Income Effects and the Value of Health

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Income Effects and the Value of Health

William N. Evans
W. Kip Viscusi

ABSTRACT
Although valuations of risk should increase with income, hedonic wage studies have not been well suited to assessing this relationship. Using survey data on consumer valuations of product safety, this paper analyzes the role of income effects for several utility functions. The methodology developed in this paper assesses the effect of income on the certainty equivalent value of the health effect (income elasticities range from 0.18 to 0.39) and on the risk-money tradeoff for small changes in risk (income elasticities range from 0.17 to 0.38). Health status is a normal economic good.

I. Introduction

Individuals differ in their attitudes towards health risks just as their preferences for other goods differ. This heterogeneity has two principal implications for public policy decisions affecting risks to life and health. First, the appropriate values of life and health will vary with the characteristics of the population at risk. This heterogeneity accounts for the lower estimated values of life for individuals who self-select into high-risk jobs or who have displayed a willingness to bear risk through smoking behavior or failure to use seatbelts.\(^1\)

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William N. Evans is an assistant professor of economics at the University of Maryland; W. Kip Viscusi is a professor of economics at Duke University. The authors wish to thank three anonymous referees for a number of helpful suggestions. Data requests should be sent from December 1993 through December 1996 to W. Kip Viscusi, Department of Economics, Duke University, Durham, NC, 27706. [Submitted September 91; accepted June 92]
Similarly, individual health habits relating to diet and exercise differ across the population, and these differences will be reflected in their valuation of the benefits of risk reduction policies.  

The second principal ramification of the heterogeneity in risk preferences is that many of the differences are systematic. The primary concern in the economic literature has been with variations due to differences in wealth. If safety is a normal economic good, then individual risk-dollar tradeoffs should be an increasing function of income, as shown in Viscusi (1979). The increased demand for safety that has accompanied society’s increased wealth is a reflection of this influence.

Evidence with regard to wealth effects is also pertinent to how people make choices under uncertainty. In the experimental studies underlying the prospect theory of Kahneman and Tversky (1979), individuals make decisions based on the incremental effects of policies rather than on the net asset position. In effect, wealth endowments are not of consequence. Examination of a major class of individual consumer safety choices will help illuminate whether one should disregard the role of one’s asset position or whether one should rely on a more conventional rational choice model.

The empirical evidence we have on the strength and direction of this wealth effect is suggestive, but not definitive. Conventional hedonic wage equations are not ideally suited to the task of analyzing the role of wealth effects. Researchers, such as Thaler and Rosen (1976) and Viscusi (1979), have used proxies for lifetime wealth, such as age and education, which are then interacted with the risk variable in the wage equation. Viscusi (1978) found a weak, but significant, negative relationship between job risks and a more direct measure of worker wealth. The conventional hedonic wage equation reflects the joint influence of firm demand and workers’ labor supply, and in all likelihood variables such as education affect both sides of the market. Better educated workers may, for example, be more efficient in producing safety so that they will command a higher wage in risky industries. The availability of job risk data by individual and occupation, but not for the individual worker, increases the problems of distinguishing supply and demand influences. Thus, the existing evidence on the role of wealth as it affects workers’ risk decisions is not conclusive.

Estimated income elasticities of demand for health insurance are positive, as discussed in Phelps (1976 and 1987). Newhouse and Phelps (1976) estimate a positive income elasticity for hospital and physician services. More affluent individuals are more likely to undertake other investments that enhance their health, such as exercise, as noted by Fuchs (1986) and Manning, et al. (1991). Evidence also suggests that more affluent individuals are also more likely to use such motor vehicle safety devices such as seatbelts, motorcycle helmets, or automobile child restraints, as found by Blomquist (1991). Moreover, Viscusi and Evans (1990) find from their analysis of the structure of utility in unhealthy states of the world that the income elasticity of the value of reducing risks of job injury is about 1.0.

In this paper we will extend our earlier analysis of heterogeneity using data on nonfatal consumer injuries. Rather than simply noting the overall relationship

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2. Differences in health habits are explored in detail by Fuchs (1986) and Manning et al. (1991).
between income and attitudes towards risk, we explicitly estimate the state-dependent utility functions and their relationship to individual income levels. This analysis consequently will not only document the positive income elasticity of the value of risk reduction but will also identify sources of this relationship based on the structure of individual preferences. Thus, these results will provide the most comprehensive perspective on the role of individual income on consumer valuation of risk.

Knowledge of the utility functions will also enable one to explore a variety of different ramifications of income. In addition to analyzing the dependence of risk-dollar tradeoffs on income, we can also assess how the compensation required to restore one's utility after an injury varies with income status.

In the next section of the paper, we construct a simple model of expected utility in a health context where the disutility of the unhealthy state can be treated as a simple monetary loss equivalent. In Section III we describe the survey data we use in our analysis. In Section IV, we define the expected utility locus suggested by the structure of the survey. In Section V, we demonstrate how, once an explicit function for utility is assumed, the expected utility locus can be transformed into an estimable equation which contains the monetary loss equivalent and other utility function parameters. In this section, we produce estimable equations for three utility functions: an unrestricted model, logarithmic utility, and a constant-risk aversion utility function, and demonstrate how we allow the loss equivalent to vary with income. In Section VI, we present the estimates and in Section VII, we show how the range of policy questions is greatly expanded once estimates of the underlying structure of utility are produced.

II. Modeling the Utility of Minor Ill Health Effects

Viewed in its most general form, one can treat health status as simply a component of an individual utility function, where utility \( U \) is a function of income \( Y \) and a health state \( H_i \). Typically, we do not have sufficient information to construct a continuous measure of health status, and therefore, health is subsumed into the analysis by indexing the utility function. This choice of modeling forms the basis for analyses of state-dependent utility.\(^3\) If each health state \( H_i \) has an associated probability of occurrence \( P_i \), and if income is also a function of health,\(^4\) then expected utility \( EU \) becomes:

\[
(1) \quad EU = \sum_{i=1}^{n} P_i U_i(Y_i).
\]

In Viscusi and Evans (1990) we demonstrate that, for severe injuries, the state-dependent characterization of utility is the appropriate transformation of utility

\(^3\) The state-dependent form of utility has been used extensively for risks to health. For example, see Zeckhauser (1970), Phelps (1973), Arrow (1974), Cook and Graham (1977), and Spence (1977).

\(^4\) Income can be a function of health, if for example, the individual is unable to work during health state \( H_i \), or if the unhealthy state requires out-of-pocket expenditures for medical care.
in the unhealthy state. In particular, these injuries alter the structure of utility, lowering both the level and the marginal utility. In Evans and Viscusi (1991) we demonstrate that for the minor health effects considered below, utility in an unhealthy state is tantamount to a drop in income, $L_i$, where $L_i$ is zero for perfect health. In this instance, the utility function in state $i$ is simply $U(Y - L_i)$ and expected utility is of the form

$$EU = \sum_{i=1}^{n} P_i U(Y - L_i),$$

where ill health lowers utility levels, but raises the marginal utility of income in comparison to the perfect health state.

In this paper, we utilize survey data on preferences toward risky consumer goods to explore the heterogeneity of the health loss $L_i$ and its variation with income. By making $L_i$ an explicit function of income, we can estimate the income elasticity of health losses and risks to health. Moreover, we will consider a broad range of functional forms for estimating the utility function so that the robustness of the relationship will be examined across different econometric specifications.

### III. The Survey and Sample

The data used in this study are drawn from a survey of adult shoppers in Greensboro, North Carolina. The demographic mix of this sample is broadly representative of the U.S. population.\(^5\) The survey was a contingent valuation study in which consumers were asked to evaluate two different formulations of a product. In addition, as discussed in Magat and Viscusi (1992), many results of the survey with respect to hypothetical consumer products were corroborated using a telephone survey pertaining to different brands currently being marketed. The product formulations varied only along two dimensions: the risk of injury posed by the use of the product and the price. In the survey, consumers are asked how much they are willing to pay for a safer product. The answer to these questions equates the expected utility from two product formulations, where respondents indicate their willingness to pay for several alternative reductions in risk. Because these survey questions define different points along the same expected utility locus, we are able to estimate the entire structure of the utility function, as was demonstrated in Evans and Viscusi (1991). The exercise is dependent on choosing an explicit utility function in the healthy and unhealthy state. In what follows, we describe the survey structure and the resulting model of the expected utility locus, and define the utility functions used in the estimation. We then describe how heterogeneity will be introduced into the analysis.

The survey began by asking consumers a series of questions regarding one of two products: an insecticide or a toilet bowl cleaner. The products were fictitious, but the labels were professionally printed and they appeared to be commercially

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\(^5\) Viscusi, Magat, and Huber (1987), and Magat and Viscusi (1992) provide a complete description of the survey.
sold brands. Subjects were asked to read the product label and were then questioned about the proper use of the product and the frequency with which they used the general class of products.

The interviewer then informed the subject that the particular product could cause harm if misused. For each product, the interviewer identified two potential injuries that might result from product misuse. For respondents shown the insecticide, the injuries were inhalations and skin poisonings, whereas the risks for the toilet bowl cleaner were gassings and eye burns. The respondents received detailed information on the characteristics of the injuries, which were largely temporary in nature. The risks of injury were specified in injuries per bottle used, and consequently, an individual’s risk of injury varied with the frequency of use.6 The original risk levels for all types of injuries were set at 15 injuries per 10,000 bottles sold. A key assumption is that respondents take these probability assessments at face value. Difficulties experienced in making decisions with respect to the probabilities may be of consequence. However, these complications should be less salient than for actual decisions where the probabilities must be assessed by the individual. Subjects were also informed that the current prices of the products were $2/bottle and $10/bottle for the toilet bowl cleaner and the insecticide respectively.

Table 1 summarizes the information about the two subsamples we use in our analysis. In all, we use data for about 950 individuals. The two populations are fairly similar, except that the toilet bowl subsample has significantly more women and substantially lower family incomes. This difference is primarily due to the fact that only those subjects who actually used the product were included in the survey. Consumers spend on average $15 a year on insecticide and $12 a year on toilet bowl cleaners, although the variance on these numbers is considerable.

Subjects were then asked how much they would be willing to pay per bottle to obtain a specified reduction in the risk of injury. This set of expenditure/risk tradeoff questions provides information on a series of points on a constant expected utility locus that will be used to specify the system of equations to be estimated.

**IV. Defining the Expected Utility Locus**

The design of the survey and the assumed structure of utility in ill health leads to the following model of the expected utility locus. Consumers purchase $n$ units of the product at the original price of $S_p/bottle. This quantity is assumed to be independent of any price change consumers express with respect to decreases in risk. This assumption is not strong since the price variations

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6. We implicitly assume that the risk per bottle is exogenous. There is the possibility that consumers may take different precautions in use and thereby alter their true probability of an accident. This would pose particular problems if precautionary behavior were related to income. Higher income groups may take greater precautions because of income effects or lower precautions because the time-cost of taking precautions may be too high. Magat and Viscusi (1992) found little evidence that for the two products we consider, the extent of precautions consumers take in the daily use of the products (such as wearing gloves or protective eyewear while using the product, or safe storage of the product) varied with income.
Table 1
Variable Definitions and Sample Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Sample Means and Standard Deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCOME</td>
<td>Yearly family income, 1986 U.S. dollars</td>
<td>27,645.57 (17,600.53)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37,835.90 (18,913.28)</td>
</tr>
<tr>
<td>YEARLY USE</td>
<td>Yearly use of product in bottle.</td>
<td>6.12 (5.80)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.45 (1.28)</td>
</tr>
<tr>
<td>AGE</td>
<td>Age of respondent.</td>
<td>39.56 (15.14)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43.10 (11.36)</td>
</tr>
<tr>
<td>EDUCATION</td>
<td>Years of education.</td>
<td>13.38 (2.70)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13.45 (2.30)</td>
</tr>
<tr>
<td>MALE</td>
<td>Sex dummy variable, = 1 if respondent is male, 0 otherwise.</td>
<td>0.16 (0.37)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.60 (0.49)</td>
</tr>
<tr>
<td>MARRIED</td>
<td>Marital status dummy variable, = 1 if respondent is married, 0 otherwise.</td>
<td>0.53 (0.50)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.72 (0.45)</td>
</tr>
<tr>
<td>$K_1$</td>
<td>Annual amount consumer is willing to pay, given an elimination of injury 1 risk.</td>
<td>5.60 (10.38)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.29 (6.36)</td>
</tr>
<tr>
<td>$K_2$</td>
<td>Annual amount consumer is willing to pay, given an elimination of injury 2 risk.</td>
<td>5.91 (20.30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.64 (6.00)</td>
</tr>
<tr>
<td>$K_3$</td>
<td>Annual amount consumer is willing to pay for elimination of both injury risks.</td>
<td>10.18 (23.90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.99 (10.80)</td>
</tr>
<tr>
<td>$N$</td>
<td>Number of observations</td>
<td>495</td>
</tr>
<tr>
<td></td>
<td></td>
<td>454</td>
</tr>
</tbody>
</table>

elicited by the survey is the willingness to pay for improved safety rather than a movement along a demand curve for a product of unchanged riskiness. Let annual family income be denoted as $Y$, and the consumer’s annual expenditures on the product be denoted as $C$, where $C = zn$. Let $P_i$ represent the original probability of experiencing injury $i$ for $i = 1, 2$. Utility in the healthy state is solely a function of income, while utility if injury $i$ occurs is a function of income minus the monetary loss equivalent $L_i$.  

7. For simplicity, we assume that the probability of observing both injuries occurring simultaneously is zero.

8. We implicitly assume that the injury will not be so severe so as to reduce labor income or cause out-of-pocket expenses for medical care. This is not a strong assumption particularly given the minor nature of the injuries. The monetary loss $L_i$ is therefore simply a dollar measure of the pain and suffering associated with the accident.
The consumer can reduce the risk of injury \( i \) through some additional expenditure on the product. Let the reduced risks of injury be denoted as \( Q_i \), where \( Q_i \leq P_i \). Let \( k \) be the amount a consumer is willing to pay per bottle for the reduced risk of injury, and let \( K = kn \) be the increase in yearly expenditure on the newly formulated product.\(^9\) Let \( Y^* = Y - C \). The variable \( K \) is the dollar amount that will make the consumer indifferent between the two versions of the product, where the equality of the expected utility locus can be specified as:

\[
(3) \quad \left(1 - \sum_{i=1}^{2} P_i \right) U[Y^*] + \sum_{i=1}^{2} P_i U[Y^* - L_i] = \left(1 - \sum_{i=1}^{2} Q_i \right) U[Y^* - K] + \sum_{i=1}^{2} Q_i U[Y^* - K - L_i].
\]

To obtain estimates of the monetary loss equivalent, we use information from three different income/risk tradeoffs. In the first round of questioning, the risk of Injury 1 is reduced to zero while the risk to Injury 2 is not altered (\( Q_1 = 0, Q_2 = P_2 \)). For Question 2, the risks are the opposite of Question 1, where \( Q_1 = P_1 \) and \( Q_2 = 0 \). Finally, for Question 3, risks were reduced to zero for both injuries.\(^10\)

The per bottle amount consumers were willing to pay for each formulation of the product are described in Table 2. Comparing the amount consumers are willing to pay for the elimination of the risks, the averages in Table 2 suggest that consumers value the two risks associated with the toilet bowl cleaner at about the same rate. This pattern is in contrast to the results for the insecticide subsample, where consumers are willing to pay a greater amount for the elimination of inhalation risks. Two points are also of note. First, there is a strong positive correlation between the responses given in all risk/dollar tradeoffs. For example, in the toilet bowl cleaner sample, the raw correlation between the consumer willingness to pay for a complete elimination of the gassing risk (the response to Question 1) and the per bottle response for the complete elimination of eyeburns (the response to Question 2) is 0.77. The positive correlation indicates that if consumers are more willing to eliminate one risk, they are also more willing to pay for the elimination of other risks as well. We will use this fact later in defining the error structure for our model. Second, the variance in the per bottle amount consumers are willing to pay for the elimination of risks is substantial, indicating that there is a tremendous amount of heterogeneity in how consumers value safety. This variation suggests that large gains are possible in understanding how consumers view risks if we can generate estimates of how these risk valuations vary across individuals as a function of observed variables.

Given the defined risk levels, we can drop the \( i \) subscripts on the risk levels, and letting \( K_1, K_2, \) and \( K_3 \) represent the income expenditures consumers are

\(^9\) The per bottle amount (\( K \)) consumers are willing to pay to reduce the risk of accident was described in the survey to be a price premium for a higher quality product. We therefore assume that individuals are only trading income for risk, and the increased price for the product will not reduce demand.

\(^10\) Given that the original risks level for both injuries are equal, we must separately reduce the risks to zero for one of the injury types in order to identify both monetary loss measures \( L_i \) in our estimation procedure.
Table 2

*Consumer Willingness to Pay for a Reduction in the Risk of Injury*

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Toilet Bowl Cleaner</th>
<th>Mean WTP\textsuperscript{a}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gassings</td>
<td>Eye Burns</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Per Bottle Risk of Injury for Second Formulation of Product (\times 1E-4)</th>
<th>Mean WTP\textsuperscript{a}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question Number</td>
<td>Inhalation</td>
<td>Skin Poisoning</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Willingness to pay.

willing to pay for the three formulations of the product, we can construct three structural equations that form the basis of our estimation. These equations are:

\begin{align*}
(4a) \quad (1 - 2P) U[Y^*] + \sum_{i=1}^{2} PU[Y^* - L_i] &= (1 - P) U[Y^* - K_1] \\
&\quad + PU[Y^* - K_1 - L_2],
(4b) \quad (1 - 2P) U[Y^*] + \sum_{i=1}^{2} PU[Y^* - L_i] &= (1 - P) U[Y^* - K_2] \\
&\quad + PU[Y^* - K_2 - L_1],
\end{align*}
and

\[(4c) \quad (1 - 2P) U[Y^*] + \sum_{i=1}^{2} PU[Y^* - L_i] = U[Y^* - K_3].\]

The term on the left-hand-side of the equals sign in Equations (4a) through (4c) represents the expected utility derived from consuming the original formulation of the product. The terms to the right of the equals sign in these equations represent the expected utility from the new formulation of the product. For example, the right-hand-side of Equation (4a) reflects the fact that the risk of Injury 1 is reduced to zero while the risk of Injury 2 remains at \(P\).

The mean values for the expenditure responses \(K_1\), \(K_2\), and \(K_3\) are given in the bottom of Table 1. To eliminate the risks of each of the toilet bowl injuries, consumers are willing to pay about 50 percent more per year for the product, whereas they are willing to pay about 15 percent more to eliminate the insecticide risks. As with the per bottle responses to Questions 1 through 3, the responses to \(K_1\) through \(K_3\) are characterized by large positive between-question correlations, and large within-question variances.

V. An Outline of the Estimation Procedure

The equations that form the basis of our estimation are the equalities (4a)–(4c). In these equations, the endogenous variables are the income responses \(K_1\), \(K_2\), and \(K_3\), since these values are conditioned on all others. As we demonstrate below, once we impose a functional form for utility, we can easily solve each of the Equations (4a)–(4c) for the response variable \(K_j\) for question \(j\) as a nonlinear function of all other variables.

The hypothesis we wish to test is whether the monetary loss equivalents are increasing in wealth. To allow for potential nonlinearities in this relationship, we will test this hypothesis by assuming that \(L_i\) for injury type \(i\) is quadratic in wealth (\(W\)), where

\[(5) \quad L_i = \alpha_{i0} + \alpha_{i1}W + \alpha_{i2}W^2.\]

If the wealth effects hypothesis is correct, we expect \(L_i\) to have a positive first derivative in wealth. If this effect is decreasing (increasing) with wealth, the second derivative will be negative (positive). As we discuss below, because the data set we use does not contain information about individual wealth, we must use income as a proxy.

As has been demonstrated in Evans and Viscusi (1991), estimates of the monetary loss equivalent can be obtained once we assume an explicit functional form of utility. Let \(\beta\) be a vector of utility function parameters to be estimated and let \(\alpha\) be the \((6 \times 1)\) vector of estimable parameters \((\alpha_{10}, \alpha_{1y}, \alpha_{1yy}, \alpha_{20}, \alpha_{2y}, \alpha_{2yy})\). The response variables \(K_j\) are therefore nonlinear functions of \(Y^*, P, W, \alpha, \) and \(\beta\). An error term with zero mean and finite variance is also added to each equation. Let the additive error for the equation corresponding to question \(j\) be denoted by \(\varepsilon_j\). The nonlinear equations that determine each \(K_j\) are of the form
(6) \( K_j = f_j(Y^*, P, W, \beta, \alpha) + \varepsilon_j \).

We assume the \((3 \times 1)\) vector of errors \( \varepsilon = (\varepsilon_1, \varepsilon_2, \varepsilon_3)' \) are jointly normally distributed with zero mean and covariance matrix \( \Sigma \). We expect the off-diagonal elements of the covariance matrix errors to be positive, reflecting the assumption that if a consumer provides a greater than expected response for \( K_1 \), we expect her to also provide greater than expected values for \( K_2 \) and \( K_3 \) as well. The three equations can be estimated as nonlinear multivariate regression model with cross-equation restrictions.

Because our estimate of the monetary loss equivalent may be sensitive to the assumed utility function, we generate estimates of the monetary loss equivalent from three separate utility functions. First, we demonstrate how estimates of the monetary equivalent can be produced without making any prior assumptions about the explicit functional form. We denote this procedure as the unrestricted utility case. Next, we estimate models with the logarithmic and the constant absolute risk aversion utility function. Because the unrestricted, logarithmic, and C.A.R.A. functions imply different constant and absolute risk aversion parameters, the breadth of utility function considered should indicate the robustness of the results. In the next section, we produce the estimable equations for (6) for each of the assumed functions of utility.

**A. An Unrestricted Utility Function**

The model derived from an unrestricted utility function is based on the proposition that individuals are risk neutral to small gambles. Given the relatively small stakes involved in the survey, we believe this to be a reasonable proposition. If injuries are valued at a monetary equivalent of $1,000, then the expected per bottle loss for using the original formulation of the product is $1.50 per year.

To generate the estimable equations for an unrestricted utility function, we must first isolate the endogenous variables in the three equalities \((4a)-(4c)\). We do so by utilizing first-order Taylor series expansion of \( U[Y^* - K], U[Y^* - K - L_i], \) and \( U[Y^* - L_i] \) about the common value \( Y^* \). From the definition of the expansion, we generate the three approximations:

\[(7a)\] \( U[Y^* - K] \approx U[Y^*] - KU_y[Y^*], \)

\[(7b)\] \( U[Y^* - L_i] \approx U[Y^*] - L_iU_y[Y^*], \)

and

\[(7c)\] \( U[Y^* - K - L_i] \approx U[Y^*] - (K + L_i)U_y[Y^*]. \)

Given the small value of \( K \) relative to \( Y^* \), the approximation for \( U[Y^* - K] \) is very accurate and the relative errors for the approximations of \( U[Y^* - L] \) and \( U[Y^* - K - L] \) are roughly the same.\(^\text{11}\)

\(^\text{11}\) For many income and loss values, and utility functions, these first-order approximations are very accurate. For example, if utility is logarithmic, income is $25,000, and the monetary loss due to injury is $1,000 (a relatively high value for these samples), the percent difference between the first-order
Substituting the approximations in (7a)–(7c) into (3) and solving for $K$, we find that the additional income a consumer is willing to pay for a reduced risk of injury is equivalent to

(8) \[ K = (P_1 - Q_1)L_1 + (P_2 - Q_2)L_2, \]

which indicates that the amount of income $K$ the consumer is willing to pay for a reduction in multiple risks of injury is equal to the reduction in the expected monetary loss for the injuries.

Let $K_j$ represent the response value for $K$ given in Survey Question $j$, where $j = 1, 2, 3$. Given the values for the risk probabilities established in the three survey questions, we can write the three estimating equations as:

(9a) \[ K_1 = PL_1 + \varepsilon_1, \]

(9b) \[ K_2 = PL_2 + \varepsilon_2, \]

and

(9c) \[ K_3 = P(L_1 + L_2) + \varepsilon_3. \]

The first expression in Equation (9) states that the amount a consumer is willing to pay for the complete elimination of the risk is the expected loss associated with the use of the product. Not surprisingly, this is also the value for $K_j$ that would arise if utility is linear in income. Heterogeneity in the monetary loss equivalent is easily introduced into the model by expressing each loss term as a linear combination of wealth or income as outlined in Equation (5).

B. Explicit Characterizations of Utility

Before defining the structural equivalents for Equation (6) in the case of an explicit utility function, we first outline a simple procedure that allows us to develop nonlinear expressions for the endogenous variables ($K_1$, $K_2$, and $K_3$) for any utility function. Following Evans and Viscusi (1991), we use a first-order Taylor Series expansions of $U[Y^* - K]$ and $U[Y^* - L - K]$ about $Y^*$ and $Y^* - L_i$, to isolate the endogenous variables $K_j$. These expansions produce the following approximations

(10a) \[ U[Y^* - K] \approx U[Y^*] - KU'_y[Y^*], \]

and

(10b) \[ U[Y^* - L_i - K] \approx U[Y^* - L_i] - KU'_y[Y^*]. \]

Substituting these approximations into (4a)–(4c) for the explicit expression of utility, and solving for each $K_j$, the estimable equations for any utility function are of the form

approximation and $U[Y^* - L]$ is 0.4 percent. Even when the monetary loss increases to one fifth of the respondent’s income, the percent difference is still only 2.2 percent. If the utility function is a constant risk aversion where $U = 1 - \exp(-rY)$, $r = 0.0001$, income is $25,000$, and the loss is $1,000$, the percent difference between utility and the approximations is 0.94 percent.
\begin{align}
(11a) \quad K_1 &= \frac{P(U[Y^*] - U[Y^* - L_1])}{(1 - P)U_y[Y^*] + PU_y[Y^* - L_2]} + \varepsilon_1, \\
(11b) \quad K_2 &= \frac{P(U[Y^*] - U[Y^* - L_2])}{(1 - P)U_y[Y^*] + PU_y[Y^* - L_1]} + \varepsilon_2, \\
\text{and} \\
(11c) \quad K_3 &= \frac{P(2U[Y^*] - U[Y^* - L_1] - U[Y^* - L_2])}{U_y[Y^*]} + \varepsilon_3,
\end{align}

By defining an explicit function for utility, calculating the corresponding equations for marginal utility, and substituting these values into Equations (11a)–(11c), we can produce nonlinear expressions for the response variables.

We choose to estimate models for two utility functions: the logarithmic, and constant absolute risk aversion (C.A.R.A.) utility functions. If utility is assumed to be logarithmic, then in the healthy state of the world, the logarithmic utility function is defined as

\begin{align}
(12) \quad U[Y^*] &= \gamma_0 + \gamma_1 \ln(Y^*).
\end{align}

Because expected utility is invariant to an affine transformation of utility we can restrict \( \gamma_0 = 0 \) and \( \gamma_1 = 1 \). We can specify the C.A.R.A. utility function as

\begin{align}
(13) \quad U[Y^*] &= 1 - e^{-rY^*}
\end{align}

where the parameter \( r \) is the measure of absolute risk aversion, \( r = -U_{y/}/U_y \), and we expect \( r > 0 \).

To illustrate how the procedure works, the estimable equations that correspond to Equations (11a)–(11c) in the case of logarithmic utility are:

\begin{align}
(14a) \quad K_1 &= \frac{P[\ln(Y^*) - \ln(Y^* - L_1)]}{(1 - P)/Y^* + P/(Y^* - L_2)} + \varepsilon_1, \\
(14b) \quad K_2 &= \frac{P[\ln(Y^*) - \ln(Y^* - L_2)]}{(1 - P)/Y^* + P/(Y^* - L_1)} + \varepsilon_2, \\
\text{and} \\
(14c) \quad K_3 &= PY^*[2 \ln(Y^*) - \ln(Y^* - L_1) - \ln(Y^* - L_2)] + \varepsilon_3.
\end{align}

\textbf{C. Estimation}

The series of equations for the unrestricted, logarithmic, and C.A.R.A. utility functions are the structural equations we will estimate. In each of these sets of equations, we could generate estimates of the parameters by estimating the equations separately. For example, all parameters of the model are identified in either (9a) or (9b). However, we expect there to be significant correlation in the errors across equations, and our econometric specification allows for such correlation. Each of the sets of equations for the three assumed functions of utility represent a nonlinear multivariate regression model with cross-equation restrictions. If we assume the errors in the above equations are multivariate normal, then following
Gallant (1986), maximum likelihood estimates of the model were derived through iterative seemingly unrelated regression (ITNSUR) with cross-equation restrictions. To appropriately capture the wealth effects on the monetary loss equivalent, we utilize the function for $L_i$ as expressed in (5) where the loss equivalent is quadratic in wealth.

One shortcoming of our data set is that we do not have a measure of family wealth from which to form Equation (5). However, we assume that family income is an approximation to wealth, which produces the monetary loss equation

$$L_i = \alpha_{ix} + \alpha_{iy} Y + \alpha_{iy} (Y^2/10,000).$$

The above assumption is obviously an oversimplification, yet there are few alternatives. Most analysts use wage or income levels as a proxy for wealth because of these data limitations. In the survey we use, as with most surveys, there is very little financial information collected other than income.

VI. Results

For both the toilet bowl cleaner and insecticide subsamples, we estimate the model for the three utility functions outlined above. The ITNSUR estimates for these six models are reported in Table 3. In each instance, the estimated covariance matrices for the equation errors $\varepsilon_p$ produced positive off-diagonal elements, indicating that consumers who have higher unobserved willingness to pay for the reduction of one risk also have a higher unobserved willingness to pay to reduce the other risks as well. The $R^2$ for each of the individual equations were similar across all three utility functions, with the $R^2$ for each individual equation varying between .20 and .40 for both types of products.

As the results in Table 3 demonstrate, the monetary loss equivalent is quadratic in income, with a positive coefficient on $Y$ and a negative coefficient on $Y^2$. The parameter estimates are not sensitive to the assumed functional form of utility. However, the precision of the estimates varies across models. In both the toilet bowl cleaner and insecticide subsamples with the unrestricted and log utility models, the coefficients on the linear and squared income terms are statistically significant at conventional levels. Considering the estimates from the unrestricted utility function, we find that in the toilet bowl cleaner subsample, the monetary

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12. The assumption that the errors are multivariate normal may be inappropriate because the response variables $K_i$ are skewed and bounded at zero. Ideally, we would like to incorporate a more appropriate error structure.

13. We also estimated the model with a quadratic utility function which has the undesirable property that individuals become increasingly risk averse with greater incomes. The quadratic utility function we estimate is one where $U[Y] = Y + cY^2$, where we expect $c < 0$. For this utility function, the estimates for the monetary loss equivalent parameters were almost identical to the estimates produced with unrestricted estimates. However, the estimate (standard error) of the utility function parameter $c$ was $-1.5E-5$ ($2.0E-7$) for the toilet bowl sample, and $-1.6E-5$ ($5.6E-7$) for the insecticide group. With these parameter values, marginal utility of income is positive for income values less than $31,000 and $33,000 for the two samples respectively. Although these values are equal to or less than the mean levels of income for the samples, marginal utilities are positive for 72 percent and 54 percent of sample incomes.
### Table 3

**ITNSUR Estimates of the Willingness to Pay for Risk Reduction Equations**

<table>
<thead>
<tr>
<th>Product</th>
<th>Type of Injury</th>
<th>Utility Function</th>
<th>Parameter Estimates and Asymptotic Standard Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\alpha_0$</td>
</tr>
<tr>
<td>Toilet bowl cleaner</td>
<td>Eye burns</td>
<td>1st Order</td>
<td>385.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expansion</td>
<td>(56.84)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logarithmic</td>
<td>369.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(53.39)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C.A.R.A.</td>
<td>297.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(61.32)</td>
</tr>
<tr>
<td>Gassings</td>
<td></td>
<td>1st Order</td>
<td>246.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expansion</td>
<td>(127.76)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logarithmic</td>
<td>240.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(120.56)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C.A.R.A.</td>
<td>159.93</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(86.71)</td>
</tr>
<tr>
<td>Insecticide</td>
<td>Skin poisoning</td>
<td>1st Order</td>
<td>376.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expansion</td>
<td>(324.13)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logarithmic</td>
<td>367.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(305.09)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C.A.R.A.</td>
<td>336.95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(236.36)</td>
</tr>
<tr>
<td>Inhalation</td>
<td></td>
<td>1st Order</td>
<td>751.62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expansion</td>
<td>(376.85)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logarithmic</td>
<td>699.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(345.10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C.A.R.A.</td>
<td>610.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(425.27)</td>
</tr>
</tbody>
</table>

The loss equivalent is increasing in income and only declines in value for family income levels above $50,000. For the insecticide subsample, the peak in the monetary loss equivalent occurs at $47,000.

The risk aversion parameter $r$ of the C.A.R.A. utility function is not precisely estimated in either sample. The estimate of the constant absolute risk aversion parameter $r$ is 0.0013 in the toilet bowl cleaner sample and 0.00058 in the insecticide group, and in both instances, the standard errors are so large that we cannot reject the hypothesis that $r = 0$. Both sample estimates of $r$ signify a moderate degree of risk aversion. If $r = 0.0013$, an individual would be willing to pay $20.26 to avoid a 10 percent chance of losing $1,000 while if $r = 0.0058$, a consumer would be willing to pay $13.50 to avoid the gamble.

The parameters values for the terms associated with the monetary loss equivalent $(\alpha_{10}, \alpha_{1y}, \alpha_{1yy}, \alpha_{20}, \alpha_{2y}, \alpha_{2yy})'$ in the C.A.R.A. utility model are very similar.
to the two previous estimates, but the standard errors on these estimates are larger, especially in the insecticide subsample. The loss in precision for these parameters in the C.A.R.A. model can easily be explained given the estimated values for \( r \). With even moderate values for \( r \), there is very little difference between utility in the healthy and unhealthy states. For a value of \( r = 0.0013 \), a moderate level of income of \( \$25,000 \), and a high value for a monetary loss equivalent of \( \$2,000 \), the difference between utility in the healthy and unhealthy state is \(-9.58E-12\) percent. In contrast, if utility is linear or logarithmic, using the identical numbers, the differences between utility in the unhealthy and healthy states are 8 and \(-0.8\) percent respectively. Therefore, in the C.A.R.A. case, the stakes of the gamble appear to be too small to generate any precise measure of risk aversion.\(^{14}\)

The similarity of the results between the unrestricted and log utility models is not surprising because both models imply zero, or near zero risk aversion. The unrestricted model is equivalent to risk neutral linear utility while the log utility model imposes a very small risk aversion parameter of \( 1/Y^* \). At the sample mean of income for the insecticide sample, the measure of risk aversion for the log utility model is \( 2.8E-5 \).

The above results indicate that the point estimates of the parameters in the monetary loss equivalent equations are not sensitive to the assumed degree of risk aversion, but the precision of the estimates are. The question we wish to address is to what degree are the results sensitive to the choice of risk-neutral, or near risk neutral utility functions. We can answer this question by estimating a model based on second-order Taylor series expansions about utility. It can easily be shown that the estimable equations based on second-order expansions are a function of the risk aversion parameter \( R = -U_{yy}(Y^*)/U_y(Y^*) \).\(^{15}\) It can also

\[ K_1 = \frac{PL_1 + PL_2R/2}{1 + PL_2R} + \epsilon_1 \]
\[ K_2 = \frac{PL_3 + PL_4R/2}{1 + PL_4R} + \epsilon_2 \]
\[ K_3 = P[L_1 + L_2 + (R/2)(L_1^2 + L_2^2)] + \epsilon_3 \]

where \( R \) is the risk aversion parameter \( R = -U_{yy}(Y^*)/U_y(Y^*) \). The advantage of this specification in comparison to the first-order expansion outlined above is that the response variables \((K_1, K_2, K_3)\) are an increasing function of the risk aversion parameter \( R \). Second, if \( R = 0 \), the first-order approximation model is a restricted version of this equation. With these two models, we can then explicitly test for the importance of the risk aversion term in determining the response variable \( K \).

To estimate the model based on the second-order expansion, we restrict the risk-aversion parameter to be identical across all individuals. Because the unrestricted model is a special case of the more
Figure 1
Monetary Loss Equivalents as a Function of Income (Estimates from Unrestricted Model)

be shown that this model collapses to the unrestricted model outlined above if $R = 0$. To test for the equivalence of the two models, we use the statistic suggested by Gallant and Jorgenson (1979), which is distributed as chi-squared with the degrees of freedom equal to the number of restrictions. In this case there is one restriction (that individuals are risk-neutral over the gambles, or $R = 0$). The test statistics equal 1.01 and 0.98 for the toilet bowl and insecticide subsamples respectively, indicating that we cannot reject the null hypothesis that $R = 0$ for both product types.\(^{16}\)

The relationship between income and the monetary loss equivalent is depicted graphically in Figure 1. Using estimates of the parameters for $L_i$ from the un-

\(16\) For the toilet bowl cleaner sample, the estimate (standard error) of $R$ based on the second-order expansion is $1.3E-3 (2.1E-3)$ while the estimates (standard errors) for $\alpha_0$, $\alpha_1$, and $\alpha_{22}$ for eye burns are $308.2 (78.0)$, $7.1E-3 (4.1E-3)$, $-8.7E-4 (5.0E-4)$, and the corresponding estimates for gassings are $172.4 (95.7)$, $1.9E-2 (1.0E-2)$, and $-2.3E-3 (1.3E-3)$. The estimated value for $R$ in the insecticide sample was $5.4E-4 (5.1E-3)$, while the estimates (standard errors) for $\alpha_0$, $\alpha_1$, and $\alpha_{22}$ for skin poisonings are $340.6 (231.2)$, $2.6E-3 (6.8E-2)$, and $-2.2E-3 (6.3E-2)$, and the corresponding values for the inhalation injury are $627.7 (650.2)$, $2.2E-2 (6.3E-2)$, $-2.0E-3 (5.5E-3)$.\)
restricted utility function, we produce monetary loss equivalent values for all four injuries considered over a wide income range. The shape of the four functions does provide some evidence that for those injuries which pose the greatest health risk (those injuries with the largest intercepts), the rate of increase in the monetary loss equivalent is also greatest.

VII. Policy Assessments of Risk Change Benefits

Knowing the shape of the utility function and how the monetary loss equivalent varies with income allows us to estimate a number of different values of policy interest. In this case, since health effects are tantamount to a drop in income, the welfare implications of health effects are greatly simplified. For example, prevention of such health effects can be treated in the same manner as avoidance of monetary losses, and full insurance equal to the value of the loss is optimal if actuarially fair insurance is available.

The fundamental issue for decision analysts in health and medical policy is what value one should place on reducing such risks. Many authors have utilized sample estimates of implicit values of life and limb for policy purposes. Yet, these values typically do not reflect the difference in character of the affected population from the sample for which the value-of-life estimates were obtained. Given the estimates presented above, we are able to calculate these values for all members of a population, given the distribution of income, so that one can establish benefit values for the specific mix of individuals bearing the risk.

For example, suppose one were interested in determining the value a consumer would place on the certain elimination of a risk. In this instance, the value is simply equal to the monetary loss equivalent \( L_i \). This is also the value of income that must be transferred to individuals in a poor state to return them to the pre-injury level of utility. This value, calculated at the sample mean using the log-utility estimates for all four injuries, is presented in Column (1) of Table 4. Given this estimate, we can also calculate the elasticity of the monetary loss equivalent with respect to income. In this instance, the elasticity values vary from 0.18 for eye burns from toilet bowl cleaners to 0.39 for skin poisonings from insecticide.

A second measure of individual valuation of health risk is the consumer willingness to pay for a marginal change in safety, \( \delta Y/\delta P_i \), holding expected utility constant.\(^{17}\) We shall refer to this valuation as \( Z_{mle} = \delta Y/\delta P_i \). This marginal valuation term is the basis of most benefit calculations in policy analysis. Again, using the estimates from the log utility model, we can generate this value for all types of injuries from the log utility estimates. These values are also reported in Table 4. The approximate equivalence of the monetary loss equivalent and the estimated derivative \( Z_{mle} \) is not surprising given the small probability of an injury and the relative size of \( L_i \) in comparison to \( Y \).\(^{18}\)

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\(^{17}\) The derivation of this value for the case of multiple health risks is reported in Viscusi, Magat, and Huber (1987).

\(^{18}\) To see this formally, suppose we have a simple model with only one type of injury, where expected utility is of the form
Table 4
Estimates of Monetary Loss Equivalents, Values of Marginal Risk Changes, and Income Elasticities

<table>
<thead>
<tr>
<th>Product</th>
<th>Type of Injury</th>
<th>Monetary Loss Equivalents $L_i$</th>
<th>$\frac{\delta \ln(L)}{\delta \ln(Y)}$</th>
<th>$\frac{\delta Y}{\delta P} = Z_{\text{mle}}$</th>
<th>$\frac{\delta \ln(Z)}{\delta \ln(Y)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet bowl cleaner</td>
<td>Eye burns</td>
<td>555.39</td>
<td>0.18</td>
<td>560.88</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(23.13)</td>
<td>(0.08)</td>
<td>(23.96)</td>
<td>(0.07)</td>
</tr>
<tr>
<td></td>
<td>Gassings</td>
<td>683.09</td>
<td>0.34</td>
<td>691.47</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(51.78)</td>
<td>(0.13)</td>
<td>(53.87)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>Insecticide</td>
<td>Skin poisonings</td>
<td>1,289.82</td>
<td>0.39</td>
<td>1,312.80</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(77.86)</td>
<td>(0.15)</td>
<td>(80.63)</td>
<td>(0.15)</td>
</tr>
<tr>
<td></td>
<td>Inhalations</td>
<td>1,546.11</td>
<td>0.28</td>
<td>1,578.36</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(89.95)</td>
<td>(0.14)</td>
<td>(93.80)</td>
<td>(0.14)</td>
</tr>
</tbody>
</table>

a. Estimates are based on logarithmic utility function model. Variables are evaluated at sample means for $Y^*$ and $P$. Standard errors are calculated via a first-order expansion of the nonlinear functions.
We also calculate the elasticity of the derivative $Z_{mle}$ with respect to income, $\delta \ln(Z_{mle})/\delta \ln(Y)$. These values range from 0.17 for eye burns from toilet bowl cleaners to 0.38 for skin poisonings from insecticide. The pattern and level of elasticity estimates mirrors that for the monetary loss equivalent. For the reasons given above, the income elasticity for marginal risk valuations and the monetary loss equivalent should be similar.

The importance of allowing the monetary loss equivalent to vary with income can be underscored when one compares the income elasticities of the derivative $Z_{mle}$ with and without income effects. The income elasticity of $Z_{mle}$ is close to zero if $L$ does not vary with income. The size of the income elasticities that we estimate for the monetary loss equivalents and the marginal willingness to pay for safety are equal in magnitude to income elasticities for medical insurance estimated by Phelps (1976), somewhat larger than the income elasticity for hospital and physician services estimated by Newhouse and Phelps (1976), yet they are substantially smaller in magnitude to elasticities estimated in Viscusi and Evans (1990). The larger values in Viscusi and Evans (1990) stem from the difference in the structure of the utility functions, which differed by more than a monetary loss equivalent in the case of a job injury.

(a) $EU = (1 - P)U(Y) + PU(Y - L)$.

Assume also that $\delta L/\delta Y = 0$. In this instance, the marginal change in income consumers are willing to pay for a small change in the risk of injury is given by

(b) $Z_{mle} = \frac{\delta Y}{\delta P} = \frac{U(Y) - U(Y - L)}{(1 - P)U(Y) + PU(Y - L)}$.

Approximate $U(Y - L)$ and $U(Y - L)$ with a second-order Taylor's series about $Y$, and assume the third derivative of utility with respect to income is zero. These approximations produce the following approximation for the derivative:

(c) $Z_{mle} = \frac{\delta Y}{\delta P} = L \cdot \frac{U_s(Y) - (L/2)U_{sp}(Y)}{U_s(Y) - PLU_{sp}(Y)}$.

For most utility functions, the second derivatives are small relative to the marginal utility of income, and therefore, the ratio $[U_s(Y) - (L/2)U_{sp}(Y)]/[U_s(Y) - PLU_{sp}(Y)]$ in Equation (c) is close to 1 and the derivative $\delta Y/\delta P$ is close to $L$. If utility is linear, then $\delta Y/\delta P = L$.

The above definition of the derivative also suggests that if one assumes declining marginal utility of income, the estimate of the ratio $[U_s(Y) - (L/2)U_{sp}(Y)]/[U_s(Y) - PLU_{sp}(Y)]$ from Equation (c) will be greater than one for $P < 1/2$. In most situations dealing with risks to health, $P$ tends to be small and therefore, the estimated value of the derivative $\delta Y/\delta P$ should be greater than the value of the estimated monetary loss equivalent. The difference in the two values will increase (decrease) as the value of $L$ increases (declines). In a previous paper (Evans and Viscusi 1991), we demonstrate empirically that $L$ is smaller than the derivative $\delta Y/\delta P$. In the case of two injuries, $P < 1/2$, and income effects in $L$, it can also be shown that $\delta Y/\delta P$ is a close approximation to $L$, and the estimate of $L$ is also smaller than the derivative $\delta Y/\delta P$.

19. The income elasticity for $Z_{mle}$ in the general case suggested by Equations (a) through (c) in the previous footnote can be shown to be approximated by the equation

(d) $\frac{\delta \ln(Z_{mle})}{\delta \ln(Y)} = Y \left[ \frac{U_{sp}(Y)}{U_s(Y) - (L/2)U_{sp}(Y)} - \frac{U_{sp}(Y)}{U_s(Y) - PLU_{sp}(Y)} \right]$.

Again, for small values of $P$ and for small $L$ relative to $Y$, the bracketed term in the above equation will be close to zero. The above equation also suggests that if $\delta L/\delta Y = 0$, then the income elasticity of $Z_{mle}$ is actually negative if $P < 1/2$. 


The marginal willingness to pay for a small change in the probability of an accident is proportional to the distance between utility in the healthy and unhealthy states. In Viscusi and Evans (1990), the type of injury considered was sufficiently consequential that consumers treat utility in the unhealthy state from a health-state perspective, where total and marginal utility decline in the unhealthy state. Therefore, as income increases, the relative difference between utility in the healthy and unhealthy states increases at an increasing rate, hence the relatively large income elasticity of $\delta Y/\delta P$ in the health state case. However, if the unhealthy state is treated as tantamount to a drop in income and $L$ is not a function of income, the relative difference between $U(Y)$ and $U(Y - L_i)$ begins to decline as income increases, thereby producing the small negative income elasticity for $\delta Y/\delta P$. Only when $L$ is a function of income does the relative distance between $U(Y)$ and $U(Y - L)$ increase when income increases, thereby generating a positive income elasticity for the derivative $\delta Y/\delta P$.

VIII. Conclusion

Although there is considerable variation in how individuals value risks to life and limb, there is surprisingly little evidence of how these valuations vary with observed population characteristics. The primary concern in the economics literature has been how these valuations vary with income. In this paper, using structural estimates of utility functions, we find strong evidence that the monetary loss equivalent for minor injuries is a positive function of income. The various measures of the value of health status follow the expected pattern for normal economic goods. The income elasticity of the monetary equivalent of an injury is between .2 and .4, and there is suggestive evidence that the elasticity increases in value as the size of the initial loss increases. The elasticities for the valuation of marginal risk changes follow an almost identical pattern. These elasticities are also not sensitive to the assumed functional form of utility.

The structural estimates we provide of the loss associated with injuries allows one to perform a much more detailed policy analysis than is possible with local risk-dollar tradeoffs, which are typically estimated in the hedonic wage and price literature. With structural estimates of the utility function and evidence of how the monetary loss equivalent varies with income, we can more precisely define the benefits of public policy by tailoring the estimates to the affected population.

References


Cook, Philip J., and Daniel A. Graham. 1977. "The Demand for Insurance and


