CHAPTER 5

LITERATURE REVIEW: PART 4 – VALUING HEALTH AND SAFETY RISKS

Benefit-cost analysis of health-related programs requires that we quantify, in monetary terms, the value of the proposed program, i.e. measure the benefits the program provides. Many of the benefits provided by environmental and public health regulations can be characterized as reductions in either mortality or morbidity. For example, Krupnick et al. (2000) point out that the results of benefit-cost analyses for the Clean Air Act (US EPA, 1997, 1999) indicate that over 80% of the benefits of this regulation can be characterized as reductions in premature mortality.

The process of benefit estimation is especially complex in the case of health-related outcomes because of the factors of risk, knowledge, and information. Holmes (1990) notes that valuation of environmental health risks forces us to confront the complex interaction between pollutants, transport mechanisms, and dose-response relationships. Sherwin Rosen (1981) identified three elements that must be confronted in the valuation of risk to human life: the assessment and measurement of risk, the valuation of a given assessed risk, and behavioral responses to changes in inherent risk. The individual's value for reducing the health risk of interest is likely to depend on the knowledge or familiarity she has with the adverse health effects involved, which can be thought of as prior information. However, the information she is provided with during the valuation task may also influence her value for reducing the risk of the adverse health effect. The researcher is also confronted with the question of how to communicate risk to the subject, and left to ponder the implications of his choice for the study's results. Baruch Fischhoff (1990) notes:

> How people respond to risks depends on how they perceive those risks, and especially on their perceptions regarding how large those risk are, how painful their realization would be, what opportunities exist for controlling them, and how costly control will be…although they play themselves out at a much slower pace, decisions regarding long-term risks are also based on perceptions of risks, benefits, and control options. The defining property of such decisions is that the ultimate consequences will not be fully realized for some (long) period of time (Fischhoff, 1990, pp.315).

This chapter discusses the special issues that must be confronted in the valuation of health risks, with particular focus on valuation using stated preference methodologies to value long-term risks. We begin by first briefly summarizing the methodologies that have been used to value health outcomes, and then turn to an overview of the risk literature and the critical roles our attitudes towards and comprehension of different types of risks play in the validity of estimated values for health-related outcomes.

5.1 Methodology for the Valuation of Health Risks

There are two primary approaches to valuing health risks, cost of illness and willingness-to-pay. The willingness-to-pay approach is further categorized into indirect (revealed preference) and direct (stated preference) methods (see Chapter Three for a detailed discussion of these methodologies). Indirect methods, or revealed-preference methods, such as avoidance cost and hedonic studies, have the advantage of producing estimates of the value for a particular good from actual market behavior. In contrast, the direct method creates a hypothetical, or contingent market, and analyzes choice within that context. Individuals are asked what they would be willing and able to pay for a given reduction in a specific health risk, as if the market for such a reduction in risk actually existed. Let us first briefly discuss the cost of illness approach, and then turn to the willingness-to-pay approaches, focusing on the benefits and challenges of using stated

preference methodology to value health and safety risks. We shall also briefly discuss another method for valuing health outcomes, called QALY analysis. QALY analysis is commonly used in the health economics and medical literature as an alternative to benefit-cost analysis, especially when individuals are particularly unwilling to place monetary values on health interventions.

5.1.1 The Cost of Illness Approach

The cost of illness (COI) approach concentrates on those aspects of the value of health that are most easily measured – medical costs and lost wages due to illness. The health expenditures portion of the COI estimate is referred to as the direct cost of illness, while forgone earnings are referred to as the indirect costs of illness. COI estimates are frequently used in benefit-cost analysis (Tolley et al., 1994).

Kenkel (1994) notes that the COI approach has a great deal of appeal due to its seeming simplicity; its task is to estimate a dollar amount that is clear and well defined. In addition, Kenkel points out that a great deal of information has been collected on medical expenditures and lost wages due to illness. Recent contributions to the approach include placing aggregate medical expenditures on an "individual per-case" and "per-day spent ill" basis, which may be more useful in evaluating policy. Kenkel argues that COI estimates have the advantages of being easily accepted by health care professionals and providing values for a broad array of health effects.

However, for the use of benefit-cost analysis in economic evaluation, the COI approach has several shortcomings. It does not take into account the benefits of reduced pain and suffering associated with health improvements. Kenkel (1994) notes that a benefit-cost analysis using the COI approach may indicate that there should be less

expenditure directed at cancer research than society desires because of the great deal of pain and suffering that cancer inflicts upon its victims. In addition, a COI estimate does not reflect many types of additional indirect costs such as the value of the time an individual may spent studying and learning about an illness, the value of lifestyle changes that an individual may have to make, or the value of potential adverse side effects from the medications an individual may have to take to treat his illness. An additional shortcoming of the COI approach is that it places little value on non-market activities, since it considers only lost wages. More recently, efforts have been made to incorporate value produced by the homemaker, but Kenkel states "leisure time in general-and thus much of the time of retired individuals in particular-is not implicitly valued at all" (Kenkel, 1994, pp.44). The use of the COI approach in benefit-cost analysis can be problematic in terms of trying to justify programs that reduce illnesses affecting the elderly or the disabled. Thus, there is a general consensus that cost of illness estimates will be a lower bound to willingness-to-pay values for a given change in illness (see, for example, Harrington and Portney, 1987; Rowe and Chestnut, 1984; Berger et al., 1987). Average WTP for a reduction in symptoms of illness is typically three to four times higher than cost of illness estimates (Cropper and Oates, 1992).

5.1.2 Willingness-to-Pay Approaches

5.1.2.1 Revealed Preference Approaches

Revealed preference, or indirect, methods of valuing health include hedonic analysis and averting cost studies. These approaches estimate the value individuals place on a particular health risk by examining the trade-offs they make in an actual market that is related to the health risk of interest. Hedonic studies for valuing health risks have

generally focused on occupational choice, while averting cost studies examine expenditures consumers are willing to make in order to avoid certain health risks (e.g. purchasing bottled water to avoid health effects associated with contamination).

Maureen Cropper and Wallace Oates state that hedonic analysis stems from the idea that "the price of a house or a job can be decomposed into the process of the attributes that make up the good…such as risk of death in the case of a job" (Cropper and Oates, 1992, pp.706). Economic theory predicts that a worker will select from possible occupations by equating the marginal cost of working a safer job (decreased wages) to the marginal benefit of an increase in life expectancy. Thus, the value that individuals place on the risk of dying from an occupational fatality may be estimated by controlling for every aspect of a job other than risk, and examining any wage premiums that those in high-risk jobs may earn over those in safer jobs. For example, a general linear form of the earnings equation is:

$$w = a + \sum b_i X_i + gp + qq + m \qquad (5.1)$$

where w is the worker's annual earnings, X_i is a series of explanatory variables ($i = 1,..,n$), p is the annual risk of death, q is the annual non-fatal injury risk, and m is the unknown, random disturbance term. The coefficient on the annual risk of death, g, represents the implicit value of life, while the coefficient on the annual non-fatal injury risk, q, represents the implicit value of a non-fatal injury. Viscusi (1986) points out that these values represent risk-dollar trade-offs, rather than the value that the worker would place on certain death or injury. A model such as the one represented by Equation 5.1 should include explanatory variables that represent income-related personal characteristics (e.g. age, race, sex, education, and job tenure), as well as variables that represent job-related

characteristics (e.g. degree of unionization, industry, occupation, supervisory status, physical conditions, and work speed). Viscusi (1986) notes that many hedonic wage studies do not include a variable for the non-fatal injury risk due to an inability to successfully separate out the premiums for fatal and non-fatal risks.

Viscusi (1993) provides an excellent review of health and safety valuation studies that used revealed-preference approaches. Estimates of the value per statistical life, in December 1990 dollars, using labor market data range from $800,000 (Thaler and Rosen, 1976) to $16.2 million (Moore and Viscusi, 1990a, 1990b). Viscusi (1986) argues that the low value Thaler and Rosen (1976) obtained was due to their sample of workers in very high-risk jobs that have an average fatality risk of 1 in 1,000. The average job has an annual risk fatality of 1 in 10,000. Viscusi states that due to "the heterogeneity of values of individual risk and the self-selection of workers with low values into high risk jobs, one should expect to obtain a lower value of life using a sample of workers in risky jobs" (Viscusi, 1986, pp.200-201). Estimates for the implicit value of nonfatal injuries, also presented in December 1990 dollars, range from $13,810-$17,761 (Viscusi and O'Connor, 1984) to $121,550 (Biddle and Zarkin, 1988). However, the range of estimates presented by Viscusi (1993) do not value a homogenous class of nonfatal injuries; he suggests that a consensus range of values for nonfatal injuries, regardless of severity, is $25,000-$50,000.

Several authors have pointed out the shortcomings of hedonic wage analysis. Maureen Cropper and Wallace Oates (1992) identify three problems: 1) the approach is valid only if workers are fully informed of the risks their job entails, 2) studies have indicated that compensating wage premiums for risk appear to be present only in

unionized industries, and 3) workers must have accurately assessed their job risks, and the measures of job risk used in the analysis must accurately measure workers' risk perceptions. Brajer, Hall and Rowe (1991) point out that one must carefully control for all job characteristics other than risk in hedonic wage studies. Finally, one could also argue that a worker must have a feasible alternative if he no longer wishes to subject himself to the high degree of risk associated with his job. In addition, many workers may successfully convince themselves that their job bears no unusual degree of risk, in which case the hedonic approach is of questionable validity.

Viscusi (1993) also present estimates of the value of a statistical life based on trade-offs made in markets other than the labor market, such as in consumption, recreation, and transportation decisions. He notes that in markets other than the labor market, at least one component of the trade-off generally needs to be imputed (e.g. the risk level the individual faces or a monetary value for an attribute, such as travel time). Consequently, Viscusi places less faith in the estimates from markets other than the labor market. These market trade-offs include the choice of highway speed, smoke detector installation, cigarette smoking, property values, and automobile safety. The implicit values of life estimated from this collection of studies are presented in December 1990 dollars and range from $70,000 for highway speed-related accident risk, an estimate based on highway speed-travel time trade-off analysis (Ghosh et al., 1975) to $4 million for automobile accident risk, an estimate based on a hedonic analysis of an automobile's purchase price (Atkinson and Halvorsen, 1990).

Averting behavior analysis stems from the observation that individuals are frequently presented with opportunities to purchase goods that can at least partially

mitigate adverse health effects. For example, if one is concerned about air quality, she may purchase an air filter. Akerman, Johnson and Bergman (1991) estimated Swedish homeowners' willingness-to-pay to reduce health risks from radon exposure. Abdalla, Roach and Epp (1992) used averting expenditures to estimate the economic costs of groundwater contamination from the volatile organic compound trichloroethylene in Pennsylvania. However, averting costs studies must confront all of the difficulties discussed in detail in Chapter Three.

Viscusi (1993) discusses what may be the two biggest downfalls of revealed preference studies. First, the results of revealed preference studies hinge on the assumption that individuals are rational, i.e. they fully understand the risks they face and respond to such risks in a rational manner. However, if this assumption is not satisfied, then "the risk trade-offs that people are actually making may not be those that researchers believe they are making based on objective measures of risk" (Viscusi, 1993, pp.1938). Secondly, using market behavior to value risk reductions necessarily restricts investigators to the valuation of a rather narrow set of health outcomes. We now turn to a discussion of stated preference, or direct, methods for valuing health risks.

5.1.2.2 Stated Preference Approaches

Stated preference methodology was discussed in great detail in Chapter Three; this approach includes both the contingent valuation method and conjoint analysis, and involves asking the individual to value a reduction in particular health risk in a hypothetical setting. The traditional contingent valuation method is now very familiar to us; respondents are directly asked to indicate their willingness-to-pay in either a dichotomous choice or open-ended format. Conjoint analysis can also be used to value

health risks. For example, the pair-wise comparisons approach asks respondents to compare two hypothetical situations, which are characterized by different attributes, including a risk attribute. The attributes can be varied until the respondent is indifferent between the two "packages".

The use of stated preference methodology to value health-related outcomes is fraught with all the general, familiar problems discussed in Chapter Three, as well as some special difficulties that arise when one attempts to value health risks in particular (these problems will be discussed in Section 5.2 of this chapter). However, stated preference methodology also has considerable appeal for the valuation of health risks. A major advantage of using stated preference methodology is that it allows us to value health risks that do not necessarily have a direct link to observable market activities.

James K. Hammitt (2000) discusses three reasons why value of a statistical life estimates obtained from examining wage premiums for risk via hedonic analysis may not be appropriate for the estimation of benefits from environmental and public-health regulation. His first point is that wage-risk studies focus on the preferences of people that are not usually the primary beneficiaries of such regulations. Hammitt argues that while individuals in high-risk occupations are typically young, healthy males, environmental and public-health regulations seek to protect children, the elderly, and other individuals with compromised immune systems. Secondly, Hammitt argues that the values for health risks obtained from wage-risk studies are biased downward because they are based upon workers in high-risk occupations, who have already suggested a greater willingness to trade-off money for increased risk by their choice of occupation. Finally, Hammitt points out that the nature of the risks that workers in high-risk jobs face is different than that of

the types of risks faced by the general public. While wage-risk studies often deal primarily with the risk of a fatal accident, environmental and public-health regulations typically attempt to lower the risks of adverse health effects and disease. Thus, Hammitt feels that stated preference methodology is an attractive alternative to wage-risk studies for the valuation of the type of health risks that regulation seeks to mitigate. He points out that stated preference questions can be targeted to those most likely to benefit from a particular regulation (Hammitt, 2000).

Let us discuss one example of how stated preference techniques are used to value the reduction of health risks. Viscsui, Magat, and Huber (1991) used an iterative computer program to estimate the value of a reduction in the risk of chronic bronchitis (CB), a chronic pulmonary disease thought to be the result of ozone pollution exposure. Values were estimated by examining individuals' willingness to make trade-offs between their income levels and their risk of CB (i.e. a risk-income trade-off), and between their risk of instantaneous death and their risk of CB (i.e. a risk-risk trade-off). Willingness-to-pay can be inferred from the risk-income choices, while monetary values can be elicited from risk-risk choices, using the value of a statistical life. Viscusi, Magat and Huber argue that the risk-risk approach has an advantage in that policy makers who are squeamish about basing decisions on dollar benefits may be more willing to consider benefits that are measured in term of another risk. The authors estimated that the median CB valuation is equivalent to 0.32 auto deaths, while the mean valuation is equivalent to 0.68 auto deaths. The estimated median dollar value per statistical case of CB was $457,000, while the estimated mean was $883,000. The median dollar value of a statistical life calculated from the auto fatality risk-dollar tradeoff was $2,286,000, while

the mean value was $8,184,000. Some individuals indicated values for a statistical life as high as $80 million, which skewed the distribution of willingness-to-pay values to the right. Surprisingly, the top two deciles of the response distribution valued a reduction in the risk of CB more highly than reduction in the risk of dying in an automobile accident. The authors offer two possible reasons for this result. First, the subject may feel that a debilitating chronic illness is a worse outcome than death due to the severe limitations and suffering the disease inflicts. Secondly, the risk of CB was described as an involuntary risk not under the subjects' control (with the exception of potentially relevant smoking behavior), while one could argue that the risk of dying in an automobile accident depends partially upon one's driving skills. The authors point out that other studies indicate people may be more optimistic about risks over which they perceive themselves to have some degree of control (Viscusi, Magat, and Huber, 1991).

5.1.3 QALY Analysis

An alternative approach for valuing health outcomes, called QALY analysis, has also been used extensively in the medical and health economics fields. The term "QALY" is an acronym for "Quality-Adjusted Life Year". The technique stems from a 1976 paper by Zeckhauser and Shepard, who viewed the individual as "choosing among alternative lotteries on quality and quantity of life" (Zeckhauser and Shepard, 1976, pp.11). Thus, QALY analysis developed in an effort to capture of both the quantity and quality of life in an individual's value for different health incomes. To aggregate health benefits, Zeckhauser and Shepard make a set of assumptions. One such assumption has been called the "egalitarian assumption", which states "QALYs returning to different individuals should be weighted equally" (Zeckhauser and Shepard, 1976, pp.15). Based

on the QALY approach, the objective of health policy is to choose the intervention that maximizes the number of quality-adjusted life years saved for a given level of expenditure (Fabian, 1994). Torrance (1986) provides an overview of the literature on the QALY approach.

The QALY format attempts to value health based on individuals' feelings towards various possible symptoms, as well as levels of pain and impairment. Individuals are asked, in a hypothetical context, to rate different health states that are described in a questionnaire. The health state may be described by several attributes, such as mobility, physical activity, social activity, and symptom/problem complex (Kaplan, Bush and Berry, 1976). An individual is asked to rate a particular health state along a scale that runs from "zero" for death (or less than zero for outcomes that may be viewed as worse than death, such as severe brain damage) to "one" for perfect health. The difference between two health states along the scale is then taken to represent the individual's difference in utility of those two health states. Health preferences for the general population are estimated by examining the average response for each health state in the sample; this produces an index of utility for various health states that is measured on an interval scale (Fabian, 1994). Torrance (1986) demonstrates how QALYs are to be interpreted with the following example:

> If a programme improves the health of individual A from a 0.50 utility to a 0.75 utility for one year and extends the life of individual B for one year in a 0.50 utility state, the total QALY's gained for that year would be 0.25 for individual A plus 0.50 for individual B for a total of 0.75 (Torrance, 1986, pp.8).

5.1.3.1 Comparison with Stated Preference Methodology

QALY analysis is similar to stated preference methodologies for valuing health in that both techniques are based on individual preferences, and both use hypothetical questions to elicit the individual's preferences for health outcomes. However, QALY analysis differs from contingent valuation and conjoint analysis in that QALY analysis does not attempt to place any monetary value on a particular health outcome. The difference between QALY analysis and conjoint analysis is that in the conjoint format, price would be included as an attribute of the health state. In QALY analysis, the individual rates the various health states based purely on her preference or aversion to certain outcomes, independent of the cost of achieving such an outcome. However, Zeckhauser and Shepard (1976) maintain that the QALY approach can incorporate cost concerns by ranking interventions according to the utility gained per dollar of expenditure. This method is often referred to as cost-utility analysis (Fabian, 1994). However, Boardman et al. (1996) caution that cost-utility analysis may reflect only budgetary costs, failing to capture other social costs. In addition, it is often unclear whether budgetary costs are based on marginal or average costs. Consequently, if the competing health interventions to be evaluated have opportunity costs that are not included in the budget, cost-utility analysis and benefit-cost analysis may result in different rankings for the potential interventions.

5.1.3.2 Three Methods for Eliciting QALYS

Three formats are used to elicit QALYS: the rating scale, the standard gamble, and the time trade-off. The most straightforward method is the rating scale, which was

described above. Respondents are presented with a scale that has well-defined points, including death and unimpaired health. The individual then assigns points along the scale to the various health states she is asked to consider, based on her level of preference or aversion to the attributes of each health state. Typically, the scale ranges from a value of zero (representing death) to one (representing perfect health). Thus, the distance between the rating of a particular heath state and zero is the estimated value of the QALY. The standard gamble method asks the respondent to choose from two outcomes: 1) impaired health for a certain number of years, or 2) normal health for a certain number of years with probability *p* and immediate death with probability (*1-p*). The probability *p* is varied until the respondent is indifferent between the two outcomes. In the case of a 0-1 scale, *p* can be interpreted as the QALY value for the impaired health state in outcome 1. The time trade-off approach asks the respondent to indicate the number of years he would be willing to give up at the end of his life to avoid a certain adverse heath state. Thus, the respondent compares a shorter life in relatively good health with a longer life in relatively poor health.

5.1.3.3 Advantages and Disadvantages of the QALY Approach

Many proponents of the QALY method for the economic evaluation of health related programs argue that a large part of the method's appeal is its equal treatment of each person's QALYs, regardless of his or her economic circumstances. This is the "egalitarian assumption" discussed earlier. Fabian (1994) describes the egalitarian assumption as a "fundamental feature" of the QALY approach, as it is "both a statement of social philosophy concerning the unique importance of health in people's lives and a technical step designed to permit the aggregation of utilities" (Fabian, 1994, pp. 124). In

contrast, stated preference methodology forces individuals to confront their economic constraints, at least in theory. However, it also appears that different individuals value health improvements very differently, and often these differences are not related to income levels. Therefore, egalitarian arguments aside, it may be inaccurate to assume that all people weigh adverse health outcomes in the same way.

The discounting of future life-years also presents a potential problem for QALY analysis. It is not clear whether or not individuals discount future life-years when making decisions in the QALY format. It seems that the time trade-off format would be particularly likely to encourage the discounting of future life-years by the respondent. If, in fact, individuals do discount when indicating their preferences in a QALY format, no further discounting of QALYs should occur. Otherwise, there is a danger of "double discounting". The discounting debate described in Chapter Four also applies to QALYs; many argue that "intertemporal egalitarianism" is also necessary, i.e. future life years should be viewed to be as important as present life years (Fabian, 1994).

Fabian (1994) argues for the integration of willingness-to-pay approaches and QALY analysis. He shows that the concept of the value of a statistical life can be used to calibrate QALY values with willingness-to-pay values; studies that have attempted such a calibration include Miller et al. (1990), and Mauskopf and French (1989). Fabian views the calibration of QALY and WTP values as an important future research direction for the economic evaluation of health care programs, stating:

> …additional research in both areas could bring the two approaches closer together and narrow the ranges of uncertainty. Ranges of uncertainty will always exist, but policy decisions for or against a certain action are greatly strengthened if they are supported by evidence from both approaches (Fabian, 1994, pp. 134).

Fabian's suggestions include designing contingent valuation studies that elicit values for health outcomes via both WTP and QALYs formats, and designing contingent valuation studies that directly measure the value of a statistical life. For example, in the first case, if QALY respondents indicated a mean of 0.033 QALYs gained and a mean annual WTP of $5,000 for a particular program, the implied value of the QALY is $150,000. An example of a possible experiment to measure the value of a statistical life is presenting a respondent with a scenario in which she faces imminent death if untreated. The respondent is then presented with two possible treatment options, both of which offer a normal life expectancy in good health, but also carry a small probability of death. Suppose the first treatment carries a 0.01 probability of death this year, while the second treatment carries a 0.01 probability of death next year. If the respondent is willing to pay $1,200 more for the second treatment option, since she gains 0.01 QALY in this year, the implied value of a QALY is $1,200/0.01, or $120,000 per QALY. Fabian argues that such integration of willingness-to-pay values and QALY analysis "would facilitate the synthesis of empirical findings that would further contribute to the body of common knowledge available to policy makers and health professionals" (Fabian, 1994, pp.135). He points out that willingness-to-pay approaches are especially useful when valuing relatively small changes in health at the "perfect-health" end of the health status continuum, since such changes would be difficult to value through QALY analysis along the 0-1 scale.

5.2 Special Considerations: how do we think about risk?

The valuation of non-market goods is plagued by many difficulties, which were discussed in detail in Chapter Three. However, the valuation of health-related outcomes is particularly troublesome due to the need to confront the element of risk inherent in all health-related outcomes. This section briefly summarizes some of the issues surrounding the nature of risk, and how individuals respond to risk, that are particularly relevant for the challenges faced in using stated preference methodology to value health risks.

5.2.1 Uncertainty in Risk Measurement

The process of measuring the magnitude and effects of a particular health risk is characterized by uncertainty, due to the dose-response relationship. The dose-response relationship connects exposure to risk to the fraction of the exposed population suffering adverse health effects. Estimating this relationship has been particularly difficult in the case of health effects stemming from environmental contamination. Rosen (1981) points out that epidemiological studies on human subjects have all the flaws associated with non-experimental data, but dose-response relationships estimated in controlled experiments on nonhuman subjects may not be easily extrapolated to humans. Thus, given the difficulties of quantifying the link between exposure to environmental contaminants and adverse health effects, respondents to stated preference surveys are apt to view the stated baseline health risk, and potential risk reductions that interventions offer, with great skepticism. Though the researcher, using stated preference methodology, often makes a good faith effort to present a situation that is as realistic as possible, she is often constrained by a lack of data.

5.2.2 The Role of Knowledge and Information

Viscusi, Magat, and Huber (1991) suggested that future research must examine how health risk valuations are influenced by the amount of knowledge the individual has about the risk being valued. In addition, they pointed out that it would be interesting to see how the "thoroughness and vividness" with which the disease's effects are described to subjects influences their values for reducing the risk of developing that particular disease (Viscusi, Magat, and Huber, 1991, pp.50-51). Krupnick and Cropper (1992) sought to address some of the issues raised by Viscusi, Magat and Huber.

Krupnick and Cropper (1992) examined whether or not familiarity with a specific disease affects the value one places on a reduction in the risk of that disease. In addition, Krupnick and Cropper wished to determine if the effect is different depending on whether the valuation is elicited in a risk-income or risk-risk trade-off. Krupnick and Cropper point out that there are two ways of viewing the problem that individuals may not be familiar with the chronic disease they are being asked to value. One may argue that persons who are not familiar with the disease cannot possibly respond appropriately to the WTP questions posed by stated preference methods. On the other hand, many contend that citizens often vote on issues about which they do not have perfect knowledge; perhaps valuing an unfamiliar disease is not so different from decisions that arise out of voting behavior. Following Viscusi, Magat, and Huber (1991), Krupnick and Cropper elicited trade-offs between income and the risk of chronic bronchitis, and trade-offs between the risk of dying in an automobile accident and the risk of chronic bronchitis. They found that individuals who had a relative with chronic bronchitis, and thus were familiar with the disease, have significantly higher willingness-to-pay values

for reductions in the risk of chronic bronchitis than those who do not have a relative who is afflicted with chronic bronchitis. However, when the value of reducing the risk of chronic bronchitis was elicited in the risk-risk format (comparisons of the risk of chronic bronchitis and the risk of dying in an automobile accident), there was no significant difference in the willingness-to-pay values of those familiar with the disease and those who are unfamiliar with the disease. In addition, there was no difference in the variance of WTP values between those familiar with chronic bronchitis and those unfamiliar with the disease. Krupnick and Cropper speculate that individuals who are familiar with chronic bronchitis might feel more strongly about reducing the level of *all* risks, and that risk-risk trade-offs may be more stable than risk-income trade-offs (Krupnick and Cropper, 1992). An earlier study by Coursey, Hovis, and Schulze (1987) focused on the disparity between willingness-to-pay and willingness-to-accept, but found that those who had tasted a particular bitter, non-toxic substance (sucrose octa-acetate) have similar willingness-to-pay values to avoid tasting the substance as those who had never tasted the substance.

5.2.3 The Trouble with Valuing Small Changes in Risk

Many studies have documented the difficulties the general public has perceiving changes in risk, particularly when the baseline risk is small (e.g. Baron, 1997; Frederick and Fischhoff, 1998). This issue is of great concern for researchers attempting to value environmental health risks; we are typically attempting to value small reductions in risk from a relatively small status-quo risk of mortality or morbidity from exposure to environmental contaminants. W. Kip Viscusi (1990) discusses the seemingly inconsistent responses of society to health related risks. He cites examples of cases

where people have responded dramatically to very small risks: the drastic drop in sales of the drug Tylenol as a result of the 1980s tampering incidents (all seven resulting deaths occurred in the Chicago area), restricting European travel due to isolated terrorist incidents, and the Food and Drug Administration's ban on the sale of Chilean fruit due to the detection of cyanide in two grapes. However, he also notes that society's response to greater levels of risk is often inadequate. For example, he points out that people continue to shun wearing seatbelts, and that we have failed to address long-run environmental problems such as acid rain and global warming until recently. Kasperson et al. (1988) believe that risks are often "blown-up" in the individual's mind; he or she may perceive the risk to be much greater than it is based upon technical assessment. Kasperson et al. believe that the two primary vehicles through which most individuals receive risk information are informal, personal conversations and the news media, rather than through any kind of scientific entity.

Viscusi (1990) discusses the relationship between perceived and actual risks within a framework illustrated by a diagram similar to the one presented in Figure 5.1, located at the end of this chapter. At actual probability levels below F_0, individuals will be likely to over-estimate risk, while at probability levels above F_0, they will be likely to under-estimate risk. The discontinuity at the zero level of risk indicates that there will be a jump in the individual's level of perceived risk once the level of actual risk is present, i.e. probability exceeds zero. Viscusi notes that the slope of the perceived risk probability function, as represented by line CD in the figure, is the key determinant of how the individual will respond to changes in risk. A preventive or safety intervention that reduces the actual risk from B_0 to A_0 is a relatively small risk reduction, represented

by the change from B_1 to A_1, *in the individual's mind*. Thus, the individual's perceptions of risk thwart the effects of such efforts. However, if an intervention is able to achieve the zero-risk level, the individual does perceive the full effect of the intervention. Consequently, Viscusi predicts that public preferences will be strong for programs that completely eliminate risk, pointing to the Delaney Clause, which requires a zero level of carcinogenic food additives, as an example of such a program. Viscusi also maintains that individuals are very prone to over-estimation of risk when the level of risk increases from a particular level to which the individual has become accustomed. As support for this assertion, Viscusi points to the results of his 1987 work with Magat and Huber, which found that although individuals expressed moderate willingness-to-pay levels for risk reductions of 15 injuries per 10,000 bottles of insecticide or toilet bowl cleaner used annually, most consumers were unwilling to buy such products at all when confronted with a risk increase of 1 in 10,000 and those that would continue to buy the product asked for a substantial cut in price (Viscusi, 1990).

5.2.4 Communicating Risk

The process of attempting to estimate the value a particular group of people place on an environmental health risk necessarily involves communicating the risk to be valued to members of that group. Recently, practitioners of stated preference methodology have begun to recognize that if the values obtained from such methodology are to be meaningful, great care must be taken to ensure that individuals have a reasonable understanding of the risks they are being asked to value. Unfortunately, the nature of environmental health risks is reasonably complex; this adds to the challenge of effective risk communication. Tversky and Kahneman (1974) argue that individuals will often

resort to heuristics or "rules of thumb" in order to deal with complex decisions. Viscusi stated in 1993 that "a major concern with survey valuations of health risks is that the responses will be reliable only to the extent that individuals understand the tasks to which they are responding. A matter of particular concern is the processing of risk information presented in survey context" (Viscusi, 1993, pp.1939). Abdalla, Roach, and Epp (1992) noted in their averting expenditure study of the value of reducing groundwater contamination risks that "another implication for policy that emerges from this study draws on the finding that averting expenditures vary with households' qualitative perception of the health risk and knowledge of contamination. Risk communication strategies which affect the perception of drinking water risks may change the estimates of benefits and costs of environmental policies which affect health" (Abdalla et al., 1992, pp.168). Beattie et al. (1998) observed:

> There is growing evidence that WTP-based values of safety are not universally transferable and that people's ex ante willingness to pay to reduce risk will instead tend to vary with their perceptions of and attitudes towards the characteristics of different hazards, such as the extent to which the hazard concerned is seen to be voluntarily assumed, under the potential victims' own control, their own responsibility, well-understood, and so on (Beattie et al., 1998, pp. 6-7).

The 1986 National Conference on Risk Communication cited several factors that contribute to the difficulties that plague effective risk communication. These factors include: 1) the technical, complex, and uncertain nature of risk information, 2) a wide range of risk estimates (even when one considers expert opinion alone), 3) public distrust of regulatory agencies, 4) varying definitions of risk, 5) strong beliefs on the part of the public that are often difficult to change, and 6) the public's general difficulties with comprehending probabilistic information (Davies, Covello, and Allen, 1987).

Many environmental health risks have a long latency period, which creates significant challenges for the design of valuation instruments. Baruch Fischhoff (1990) believes that individuals particularly struggle with long-term risks for two reasons: 1) in this context, the decision maker does not receive immediate feedback as to how wise his decision was, and 2) because decisions about long term risks are spread out through time, it may be difficult to link decisions with their consequences. He argues that if an individual established a way to "think" about a particular problem, she may view it differently each time she is confronted with it. In this case, how the individual views the problem at any given time will depend upon the particular cues and reminders that accompany the question being asked. Fischhoff feels that survey researchers may be deluding themselves if they take an individual's responses to a particular set of questions to be a result of stable personality characteristics, rather than the particular circumstance in which the individual finds herself. However, he also recognizes, "Unfortunately, eliciting more appropriate answers is fraught with its own methodological difficulties. Quantitative judgments are hard whenever people are uncomfortable with the needed numbers (especially very large or very small numbers)" (Fischhoff, 1990, pp.322). Fischhoff developed a set of suggestions for how data should be presented to aid people's understanding of long-term environmental risks. His guidelines for presenting data include, but are not limited to: 1) laying out the basic issues relevant for managing the specific risk, 2) prioritizing information by importance, 3) awareness of documented obstacles to risk communication, and showing that awareness in the presentation of quantitative information, 4) summarizing information form multiple sources systematically (e.g. use of meta-analysis), 5) presenting alternative perspectives, 6)

presenting qualitative information in addition to quantitative information, and 7) evaluating the risk communication devices used (Fischhoff, 1990).

V. Kerry Smith and William Desvousges (1987) used a series of pie charts to communicate changes in the probability of death due to hazardous waste under a series of programs. The first pie chart indicated the probability that the typical individual would be exposed to the hazardous substance, while a second pie chart showed the probability that one would die if exposed to the hazardous substance. The third pie chart, which was titled "Combined Risk: Exposure and Death", indicated the combined (multiplied) probability of the first two charts. Individuals were then asked to value a reduction in their combined risk level. Smith and Desvousges argued that this communication format (three separate pie charts) was found in a series of focus groups to be most effective in helping individuals to associate changes in environmental regulation with changes in risk.

John B. Loomis and Pierre H. duVair (1993) cited several shortcomings of the risk communication format used by Smith and Desvousges (1987), arguing that risk ladders are a more appropriate risk communication device. Specifically, Loomis and duVair felt that, particularly for low levels of risk, 1) individuals may not be able to associate a small, darkened "slice of the pie" with their risk of premature death relative to more familiar risks, 2) individuals may have difficulty perceiving small changes in risk in the third pie chart, i.e. knowing how much "safety" they are purchasing, and 3) the presentation of three separate pie charts may be confusing to individuals who are not used to thinking in terms of combined probabilities. To explore their position that risk ladders have advantages over pie charts in effectively communicating risk, Loomis and duVair (1993) compared the use of risk ladders and risk circles/pie charts in the context of the

contingent valuation method (CVM). Respondents were asked to value a reduction in the risk of premature death via state-financed incentives for hazardous waste minimization by private industry in the state of California. Two versions of the survey were designed. One version used a multi-color risk ladder to show a series of involuntary risks, including the individual's risk of premature death from hazardous waste under three different programs. The figure used by Loomis and duVair is presented (in black and white) at the end of this chapter in Figure 5.2. The second version of the survey used a series of pie charts that were modeled after those used by Smith and Desvousges (1987). Three separate pie charts are presented for the status quo and the alternative program. As in Smith and Desvousges (1987), the third pie chart represents the combined probability of the risk of being exposed to the hazardous substance and of the risk of dying prematurely given that one is exposed. This format is presented at the end of this chapter in Figure 5.3.

Loomis and duVair (1993) tested several hypotheses directed at exploring potential advantages of the risk ladder over the pie chart. The first concerned the possibility that individuals may find the risk ladder favorable because it portrays changes in risk using linear distances, while the pie chart involves two dimensions. Loomis and duVair tested their hypothesis by both testing the equality of the two logit equations using a likelihood ratio test and by pooling the WTP responses from the two versions of the survey, but including a dummy variable for the risk communication device used. The authors also examine whether or not risk levels affect the individual's response to the CVM valuation question. Finally, they hypothesize that the percentage of respondents who vote 'yes' will be higher for the version of the survey that employs a risk ladder,

since they believe that this communication device makes it easier for respondents to perceive small changes in risk. The results of Loomis and duVair's analysis generally support their hypotheses: the two risk communication devices do, in fact, yield statistically different equations; the dummy variable in the pooled model is significant, suggesting that the pie chart version of the survey resulted in lower willingness-to-pay estimates; the level of risk reduction positively and significantly affects willingness-to-pay for both version of the survey, and the risk ladder version of the survey yields a statically greater percentage of 'yes' responses to the valuation question. Loomis and duVair note that while the risk ladder may be more effective at portraying information on relative risk, the pie chart format is able to effectively communicate how a proposed program would affect the risks the respondent is confronted with and is also able to portray the absolute level of risk reduction. Loomis and duVair are greatly encouraged by the fact that both risk communication devices provide WTP responses that are sensitive in the theoretically correct direction to the level of absolute risk reduction, and conclude that either risk communication device may be appropriate in the CVM context. However, they advocate future research that examines the efficacy of both approaches for a wide range of risk levels and seeks to develop new risk communication devices that may prove to be even more effective (Loomis and duVair, 1993).

More recently, Krupnick et al. (2000) used both audio and visual aids to communicate risk. The risk of death was represented by colored squares on a rectangular grid, which contained a total of 1,000 squares. These authors stated that respondents found grids containing more squares confusing, viewing such small changes in risk as irrelevant. In addition, respondents were asked a series of questions to test their risk

comprehension before answering the valuation questions. For example, the respondent was given a graphical representation of the risk of death for two different individuals. The respondent was then asked to indicate which person had the higher risk of death, and which person they would rather be. The results of the comprehension tests indicate that a lack of understanding of risk information is a problem for a small percentage of respondents; 2.6% of the sample failed both tests, and in a question at the end of the survey, while 7% rated their understanding of probability fair to poor.

Carson and Mitchell (2000) valued the benefits of reducing trihalomethanes in a town's public water system via the installation of a carbon filtration system. Trihalomethanes are a chemical by-product of chlorination, and have been shown to be a carcinogenic, but low-level, risk. Carson and Mitchell conducted focus groups for the purpose of pre-testing their stated preference instrument. They report, "the focus group participants found it difficult to grasp the nature of mortality risks and how a contaminant can affect them" (Carson and Mitchell, 2000, pp.4). To facilitate risk comprehension, Carson and Mitchell first described the "basic" risk of dying that we all face as we age, and then described what they called "extra" or "special" risks that some individuals face, but others do not (e.g. risks faced by stuntmen, police officers, or those flying on an airplane). Carson and Mitchell also found that respondents had trouble processing low-level risks; to aid respondent understanding, they provided examples of low-level risks such as the risk of dying in a scheduled U.S. air flight and the risk of being killed by lightening.

Carson and Mitchell (2000) devoted a great deal of effort to testing different types of risk communication devices. They developed a risk ladder that portrayed risk as

annual mortality per 100,000 people, and used various types of risks as anchors on the ladder. In addition, the lowest portions of the ladder were magnified to aid comprehension of the small risk reductions the Carson and Mitchell study sought to value. The authors chose to include as a risk anchor the risk of dying in an automobile accident, but decided against using recreational risk examples (e.g. the risk of dying while hand gliding) because focus group participants regarded such voluntary risks as irrelevant to the involuntary risk presented by drinking water contamination. In addition, the authors converted all risks to a common metric -- the risk faced from smoking a certain number of cigarettes in a lifetime. The risk reductions offered by each of three possible programs were presented in three ways: 1) the absolute change in trihalomethane levels, 2) the general risk of dying per 100,000 and 3) the cigarette equivalent consumption (Carson and Mitchell, 2000).

5.2.5 Are WTP estimates adequately sensitive to the size of the risk reduction?

The validity of stated preference methods is often judged, in part, on the basis on the sensitivity of willingness-to-pay estimates to the quantity or quality of the good being valued. Economic theory would expect the values individuals place on risk reductions to be sensitive to the size of the risk reduction provided. This criterion is often referred to as the “scope test”. A more stringent criterion requires that estimated willingness-to-pay should be proportional to the size of the risk reduction. For example, Hammitt and Graham (1999) suggest that if one states a WTP value of $20 from a reduction in annual mortality risk from 20 in 100,000 to 18 in 100,000, that individual should be willing to pay about $40 for a reduction from 20 in 100,000 to 16 in 100,000. Hammitt (2000) maintains that proportionality is necessary because otherwise the estimated value of a

statistical life will be dependent on the arbitrary choice of how large the risk reduction presented in the survey instrument is. However, one may argue that the proportionality test is irrelevant if respondents experience diminishing marginal utility in the risk reduction, i.e. if willingness-to-pay is nonlinear with respect to the size of the risk reduction. In a study of willingness-to-pay for reductions in the risk of being exposed to trihalomethanes, Carson and Mitchell (2000) find evidence to support the hypothesis that willingness-to-pay is non-linear in the level of risk reduction.

Hammitt and Graham (1999) summarize possible explanations for why WTP values may not be adequately sensitive to changes in risk. First, respondents may have difficulty evaluating events that have small probabilities, such as many of the health risks typically addressed by stated preference studies. Kahneman and Tversky (1973) and Baron (1997) have suggested that individuals have difficulty processing numerical changes in magnitude. Secondly, individuals may not see the risks presented as being relevant for them, choosing instead to form their own subjective perceptions of their personal risk, which are based both on their prior risk perceptions and the information presented by the stated preference instrument (Viscusi, 1985; Viscusi, 1989; Smith, 1992). Krupnick et al. (2000) found that when respondents were told their baseline risk of dying in the next twelve months, they often expressed skepticism that the stated risk applied to them. This creates an obvious difficulty for the researcher; he cannot estimate the respondent's marginal rate of substitution for money and risk without knowing what risk reduction the respondent is actually valuing. Finally, individuals may not values changes in risk according to expected utility theory (Anand, 1993). For example, Kunreuther et al. (1978) studied of the property owner's decision to purchase flood

insurance, and found that the decision is simply not based on whether or not the expected reimbursable damage from floods is greater than the insurance premium. The households that did purchase insurance typically did so because of prior experience with floods, or because someone the homeowners knew had such experience.

However, Hammitt and Graham (1999) maintain that, even in this case, willingness-to-pay should be linear in the risk probabilities (Machinia, 1987; Smith and Desvousges, 1988) and to their knowledge, there are no prescriptive choice models that advocate nonlinear valuations in the changes in small risks of adverse events (Bell et al., 1988). Furthermore, though some descriptive choice models, such as prospect theory (Kahneman and Tversky, 1979) account for responses to risk that are nonlinear in the probabilities, these models are locally linear, with the possible exception at the zero risk level. However, as noted earlier, there has been at least one more recent study (Carson and Mitchell, 2000) to suggest that willingness-to-pay may in fact be non-linear with respect to the size of the risk reduction; Carson and Mitchell (2000) found that the linear model resulted in an inferior fit relative to both the log-log model and quadratic model.

Let us now examine whether previous valuation studies of health risk reductions have passed the "scope" and "proportionality" tests, bearing in mind that the relevance of the proportionality test for the valuation of risk reductions remains subject to debate. Unfortunately, the results are non-conclusive. Hammitt and Graham (1999) reviewed twenty-five studies of health risk valuations, all of which have been published since 1980. These studies all shared three characteristics: 1) they value some type of human health and safety protection, 2) willingness-to-pay was elicited using stated preference methodology (personal interviews, written questionnaires and telephone interviews), and

3) WTP values are linked to specific numerical changes in the respondent's probability of mortality or morbidity. While these studies presented respondents with information about risks, the baseline risk they face, and the risk reduction provided by the proposed intervention, Hammitt and Graham note, "some respondents may mistrust the objective risk information that is provided by investigators or may doubt whether the stated-often averaged-probabilities are applicable to the respondent's personal circumstances" (Hammitt and Graham, 1999, pp. 36). In an attempt to address this problem, ten of the twenty-five studies collected information regarding the respondent's perceptions of his risk, and thus, the perceived risk reduction offered by the program (see Gerking et al., 1988; Hammitt, 1990; Johannesson and Jonsson, 1991 for examples of such studies).

Hammitt and Graham discuss both "internal" (within sample) and "external" (between sample) tests of the sensitivity of WTP estimates to the size of the risk reduction. They argue that internal tests are less stringent, because respondents are likely to base their WTP value for one particular risk reduction on their responses to earlier elicitation questions for smaller or greater risk reductions. Thus, the anchoring effect is likely to result in some consistency. In contrast, an external test is based on the responses of different respondents to different types of health risks. Hammitt and Graham find that this collection of previous valuation studies for reductions in heath risks does not adequately examine the sensitivity of WTP estimates to changes in risk reduction. An internal test was possible in only ten of the twenty-five studies; in these studies the size of the risk reduction affects WTP in the expected way. However, Hammitt and Graham report that in many of these studies, many respondents indicate the same WTP regardless of the amount of risk reduction offered (see Jones-Lee et al., 1985 for an example),

exhibiting an “embedding effect”. Hammitt and Graham also find that internal proportionality tests fail, as mean willingness to pay is generally much less than proportional to the risk reduction.

An external consistency check was possible for only nine of the twenty-five studies reviewed; Hammitt and Graham report that none of the studies included in their review were explicitly designed to allow for external testing. They find that each of the nine studies fails an external test of proportionality, and while some studies passed the less stringent test that WTP be positively affected by an increase in the size of risk reduction (see, for example, Muller and Reutzel, 1984), others did not (e.g., see Smith and Desvousges, 1987). In addition, Hammitt and Graham report that studies that allowed for inclusion of the individuals’ subjective, or perceived, risks did not fare much better; they found that in these studies, WTP was significantly different for perceived risk reductions of different sizes, but changes in WTP were less than proportional to changes in the size of the perceived risk reduction (Hammitt and Graham, 1990).

Beattie et al. (1998) used stated preference methodology (direct CVM and indirect relative valuation questions) to value a reduction in the risk of injury from an automobile accident. A dot chart was used as an aid to communicate risk. Beattie et al.’s approach differs from that of many authors in that their study involved a three-stage process. Respondents first participated in focus groups that were designed to introduce risk concepts and the dot chart communication device; however, respondents were not given any information regarding potential risk reductions or valuation questions at this time. In the second stage, respondents completed the valuation questionnaires in a one-to-one interview. Finally, respondents were given an opportunity to view the study’s results,

and provide further comments regarding their thought processes during the valuation process, in a follow-up session. The authors found that despite these efforts, significant scope, embedding, and sequencing effects persisted. They state "it appeared that a major contributory factor in the relative failure of the direct CV questions was the difficulty experienced by many respondents in dealing with small reductions in already small probabilities" (Beattie et al., 1998, pp.15).

Results such as these have led the authors to be skeptical about the applicability of stated preference methodology to the valuation of health and safety risks. Hammitt and Graham state:

> …many of the stated WTP estimates reported in the literature on health risk do not represent economic preferences. Thus, some of the enthusiasm that has been expressed regarding the use of CV in risk analysis (e.g. Kenkel, 1997) is not warranted by the state of the science, though we recognize that there are few good alternatives to CV (Hammitt and Graham, 1999, pp.58).

Beattie et al. add:

> Whatever thought processes and strategies brought to bear in answering the CV questions…it would appear that in an uncomfortably large proportion of cases these were not of the type presupposed by the theory usually undertaken to underpin the WTP to the valuation safety. One can therefore have little confidence that the VOSL estimates that emerged from these studies can be used as a reliable basis for public policymaking (Beattie et al., 1998, pp.20).

However, the results of other studies have been more encouraging. Other studies have found that willingness-to-pay is indeed sensitive, if not proportional, to the size of the risk reduction. Loomis and duVair (1993), in a study discussed earlier in this chapter that values reductions in the risk of premature death from hazardous waste exposure, found that the absolute level of a risk reduction positively and significantly affects WTP estimates for both versions of their survey; one version used a risk ladder to communicate

risk, while the other version used a series of pie charts. Thus, the estimated WTP values from this study pass the less stringent "scope" test. Krupnick et al.'s results (2000) are also encouraging with respect to the question of scope; median WTP for a 5 in 10,000 annual reduction in the risk of death is 1.6 times greater than median WTP for an annual risk reduction of 1 in 10,000. The authors attribute this finding to their efforts to successfully communicate risk to the respondents and their test of respondent comprehension of risk. However, WTP does not appear to be proportional to the size of the risk reduction in this study. Carson and Mitchell's (2000) study of willingness-to-pay to reduce the level of trihalomethanes in public drinking water systems finds that willingness-to-pay is indeed sensitive to the level of the risk reduction, but find that willingness-to-pay is not proportional to the size of risk reduction because of diminishing marginal utility for the risk reduction.

Corso et al. (1999) stressed the problem of risk communicating small changes as a factor in the lack of sensitivity of willingness-to-pay values to the size of the risk reduction. This study estimated WTP for reductions in the annual risk of a fatal automobile accident. The two risk reductions offered were 5/100,000 and 10/100,000. The sample was split into four groups. Three groups were presented with some type of visual risk communication device (a chart with 25,000 dots, a logarithmic risk ladder, or a linear risk ladder); the control group was not presented with a visual risk communication device. This study found that the sensitivity of WTP to the size of the risk reduction depended upon the type of visual aid used. Let us first consider the less stringent test that willingness to pay be positively affected by an increase in the risk reduction. For the control group, median WTP for the larger risk reduction is 1.10 times

greater than WTP for the smaller risk reduction; however, the difference in median WTP is not statistically significant. This is also the case for the linear risk ladder. However, for the logarithmic risk ladder and the dot chart, median WTP for the larger risk reduction is significantly greater than median WTP for the smaller risk reduction. Now, let's us consider the proportionality issue. For the group presented with the dot chart, median WTP is almost proportional and the null hypothesis that WTP is proportional to the risk reduction cannot be rejected. In addition, the null hypothesis of proportionality is not rejected for the logarithmic risk ladder. However, the control and linear risk ladder groups fail the proportionality test.

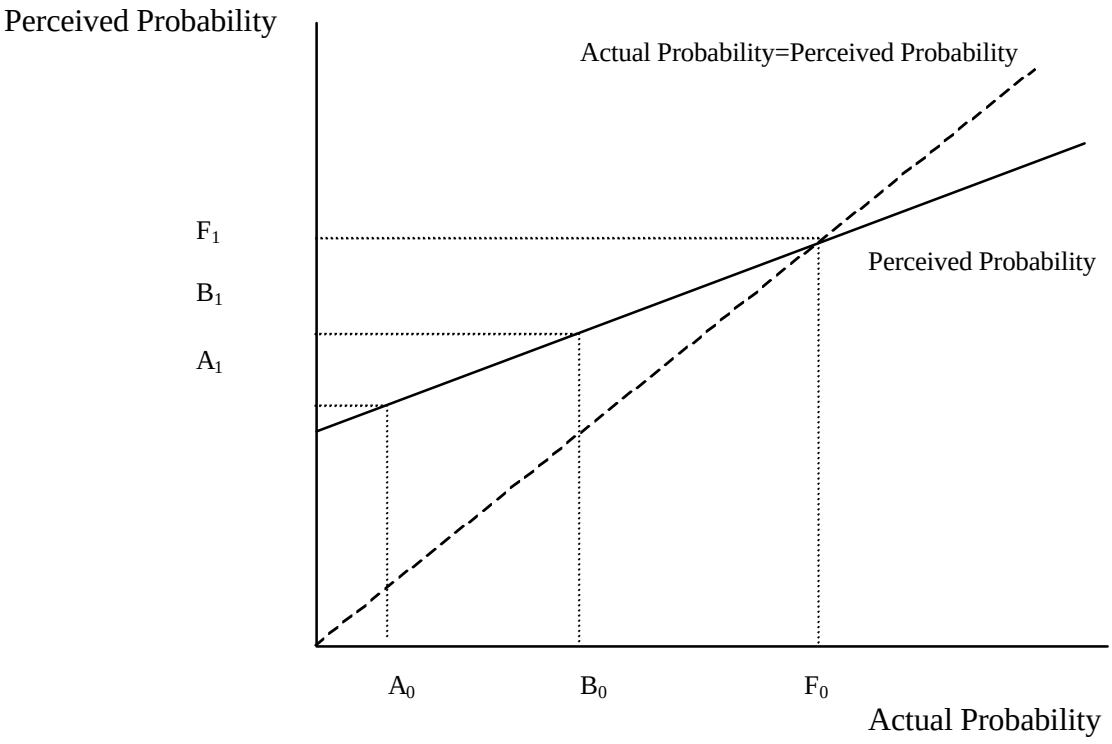
5.3 Summary

This overview of the health risk valuation studies clearly suggests that further research is necessary to strengthen the efficacy of stated preference methodology for valuing reductions in health and safety risks. It appears that the key to doing so lies in overcoming the problems inherent in risk communication. Telephone or mail surveys may be inadequate survey instruments for the valuation of health and safety risks, as there is limited opportunity in these formats to uncover the effectiveness of risk communication devices, which are reflected by the respondent's level of understanding regarding the risks in question and his thought process in evaluating such risks. Not only do we know that individuals have difficulties thinking about small levels of risks and small changes in risk, but it also appears that they often think certain risks simply do not apply to them and have difficulty distinguishing between different types of risk. Carson and Mitchell (2000) noted in their study of the benefits of removing trihalomethanes in public drinking water that many respondents tended to confuse the risks associated with

trihalomethanes with the risks presented by other drinking water contaminants, such as PCBs.

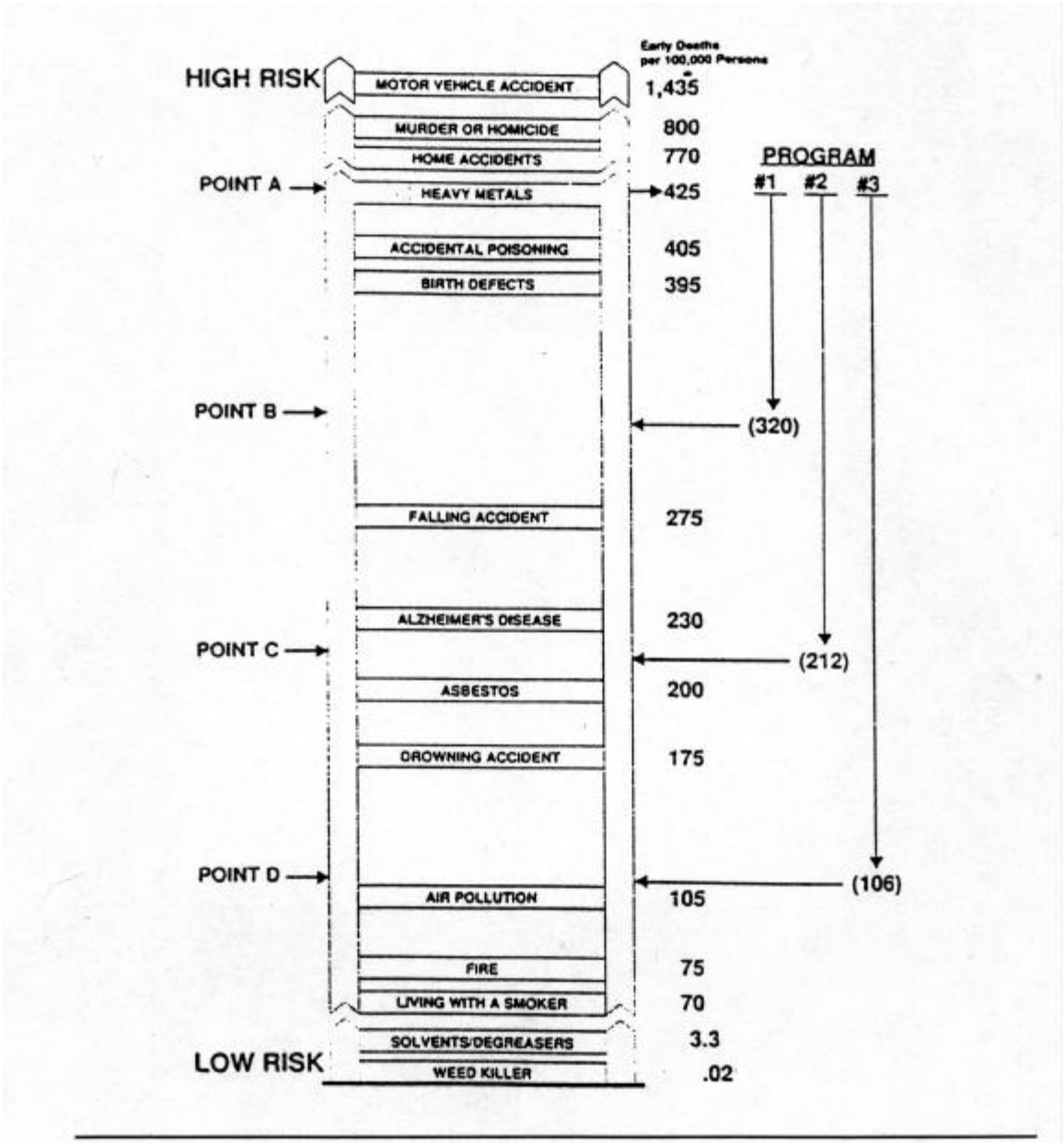
Until we can be more certain that the well-documented difficulties individuals have in comprehending risk information are more adequately addressed by stated preference survey instruments, researchers cannot claim to have much confidence about the validity of willingness-to-pay values to reduce health risks. This lack of confidence makes it difficult for researchers to advocate the use of these questionable willingness-to-pay values in policy decision-making, despite their feeling that the alternatives to stated preference methodology are wanting. It is encouraging to see that much of the most recent stated preference methodology research is painfully aware of these problems, and considerable effort is being made to address them. Such efforts must be continued.

Figure 5.1-Relationship Between Actual and Perceived Probabilities



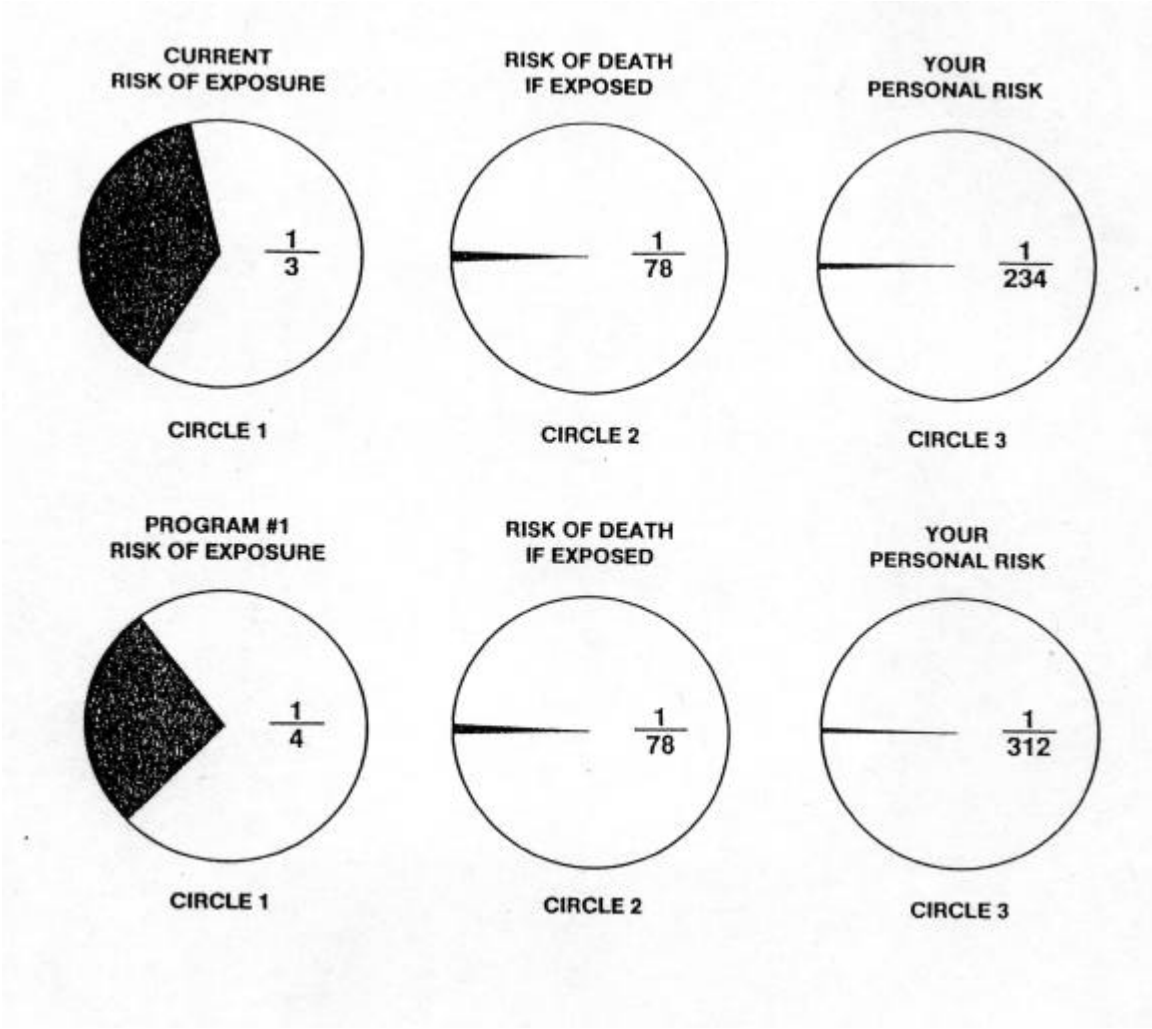
Source: Viscusi, 1990, pp.258.

Figure 5.2-Risk Ladder to Communicate Risk



Source: Loomis and duVair, 1993, pp.291

Figure 5.3-Pie Charts to Communicate Risks



Source: Loomis and duVair, 1993, pp. 292