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THE AUTOMOBILE RISK METRIC FOR VALUING HEALTH RISKS

W. Kip VISCUSI

THE RATIONALE FOR THE AUTOMOBILE RISK METRIC

In the usual policy analysis contexts in which one is seeking to value health risks, the standard economic approach is to ascertain an appropriate monetary equivalent. Money is the currency in which most economists operate, as it provides a standardised basis for converting all impacts, such as costs of treatment and health benefits, into a common metric.

In many cases, tradeoffs involving money and risk arise in the course of natural market experiments from which it is feasible to ascertain the pertinent tradeoffs. Individuals' purchases of safer cars involve a price-risk tradeoff from which one can impute the implicit value of life[1]. In Dreyfus and Viscusi (1995), we use the prices of used cars coupled with information on car attributes, driver characteristics, and the mortality risks over the lifetime of the car to estimate the implicit value of life for automobile drivers. There also exists a considerable literature on wage-risk tradeoffs in a large number of countries, as economists have estimated the implicit value of life that workers attach to their jobs based on the compensating differentials they receive for hazardous work[2]. This kind of analysis is most instructive in markets which function competitively. Countries in which labour unions play a dominant role or in which wages are subject to substantial administrative control provide less guidance regarding risk-money tradeoffs.

Despite the substantial volume of this literature, the health risks that have been addressed are quite narrow. Analysts have limited themselves to assessing the valuation of deaths and nonfatal job injuries. Moreover, given the character of the injury data that are available, these injuries also tend to be acute accidents rather than illnesses. Indeed, in most cases it is not feasible to estimate reliably both the implicit value of life and the implicit value of nonfatal injuries. The data are also not sufficiently refined to enable one to distinguish the values associated with different forms of death, such as a manufacturing worker being killed in a job-related motor vehicle accident as opposed to a hospital worker contracting AIDS from a patient due to an accidental skin puncture while drawing blood. Analysts who are attempting to monetise the prevention of risks of cancer, the saving of the life of a heart attack victim, or reduced abnormalities arising from genetic damage will be able to draw little specific guidance from the health valuation literature based on market evidence.

To address concerns such as these, it is necessary to undertake a survey or contingent valuation-type study in which respondents are asked how much they value different outcomes. The usual approach is to attempt to mimic the information made available based on market studies. Analysts typically inquire, if a market existed for the risk-reducing commodity, how much would people be willing to pay for it ? One might, for example, ask respondents how much they would be willing to pay for a superior medical treatment that offered a greater prospect for long-term survival from an illness such as cancer. Using these responses, one could then assess the implicit value attached to the health outcome of concern.

In this paper I will outline the basis for an alternative approach that uses automobile accident risks as the metric for valuing health status. In effect, the reference point for assessing the severity of the health outcome will not be a monetary equivalent associated with the risk but rather the automobile accident risk that respondents view as being tantamount to the health risk they are facing. Thus, respondents will be equating two lotteries, each of which involves different health status consequences, rather than identifying a certain monetary payment that they would be willing to pay for a change in a health status lottery.

If reliance on the direct approach of ascertaining money-risk tradeoffs were entirely successful, utilisation of the indirect procedure of establishing an automobile death risk equivalent would be a needless

intermediate stage. However, contingent valuation studies that have attempted to value health risks have a variety of intrinsic problems that impede researchers' efforts to utilise this methodology to obtain reliable estimates of the value of health status.

The first difficulty is that the respondents are being asked to make unfamiliar kinds of tradeoffs. Since the survey is not replicating an existing market transaction, but instead is constructing a hypothetical transaction, it is essential to engage respondents so that they can give meaningful answers. They must understand what is at stake and give appropriate valuations of the pertinent tradeoffs.

This task is complicated by the different kinds of commodities involved. The usual survey approach is to ask respondents to trade off a certain monetary payment versus a lottery on health status. These tradeoffs consequently involve incommensurable attributes, as metrics for money and health are quite different. Indeed, given the substantial role of private and social insurance efforts in the health area, there is little familiarity of respondents with actually making tradeoffs between monetary expenditures and health care choices, much less explicit tradeoffs between money and explicit probabilities of changing one's health status. Respondents consequently will find this a difficult tradeoff to make, thus introducing potential error into the contingent valuation responses.

Even if respondents view the two tradeoff metrics as being commensurable, there are additional problems encountered by respondents as the health risk lotteries involve low probabilities of health outcomes. Low probabilities pose notoriously difficult problems for individual decisions[3]. There is a well documented tendency of individuals to overestimate low probability events that are called to their attention[4]. This overestimation will generate higher observed values for the willingness to pay for prevention of the risk of the adverse health outcome. As a consequence, when valuing the risk-money tradeoff based on the stated probability and the respondent's stated willingness to pay to reduce the risk, one will obtain an overestimate of the implicit value of the health outcome in question. In other situations there may be different kinds of biases since the difficulty individuals have in processing low risk information may yield erroneous decisions of a different character depending on a wide variety of different attributes of the risk and the manner in which the information is presented[5].

These kinds of difficulties are more than mere conjecture and extrapolation based on related empirical phenomena. In one context in which my colleagues and I surveyed households regarding their value of risks associated with household chemicals, the implicit valuations of the health status for reductions in low probabilities of the health outcome dwarfed those obtained for more modest probabilities[6]. A survey in which respondents were presented with risks on the order of 1 per 2 million households generated valuation of adverse health consequences associated with bleach and drain opener in a range of $0.65 million to $1.78 million. In contrast, utilisation of a survey approach in which these probabilities were in terms of the risks per 10,000 households yielded implicit values of health impacts of insecticide and toilet bowl cleaner ranging from $744 to $3489. Moreover, there was one health outcome in common for the two studies - chloramine gassings that result when consumers mix bleach and ammonia-based products - for which the health outcome valuation was $1.78 million in the small probability study and $1113 in the larger probability study. A change in the magnitude of the probabilities involved consequently altered the implicit value of the health outcome by a factor of more than 1000.

This sensitivity of the implicit valuations to the level of the probabilities suggests that willingness-to-pay surveys involving small probabilities of health outcomes may be potentially sensitive to the magnitude of the probabilities involved. More specifically, the choice of the denominator for these risk values seems to be particularly influential in determining the ability of respondents to make sensible judgements. Extremely small probabilities involve risks that are outside of the realm of the usual individual experience. Risks of 1 in 100,000, 1 in a million, and 1 in 10 million all are quite small and represent the kinds of risks that are difficult to distinguish other than to note that the event is highly unlikely. For example, it has been well documented that individuals view ratios such as (.00002)/(.00007) as being much closer to 1.0 and consequently larger than ratios such as (.2)/(.7). Low probability events are subject to a variety of perceptional biases such as these.

Even if the responses one elicits with respect to the health risk-money tradeoffs are meaningful, utilisation of a monetary metric may not be the ideal way to characterise and evaluate a particular policy in question. Risk-money tradeoffs are based on a currency that some non-economist

observers find morally offensive. For the most part, society adheres to the myth that if any expenditure can save lives, society will spare no expense in doing so. However, in actual situations, there are obvious limitations to what we are willing to pay. In many instances, health care is denied to patients with a low probability of survival based on "good medical practice" and the professional judgement of the physician. There the tradeoffs being made are hidden from view. In less extreme instances, there are options involving different medical procedures in which greater safety can be purchased for additional resources, but we choose not to do so. There are, for example, two leading dyes that can be used for CAT scans. One produces allergic reactions and fatalities in a low percentage of the patients, whereas the other more expensive dye does not produce these allergic effects. The most widely used contrast agent of this type is the less expensive, but higher risk product. Medical personnel do not use the safer dye because of its apparent high cost, on the order of $1 million per statistical life saved. This cost level represents a comparative bargain in life-saving activities. In other safety contexts, such as traffic safety, the US Department of Transportation currently has a $3 million per statistical life ceiling on any safety efforts that it will undertake. Policies that cost this amount or more per life saved will not be pursued. Both the job safety and environmental safety standards for asbestos save lives at a cost of over $100 million per life.

Although in many situations society has imposed expenditures to enhance limits on health status, there is an understandable reluctance to make these tradeoffs explicit. Establishing an explicit dollar value to be used to value health status consequently may offend moral sensitivities that need not be disturbed. For many policy decisions, it is not necessary to convert all outcomes into a common metric. For example, in the case of cost-effectiveness analysis it is sufficient to convert all the nonmonetary outcomes into common units, such as death risk equivalents, from which one can then analyse the associated costs and the cheapest way of achieving a particular reduction in death risk equivalents. Once all outcomes are converted into the intermediate currency of automobile death risk equivalents, existing estimates of the value of life can be used as a bridge to establish tradeoffs between financial resources and health risks.

One can also envision metrics other than automobile fatality risks that could be used to establish a common risk metric as an alternative to utilising money as the currency. For example, job risks can serve a similar function. However, automobile accident risks have the advantage that they are familiar to all respondents, whereas employment risks are not pertinent to those who do not hold jobs. Moreover, manipulations of the risk level may be more plausible in the case of automobile safety. Public expenditures play a substantial role in influencing highway safety, whereas job risks may appear to the respondent to be less easily manipulated through a survey scenario.

The usual contingent valuation study has a somewhat fictional character associated with it. Those undertaking the survey are seeking to create hypothetical markets for commodities in markets that do not currently exist. In contrast, for automobile accident risks, government policies affecting these risks already exist, as do expenditure mechanisms such as taxes, tolls, and vehicle fees that could potentially be manipulated by the government. Thus, one does not have to construct mechanisms and abstract policy scenarios in order to establish situations in which there could be a tradeoff involving the two types of risk. In our surveys, respondents usually face the choice of moving to one of two different areas, which are characterised by differing levels of automobile safety and differing values of the particular health risk. Such choices are well within the realm of human experience.

One of the strongest attributes of automobile accidents is that these are very familiar health outcomes. Automobile accidents are a prominent source of fatalities throughout the world. In the United States, about 50,000 people are killed in automobile accidents annually. The outcomes of these accidents also can be occasionally observed while driving by the accident scene. Driver interest in accident outcomes accounts for the often major traffic jams that arise even from accidents that do not obstruct the highway. Such accidents are often publicised in newspapers, television, and movies. In contrast, the frequent objects of contingent valuation studies, such as the preservation of rare ecological conditions in a distant country, may entail much more education of the respondents regarding the nature of the commodity being valued.

The automobile accident lottery metric also has the advantage that automobile deaths are usually immediate. As a consequence, one does not have to deal with time lags before the adverse health consequence occurs,

which would introduce the additional complication of assessing individual implicit rates of discount.

Utilisation of an automobile accident lottery as the reference point will enable one to present respondents with alternative lotteries involving comparable probabilities. Doing so facilitates the choice process in that respondents are dealing with two outcomes, each of which involves health attributes, and each of which also involves a risk of the adverse health outcome that is expressed in a similar probabilistic manner.

The methodology to be developed below will be used to assess health outcomes unrelated to accident situations, such as cancer. It is also possible to use the automobile fatality metric to scale outcomes such as nonfatal injuries associated with traffic accidents[7].

THE AUTOMOBILE RISK METRIC METHODOLOGY

To indicate the character of the approach, we must introduce some additional notation[8]. Respondents will be considering two areas in which they might live. Let subscript a denote area A and subscript b denote area B. The objective is to privatise the choice affecting safety so that this will be done by offering respondents the option of moving to one of two different areas. The health outcomes involved include ill health (I), automobile accident death (D), and good health (H), where there is some utility function U in each of these states. The ill health outcome caries with the survey depending on whether the matter of interest is chronic bronchitis, cancer, or some other disease. The probabilities associated with the different possible outcomes in area A are X_a for ill health, Y_a for automobile accident death, and $1-X_a-Y_a$ for good health. For area B, the respective probabilities are X_b for ill health, Y_b for death, and $1-X_b-Y_b$ for good health. Let us assume without any loss of generality that $X_a > X_b$ and $Y_b > Y_a$. Then after some rearrangement of terms, we have the condition that the respondent will continue to alter the choices available until they see choices equilibrate the expected utility in the two areas. These preferences will consequently satisfy

$$X_aU(I)+Y_aU(D)+(1-X_a-Y_a)U(H) = X_bU(I)+Y_bU(D)+(1-X_b-Y_b)U(H), \quad (1)$$

which after some rearrangement becomes

$$(X_a - X_b)U(I) = (Y_b - Y_a)U(D) + (X_a - X_b + Y_a - Y_b)U(H), \qquad (2)$$

or

$$U(I) = \frac{Y_b - Y_a}{X_a - X_b}U(D) + (1 - \frac{Y_b - Y_a}{X_a - X_b})U(H). \qquad (3)$$

The main matter of interest will be the tradeoff rate between ill health and death, which we will define as t_l, where

$$t_l = \frac{Y_b - Y_a}{X_a - X_b}. \qquad (4)$$

As a result, we obtain the finding that

$$U(I) = t_l U(D) + (1 + t_l)U(H). \qquad (5)$$

In effect, the utility of ill health is simply tantamount to some probability t of death, where in this case the death is the result of an automobile accident.

These findings will be in terms of the auto accident equivalent for a health risk. Obtaining a value in monetary terms is also feasible. Acute health outcomes such as automobile accidents are roughly comparable in severity to job accidents. As a result, one can either use automobile accident-specific valuation amounts or else implicit values of life for job safety to make the conversion.

EMPIRICAL ESTIMATES OF AUTOMOBILE DEATH RISK EQUIVALENTS

All of the survey results to be described below were administered using an interactive computer program. This approach, which is described in further detail in the appendix, makes it possible to present respondents with a series of pairwise comparisons and then to manipulate these choices until indifference is achieved. This approach can be viewed as an extension of conjoint analysis, where the conjoint procedure is iterated until respondents rate the two areas available as being equally attractive. Use of a computer to administer the survey also standardises the administration of the survey, eliminating interviewer bias. Respondents also are more willing to disclose confidential information, such as income levels, to a computer than in a face-to-face interview. The honesty of the responses may also be greater, particularly for contexts in which the respondent's concern with the public welfare is an issue.

We have utilised automobile accident reference lotteries to assess a wide variety of health outcomes. Table I summarises several different health outcomes to which this methodology has been applied. The first two entries in Table I consist of the health outcomes that comprise the automobile accident lottery reference points. On a utility scale, death has the utility value of 0 and good health has a value of 1.0. Similarly, the death risk equivalent of death is 1, and for good health it is 0.

Table I *Summary of Valuation Findings for Median Subjects*

Health Outcome	Value on Lottery Scale	Value on Utility Scale U(H) = 1, U(D) = 0	Death Risk Equivalent
Death in an Automobile Accident	U(D)	0.00	1.00
Good Health	U(H)	1.00	0.00
Chronic Bronchitis	0.32U(H) + 0.68U(D)	0.32	0.68
Nerve Disease	0.60U(H) + 0.40U(D)	0.60	0.40
Morbidity Component of Curable Lymph Cancer	0.42U(H) + 0.58U(D)	0.42	0.58
Curable Lymph Cancer	0.38U(H) + 0.62U(D)	0.38	0.63
Terminal Lymph Cancer	0.00U(H) + 1.00U(D)	0.00	1.00

The five other health outcomes considered in Table I all represent potential consequences of air pollution. In the case of chronic bronchitis, patients were given symptoms for a particularly severe variant of the disease. The chronic bronchitis outcome attributes consisted of a series of health effects including the following symptoms: living with an uncomfortable shortness of breath for the rest of your life, being easily winded from climbing stairs, coughing and wheezing regularly, suffering more frequent deep chest infections and pneumonia, having to limit your recreational activities, experiencing periods of depression, being unable to do the physical parts of your job, being limited to a restricted diet, having to visit your doctor regularly and to take several medications, having to have your back mildly pounded to help remove fluids built up in your lungs, having to be periodically hospitalised, having to quit smoking, and having to wear a small portable oxygen tank. Respondents were given comprehensive descriptions of the consequences of each disease, such as this sketch of the implications of chronic bronchitis. In addition, in some cases the presentations were accompanied by visual characterisations, such as a photo of a patient with a portable oxygen tank.

After being acquainted with the implications of the disease, respondents then addressed a series of questions that asked them how important various consequences of the disease were to their lives. These qualitative questions were not intended to be used directly for economic analysis. However, this form of question leads respondents to think about the consequences of the disease for their well-being and to give more meaningful responses to the quantitative questions that will follow. The objective is to make the health outcome well understood by respondents so that different respondents have the same attributes of the health consequences in mind when giving their subsequent valuation responses.

Each questionnaire then asked respondents to consider moving to one of two areas, each of which was said to pose a lower risk of chronic bronchitis and automobile risks than the current area in which they lived[9]. The participants were first given an initial lottery choice in which they were required to demonstrate that they could identify a dominance relationship. Approximately one-fourth of all respondents initially answered the dominance question incorrectly. After being alerted to their error, only 1 percent of respondents gave an incorrect answer to the dominance question in the second iteration. The few respondents who did err in this manner succeeded in the third iteration of the question.

Respondents then faced a sequence of pairwise comparison that was presented utilising an interactive computer program. After respondents indicated their relative preference for area A or area B, the attributes of the areas were manipulated until indifference was achieved. The figures in Table I consequently pertain to the values obtained at these points of indifference. Moreover, these surveys reflect values for which preferences were only elicited for a single disease category. Thus, for example, because of the length of the questionnaire and to prevent confusion regarding the attributes being valued, respondents were only asked to assess, for example, chronic bronchitis rather than several different health outcomes. Additional survey details appear in the Appendix.

Based on the responses obtained, chronic bronchitis is the most severe of the nonfatal impacts of the health outcomes listed. A case of chronic bronchitis is tantamount to a lottery posing a 0.68 probability of death and a 0.32 probability of good health.

The second of the test health outcomes listed is that of nerve disease or, more specifically, peripheral neuropathy. Peripheral neuropathy has been linked to exposures to lead pollution from smelters and batteries as well as other environmental risks, such organophosphates, pesticides and solvents. The nerve disease health outcomes as characterised to respondents elicited a valuation in which respondents viewed the outcome as tantamount to a 0.40 probability of death and a 0.60 probability of good health.

The next set of health outcomes pertains to different variants of lymph cancer. The survey explored two different types of lymph cancer - a "nonfatal" type for which the symptoms were probably curable and a terminal variant in which lymph cancer always led to death. In the nonfatal case, the survival probability was specified, making it possible to estimate the morbidity valuation and the mortality valuation separately. The terminal lymph cancer case resulted in a valuation in which the median respondents viewed the health outcome as being tantamount to an automobile accident death.

The nonfatal lymph cancer cases in Table I consist of the curable lymph cancer situation overall in which there is some chance of death and the morbidity component of this lottery. For curable lymph cancer, respondents were told that there was a probability of death from lymph cancer of only 10 percent, where complete recovery will occur if the cancer is detected early. Respondents viewed curable lymph cancer as being equivalent to a 0.63 probability of death, which is a reflection of the very unattractive nature of even the morbidity aspects of curable lymph cancer. In particular, respondents were told about the symptoms of the disease (painful swelling of the lymph nodes, fever, tiredness, weight loss, etc.) and the treatment of lymph cancer (radiation therapy with adverse effects such as fatigue, nausea, and vomiting or chemotherapy with side effects such as hair loss, nausea, and vomiting). Even if survival is assured, respondents viewed these morbidity aspects of the disease as being equivalent to better than a 50/50 proposition of being killed in an automobile accident.

For many purposes it may be sufficient to characterise the outcomes in terms of the death risk equivalent indicated in Table I. Equivalently, one can view the results from a different perspective and use as the metric the values on the utility scale given in the final column of Table I. One could then undertake the standard decision analysis procedures to assess the optimal medical decision or policy choice.

However, it is also possible to undertake an additional bridge to convert these results into a monetary equivalent. In the situation of chronic bronchitis, for example, respondents view the disease as being equivalent to a 0.32 probability of life. However, we also note from labour market studies that the midpoint estimate of the implicit value of life is in the vicinity of $5 million[10]. Multiplying the $5 million per life figure by 0.32 probability indicates that the value associated with having chronic bronchitis and remaining alive is $1.6 million whereas the value of being alive and in good health would be $5 million and the value of being dead would be $0.

An alternative to using results from previous studies of labour market or automobile safety tradeoffs is to incorporate in the automobile accident death risk equivalent study questions that ascertain the tradeoff between fatalities and money. A separate component of the chronic bronchitis survey included such a procedure. Using pairwise area comparison in which the two attributes were automobile accident risks and cost of living, it is possible to infer the implicit dollar value of automobile accident deaths. This procedure can be viewed as the pairwise comparison approach to contingent valuation of willingness to pay. The implicit dollar values of automobile accident deaths in that study ranged quite broadly from $1 million at the 0.10 decile to $2.3 million at the median, with a mean value of $8.2 million. The questions pertaining to the willingness to pay for reduced automobile accident death risks involved associated risk reduction probabilities on the order 1/100,000. These probabilities may have been sufficiently small to be not well understood by the respondents.

The greatest potential for extreme responses was for the few outliers at the upper right tail of the distribution. Rather than serving as the basis for making a bridge to a dollar metric, these findings may in part provide further evidence that risk-risk tradeoffs are often more reliable than risk-money tradeoffs obtained in survey contexts.

CONCLUSION

Researchers who have been asked to assess the implicit value of health outcomes might profit from expanding the domain of their inquiry. Rather than focusing simply on monetary metrics, utilisation of the automobile death risk metric has proven to be a successful approach enabling respondents to address a wide variety of health outcomes. Nonfatal traffic safety outcomes might be a good candidate for future studies of this type. The practical advantages of the automobile accident risk metric approach are considerable in that the automobile accident metric greatly simplifies the pertinent choices and puts them in a familiar context that could be more readily understood by respondents. Through appropriate chaining of these findings with risk-money tradeoffs from either automobile accident valuation studies or other contexts, such as compensating wage differentials, one could then convert these estimates into a more conventional monetary metric as well. In situations in which reliance on the monetary metric offends people's moral sensitivities, the automobile accident metric may provide a more acceptable alternative. Moreover, if it is necessary to utilise the monetary currency, there is no barrier to doing so even if the automobile accident metric is utilised.

NOTES

1 See Atkinson and Halvorsen (1990) and Dreyfus and Viscusi (1995). See Jones-Lee (1989) for contingent valuation of highway safety.

2 For a review of this literature, see Viscusi (1992,1993).

3 See, for example, Kunreuther *et al.* (1978), Kahneman and Tversky (1979), and Viscusi (1992).

4 See Lichtenstein *et al.* (1978).

5 The multi-attribute character of the risk (e.g. the dread associated with it) and the influence of these attributes or reactions to risk is discussed in Fischhoff *et al.* (1981).

6 See Viscusi (1992,1993).

7 Although unpublished pilot tests by Michael Jones-Lee and Graham Loomes using a lottery metric for nonfatal risks were not particularly successful, their approach was different than that used here.

8 See Viscusi *et al.* (1991) for a fuller development in a somewhat different context.

9 The rationale for stating that the risk is lower is that increased risk tends to produce alarmist responses. Respondents, for example, might indicate that they are not willing to move to either higher risk area so that it would not be possible to obtain a tradeoff amount.

10 See Viscusi (1992,1993).

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