	Model 4
Intercept	12.040*** (1.220)	11.880*** (1.738)	11.161*** (3.301)	13.242*** (2.006)
Baseline Risk is 4 in 10,000 per Year	-0.057 (0.091)	0.065 (0.130)	-0.217 (0.239)	-0.148 (0.150)
Log of Risk Reduction	0.614*** (0.132)	0.635*** (0.189)	0.578* (0.346)	0.600*** (0.218)
Log of Loss in Health-Related Quality of Life	0.372*** (0.057)	0.358*** (0.079)	0.197 (0.179)	0.436*** (0.093)
Log of Duration of Illness in Years	0.126*** (0.018)	0.118*** (0.027)	0.136*** (0.044)	0.137*** (0.031)
Named Illness	-0.516*** (0.094)	-0.483*** (0.135)	-0.921*** (0.251)	-0.396** (0.155)
Current Health-Related Quality of Life	-1.265*** (0.331)	-0.940** (0.462)	0.542 (1.045)	-2.152*** (0.530)
Health and Illness have same EQ-5D Profile	1.161*** (0.251)	0.863** (0.343)	0.366 (1.327)	1.620*** (0.397)
Risk is to Child in Household	1.060*** (0.136)			
Risk is to Other Adult in Household	0.541*** (0.100)			
Residual Standard Deviation	3.615 (0.064)	3.571 (0.091)	3.756 (0.171)	3.598 (0.104)
Sample Size	9,103	4,346	1,441	3,316
Log Likelihood	-10,298	-4,900.9	-1,615.9	-3,771.8

Note: Standard errors are in parentheses. ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively, based on likelihood-ratio tests.

Table 4. Basic model with respondent and target characteristics

	Household Member at Risk			
	Pooled	Self	Child	Other Adult
Variable	Model 1	Model 2	Model 3	Model 4
Intercept	8.644***	8.214***	6.785*	10.560***
	(1.373)	(1.947)	(3.797)	(2.249)
Baseline Risk is 4 in 10,000 per Year	-0.053	0.059	-0.214	-0.135
	(0.091)	(0.130)	(0.239)	(0.149)
Log of Risk Reduction	0.608***	0.623***	0.569*	0.587***
	(0.131)	(0.188)	(0.345)	(0.216)
Log of Loss in Health-Related Quality of Life	0.376***	0.361***	0.179	0.445***
	(0.057)	(0.079)	(0.179)	(0.093)
Log of Duration of Illness in Years	0.129***	0.126***	0.134***	0.135***
	(0.018)	(0.027)	(0.043)	(0.031)
Named Illness	-0.553***	-0.530***	-0.900***	-0.425***
	(0.095)	(0.136)	(0.251)	(0.155)
Current Health-Related Quality of Life	-1.259***	-0.970**	0.627	-2.087***
	(0.343)	(0.484)	(1.049)	(0.552)
Current Health and Illness have same EQ-5D Profile	1.177***	0.899***	0.343	1.637***
	(0.251)	(0.342)	(1.325)	(0.395)
Risk is to Child in Household	1.201***			
	(0.200)			
Risk is to Other Adult in Household	0.600***			
	(0.102)			
Age of Other Person at Risk	-0.000***		-0.017	0.001***
	(0.005)		(0.023)	(0.006)
Other Person at Risk is Male	0.040***		0.035*	0.283***
	(0.095)		(0.240)	(0.184)
Respondent Age	0.015***	0.012***	0.027**	0.018***
	(0.005)	(0.004)	(0.011)	(0.006)
Male Respondent	-0.260***	-0.342***	0.093	-0.107
	(0.095)	(0.131)	(0.243)	(0.184)
Log of Household Income	0.219***	0.276***	0.318*	0.080
	(0.065)	(0.090)	(0.179)	(0.108)
Respondent's Education in Years	0.042**	0.027	0.030	0.073**
	(0.019)	(0.027)	(0.053)	(0.032)
Married Respondent	-0.371***	-0.246*	-0.909***	-0.427**
	(0.102)	(0.140)	(0.278)	(0.180)
Residual Standard Deviation	3.597	3.559	3.729	3.563
	(0.063)	(0.090)	(0.170)	(0.103)
Sample Size	9,080	4,346	1,434	3,300
Log Likelihood	-10,245	-4,888.3	-1,601.8	-3,738.9

Note: Standard errors are in parentheses. ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively, based on likelihood-ratio tests.

Table 5. Basic model with illness names

	Household Member at Risk			
	Pooled	Self	Child	Other Adult
Variable	Model 1	Model 2	Model 3	Model 4
Intercept	11.759*** (1.222)	11.530*** (1.741)	10.919*** (3.323)	13.245*** (2.004)
Baseline Risk is 4 in 10,000 per Year	-0.052 (0.091)	0.065 (0.130)	-0.228 (0.239)	-0.145 (0.150)
Log of Risk Reduction	0.618*** (0.132)	0.630*** (0.188)	0.584* (0.346)	0.636*** (0.217)
Log of Loss in Health-Related Quality of Life	0.299*** (0.063)	0.290*** (0.087)	0.083 (0.199)	0.371*** (0.103)
Log of Duration of Illness in Years	0.069*** (0.022)	0.067*** (0.032)	0.111*** (0.052)	0.060*** (0.036)
Influenza	-1.108*** (0.260)	-0.995*** (0.354)	-0.895 (0.664)	-1.441*** (0.469)
Respiratory Infection	-0.518* (0.286)	-0.003 (0.436)	-1.382* (0.751)	-0.694 (0.438)
Bronchitis	-0.592** (0.238)	-0.511 (0.345)	-0.450 (0.598)	-0.747* (0.391)
Migraine Headaches	-0.807*** (0.201)	-0.635** (0.285)	-0.869 (0.556)	-0.977*** (0.328)
Parkinson's Disease	-0.158 (0.200)	0.044 (0.280)	-0.433 (0.594)	-0.330 (0.325)
Heart Disease	0.022 (0.216)	-0.269 (0.301)	-0.611 (0.597)	0.674* (0.362)
Hepatitis	-0.718*** (0.249)	-0.817** (0.363)	-1.963*** (0.709)	-0.160 (0.390)
Liver Disease	-0.336 (0.255)	-0.131 (0.356)	-1.125* (0.636)	-0.310 (0.445)
Liver Cancer	-0.168 (0.244)	-0.355 (0.342)	-0.533 (0.670)	0.218 (0.406)
Skin Cancer	-1.353*** (0.278)	-1.563*** (0.399)	-1.585** (0.711)	-0.972** (0.463)
Lung Cancer	0.351 (0.254)	0.229 (0.372)	-0.538 (0.643)	0.864** (0.414)
Current Health-Related Quality of Life	-0.998*** (0.341)	-0.673 (0.479)	0.753 (1.064)	-1.870*** (0.544)
Current Health and Illness have same EQ-5D Profile	1.088*** (0.254)	0.806** (0.346)	0.095 (1.336)	1.562*** (0.403)
Risk is to Child in Household	1.084*** (0.136)			
Risk is to Other Adult in Household	0.536*** (0.100)			
Residual Standard Deviation	3.606 (0.064)	3.558 (0.090)	3.743 (0.171)	3.575 (0.104)
Sample Size	9,103	4,346	1,441	3,316
Log Likelihood	-10,281	-4,891.6	-1,613.1	-3,757.2

Note: Standard errors are in parentheses. ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively, based on likelihood-ratio tests.

Table 6. Basic model with baseline health and potential loss by EQ-5D attribute

	Household Member at Risk			
	Pooled	Self	Child	Other Adult
Variable	Model 1	Model 2	Model 3	Model 4
Intercept	8.985***	9.511***	11.779***	9.029***
	(1.203)	(1.721)	(3.232)	(1.984)
Baseline Risk is 4 in 10,000 per Year	-0.069	0.062	-0.248	-0.159
	(0.091)	(0.130)	(0.240)	(0.150)
Log of Risk Reduction	0.603***	0.626***	0.546	0.597***
	(0.132)	(0.188)	(0.345)	(0.217)
Baseline Impairment in Mobility	-0.104	-0.261	-1.848**	0.369
	(0.168)	(0.233)	(0.813)	(0.259)
Baseline Impairment in Self-Care	-0.623***	-0.804**	-0.091	-1.209***
	(0.194)	(0.339)	(0.316)	(0.402)
Baseline Impairment in Usual Activities	0.323*	0.636***	0.277	0.184
	(0.171)	(0.245)	(0.595)	(0.269)
Baseline Impairment in Pain and Discomfort	0.671***	0.520**	0.585	0.819***
	(0.152)	(0.212)	(0.638)	(0.242)
Baseline Impairment in Anxiety and Depression	0.127	0.058	0.020	0.236
	(0.132)	(0.186)	(0.425)	(0.212)
Loss in Mobility	0.278**	0.375**	-0.031	0.308*
	(0.111)	(0.161)	(0.283)	(0.185)
Loss in Self-Care	0.085	-0.027	0.356	0.042
	(0.139)	(0.200)	(0.370)	(0.226)
Loss in Usual Activities	0.077	0.059	-0.253	0.354*
	(0.117)	(0.167)	(0.306)	(0.196)
Loss in Pain and Discomfort	0.245**	0.118	0.344	0.371*
	(0.121)	(0.173)	(0.331)	(0.196)
Loss in Anxiety and Depression	0.163	0.288	0.180	-0.020
	(0.124)	(0.181)	(0.319)	(0.204)
Log of Duration of Illness in Years	0.116***	0.113***	0.134***	0.117***
	(0.019)	(0.028)	(0.045)	(0.031)
Named Illness	-0.515***	-0.504***	-0.918***	-0.373**
	(0.095)	(0.135)	(0.253)	(0.155)
Current Health and Illness have same EQ-5D Profile	0.256	0.012	-0.305	0.703**
	(0.202)	(0.275)	(1.316)	(0.313)
Risk is to Child in Household	1.292***			
	(0.141)			
Risk is to Other Adult in Household	0.535***			
	(0.100)			
Residual Standard Deviation	3.605	3.560	3.737	3.570
	(0.064)	(0.090)	(0.170)	(0.104)
Sample Size	9,103	4,346	1,441	3,316
Log Likelihood	-10,279	-4,890.2	-1,612.2	-3,755.5

Note: Standard errors are in parentheses. ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively, based on likelihood-ratio tests.

Table 7. Basic model with EQ-5D valuation variables

Variable	HRQL Value Function	Household Member at Risk			
		Pooled	Self	Child	Other Adult
		Model 1	Model 2	Model 3	Model 4
Intercept		10.353*** (1.174)	10.529*** (1.678)	11.551*** (3.136)	10.893*** (1.927)
Baseline Risk is 4 in 10,000 per Year		-0.064 (0.091)	0.052 (0.130)	-0.228 (0.240)	-0.140 (0.150)
Log of Risk Reduction		0.609*** (0.132)	0.631*** (0.188)	0.592* (0.345)	0.626*** (0.217)
Loss to Level 2 Mobility	0.146 (0.008)	0.448* (0.231)	0.996*** (0.334)	0.181 (0.691)	-0.064 (0.377)
Loss to Level 3 Mobility	0.558 (0.016)	1.883*** (0.631)	2.620*** (0.954)	1.321 (1.597)	1.563 (1.042)
Loss to Level 2 Self-Care	0.175 (0.008)	0.265 (0.311)	0.870* (0.469)	0.339 (0.736)	-0.464 (0.526)
Loss to Level 3 Self-Care	0.471 (0.016)	0.897 (0.627)	1.977** (0.911)	0.077 (1.678)	-0.246 (1.042)
Loss to Level 2 Usual Activities	0.140 (0.008)	-0.051 (0.226)	-0.067 (0.331)	-0.159 (0.600)	0.142 (0.374)
Loss to Level 3 Usual Activities	0.374 (0.013)	1.221* (0.629)	1.309 (0.947)	0.828 (1.670)	1.842* (1.038)
Loss to Level 2 Pain and Discomfort	0.173 (0.008)	-0.521*** (0.119)	-0.491*** (0.163)	-0.100 (0.589)	-0.572*** (0.184)
Loss to Level 3 Pain and Discomfort	0.537 (0.020)	0.329 (0.294)	0.263 (0.415)	0.623 (0.998)	0.518 (0.471)
Loss to Level 2 Anxiety and Depression	0.156 (0.008)	0.132 (0.160)	0.331 (0.228)	0.011 (0.428)	-0.022 (0.273)
Loss to Level 3 Anxiety and Depression	0.450 (0.015)	1.664*** (0.549)	3.157*** (0.852)	1.473 (1.440)	0.179 (0.891)
Change in Number of Attributes at Level 2 Squared	0.011 (0.002)	-0.042 (0.040)	0.005 (0.058)	-0.074 (0.115)	-0.102 (0.066)
Change in Number of Attributes at Level 3	-0.122 (0.018)	1.726*** (0.633)	2.967*** (0.977)	1.559 (1.762)	0.523 (1.005)
Change in Number of Attributes at Level 3 Squared	-0.015 (0.003)	-0.242 (0.150)	-0.436** (0.220)	-0.401 (0.509)	0.024 (0.226)
Change in Number of Attributes at Level 2 or 3	-0.140 (0.010)	0.232 (0.198)	0.315 (0.291)	0.229 (0.495)	0.261 (0.334)
Log of Duration of Illness in Years		0.117*** (0.019)	0.117*** (0.028)	0.125*** (0.045)	0.125*** (0.031)
Named Illness		-0.500*** (0.095)	-0.461*** (0.135)	-0.885*** (0.253)	-0.370** (0.155)
Current Health and Illness have same EQ-5D Profile		0.245 (0.205)	-0.084 (0.281)	-0.417 (1.325)	0.746** (0.321)

Continued on next page

Table 7. Basic model with EQ-5D valuation variables

Variable	HRQL Value Function	Household Member at Risk			
		Pooled	Self	Child	Other Adult
		Model 1	Model 2	Model 3	Model 4
Risk is to Child in Household		1.280***			
		(0.141)			
Risk is to Other Adult in Household		0.540***			
		(0.100)			
Residual Standard Deviation		3.603	3.550	3.738	3.570
		(0.064)	(0.090)	(0.171)	(0.104)
Sample Size		9,103	4,346	1,441	3,316
Log Likelihood		-10,271	-4,877.2	-1,613.3	-3,757.7

Note: Standard errors are in parentheses. ***, **, and * denote statistical significance at 1, 5, and 10 percent, respectively, based on likelihood-ratio tests. HRQL Value Function reported in Shaw et al. (2005); all of the reported coefficients are statistically significant at 1 percent.