# Using Estimates of the Value of a Statistical Life in Evaluating Regulatory Effects

**by Donald Kenkel**

## Basic Concepts and Current Practice

The problem of allocating scarce societal resources to life-saving activities arises when evaluating a wide variety of regulations and government programs. Most economists and policy analysts agree on the general principle that the life-saving benefits of public sector activities should somehow be compared to the costs of the activities. The agreement fades, however, when this general principle is put into practice to evaluate specific regulations. Several different conceptual approaches that have been proposed over the years continue to influence the current practice of economic evaluation of the life-saving benefits of regulations. This section briefly reviews selected evaluations conducted by the U.S. Environmental Protection Agency (EPA), the Economic Research Service of the U.S. Department of Agriculture (USDA), and the U.S. Food and Drug Administration (FDA). The review of current practice also allows some basic concepts to be defined and illustrated.[1] The following sections of the paper propose a common-sense rule for improving current practice: The same life-saving benefit should always be given the same value, but different life-saving benefits should be given different values.

The standard approach to placing a dollar value on the life-saving benefits of regulations is based on societal willingness to pay (WTP) for mortality risk reductions. Unlike an emergency rescue operation, the specific people whose lives are saved by regulations cannot be identified. Instead, regulations reduce mortality risks in the population affected by the regulation. As a hypothetical example, suppose a new food safety regulation reduces the annual risk of dying of a foodborne illness by 0.00001. In a population of 100,000, the regulation is expected, in a statistical sense, to result in 1 fewer death from foodborne illness each year. Using this reasoning, regulations are sometimes said to save "statistical lives" as opposed to identified lives. If each person in that population of 100,000 is willing to pay $20 a year for the reduction

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[1] The phrase "current practice" is used loosely and refers to the selected published evaluations conducted by the EPA, USDA, and FDA. These past evaluations may no longer be representative of "current practice." In addition, it is simplistic to describe the methods used by an agency as a single, current practice; in reality, each agency may use a variety of methods depending upon the circumstances of the regulatory evaluation.

in mortality risks, the total WTP is $2 million for an annual risk reduction that can be expected in the statistical sense to save one life. In this case, $2 million is said to be the value of a statistical life (VSL). The VSL should be thought of as a convenient way to summarize the value of small reductions in mortality risks. It is not meant to be applied to the value of saving the life of an identified person (i.e., the value of changing the risk of mortality from one to zero).

Based on an extensive review of the research literature, the U.S. EPA (1997) suggests that a reasonable estimate of the VSL has a mean of $4.8 million with a confidence interval of plus or minus $3.2 million (in 1990 dollars). The suggested range for the VSL suggested by the EPA is consistent with other reviews including Fisher, Chestnut and Violette (1989), Viscusi (1992, 1993), and the meta-analysis by Desvousges et al. (1998). The EPA's review identified 26 studies that were judged to reflect "sound and defensible" methods. Five of these studies used the contingent valuation method, where survey respondents are directly asked about their WTP for mortality risk reductions. The remaining 21 studies estimated the value of risk reductions based on workers' willingness to accept riskier jobs in return for higher wages. The conceptual foundation of both empirical approaches to estimating the VSL is that societal WTP for risk reductions should reflect individuals' risk valuations, whether elicited directly through surveys or revealed in their labor market decisions.

The WTP approach to valuing the lifesaving benefits of regulatory effects is consistent with Haveman and Weisbrod's (1983, p. 82) more general argument that "cost-benefit analysis can be viewed as an attempt to develop a public-sector analogue for private market decision-making." In their private-market decisionmaking, consumers do not demonstrate an infinite WTP for safety. Instead, they often demonstrate their willingness to trade off safety for other desirables, such as time and money. Evaluating regulatory effects based on estimates of consumers' WTP allows public-sector safety decisions to reflect that same willingness to make tradeoffs involving safety. However, the relevance of private-market decisionmaking will be limited when there are questions about the competence of individual decisionmaking under uncertainty. For example, evidence shows that people tend to underestimate risks of common causes of death, while they tend to overestimate the risks of rare causes of death (Slovic, Fischhoff, and Lichenstein, 1985). Ideally, public-sector safety decisions should reflect people's preferences but not reflect their mistakes.

Several recent evaluations of EPA regulations use the $4.8 million VSL estimate, with the only adjustment being for inflation to express benefits in current dollars. As part of its estimates of the benefits of drinking water regulations related to disinfectants and disinfection byproducts, the EPA (1998) uses a value per statistical life saved for fatal bladder cancers represented by a distribution with a mean of $5.6 million (1998 dollars). In a Regulatory Impact Analysis of a proposed rule on surface water treatment, improvements in drinking water filtration are estimated to reduce mortality from Cryptosporidium illnesses (EPA, 2000a). The benefits of these mortality reductions are based on a mean value of $5.7 million (January 1999 dollars) per statistical life saved. In a Regulatory Impact Analysis for a proposed ground water rule, the EPA (2000b) estimates the monetized benefit from viral deaths avoided using a VSL of $6.3 million (1999 dollars).

In several of its evaluations conducted several years ago, the Economic Research Service of the USDA supplemented WTP-based estimates of the VSL with estimates based on the human capital/WTP hybrid approach (Landefeld and Seskin, 1982). Estimated this way, the VSL ranges from roughly $15,000 to $2,037,000 (1996 dollars), depending on the age group benefiting from the mortality risk reduction (Buzby and Roberts, 1997). The conceptual foundation of this empirical approach to estimating the VSL reflects two schools of thought. In the human capital or cost of illness approach, life-saving benefits are estimated by the impact of mortality reductions on the measured productivity of the economy. In the standard human capital approach, the VSL is therefore equal to the discounted present value of lifetime earnings lost due to the premature mortality. This approach has been criticized on a number of grounds, with the most fundamental objection being that an individual's WTP to reduce mortality risks has no necessary relationship to his or her discounted lifetime earnings.[2] Landefeld and Seskin (1982) develop an adjusted process to calculate forgone earnings, allowing for the individual's perspective in that earnings are computed net of tax, nonlabor income is included, an individual discount rate is used (as opposed to the social discount rate), and a risk-aversion factor is applied. The USDA's analyses also include the value of housekeeping services as a component of lifetime earnings. Compared to the methodology of the original human capital approach, this hybrid approach yields VSL estimates that are closer theoretically and empirically to individual WTP-based estimates of the VSL, such as those reviewed by the EPA (1997).

The USDA used estimates from the hybrid human capital/ WTP approach in two conceptually distinct types of analyses. The first type are cost-of-illness studies that quantify or account for the impact of specific conditions on the economy (Kuchler and Golan, 1999, p. 53). Cost-of-illness studies include medical expenditures as the direct costs of treating illness and productivity losses, including the present value of future earnings forgone due to premature mortality, as the indirect costs of illness. Cost-of-illness studies use a standardized accounting framework and methodology, enhancing the comparability of studies of different illnesses and conditions (Hodgson and Meiners, 1982). The National Institutes of Health [NIH] (1998) presents over 50 disease-specific estimates of the direct and/or indirect costs of illness. USDA analyses include a study of the economic costs of congenital toxoplasmosis, which can result from handling raw meat or eating undercooked pork and other meats (Roberts and Frenkel, 1990). The present value of an infant's lifetime earnings, estimated at $983,000 (1989 dollars), is one component of the indirect costs of toxopolasmosis. Similarly, Roberts and Pinner (1990) use an estimate that the present value of forgone lifetime earnings is $1.1 million per infant to estimate the economic costs of disease caused by *Listeria monocytogenes*. Buzby, Roberts, Lin, and MacDonald (1996) include forgone lifetime earnings in their estimate that foodborne bacteria impose between $2.9 and $6.7 billion of economic costs. In an update, Buzby and Roberts (1997) include estimates of the costs of Guillain-Barré, syndrome related to *Campylobacter jejuni* infection.

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[2]In one response to the criticisms of this approach, Robinson (1986) argues that it is based on assumptions that are similar to the propositions of the material welfare school of thought, dominant in English economics between 1880 and 1940. Robinson agrees with the critics that the approach is not consistent with the approach of modern welfare economics that provides the conceptual foundation for cost-benefit analysis.

The USDA also used estimates from the hybrid human capital/WTP approach as an alternative approach to estimating the value of the life-saving benefits of specific interventions. Compared with the WTP-based estimates such as those reviewed by the EPA (1997), the hybrid human capital/WTP approach generally yields lower estimates of the VSL, so this approach is sometimes seen as a more conservative approach to estimating the value of life-saving benefits. For example, Roberts, Buzby, and Ollinger (1996) and Crutchfield et al. (1997) use the hybrid approach to estimate the value of the life-saving benefits of a food safety regulation the Hazard Analysis and Critical Control Point regulation for meat and poultry plants. The VSL estimates ranged from $12,000 to $1,585,000 (1993 dollars), or $15,000 to $1,979,000 (1995 dollars), depending upon age. Crutchfield et al. (1997) explicitly acknowledge that their VSL estimates are low compared with WTP-based estimates around $5 million used in other agencies' evaluations of regulatory effects. In these studies, as well as in the review by Kuchler and Golan (1999), WTP is described as the conceptually correct approach, with the VSL estimates based on the hybrid human capital/ WTP approach presented as more conservative.

Several evaluations conducted by the FDA measure the life-saving benefits based on the value of a life year (FDA 1999a, 1999b). For example, the FDA (1999b) values each life year saved by a nutrition labeling regulation at $100,000. Similar values for a life year are suggested by Zarkin et al. (1993), Tolley, Kenkel, and Fabian (1994), and Cutler and Richardson (1997). Placing a dollar value on a life year begins to build a bridge between two different conceptual approaches to economic evaluation: cost-benefit analysis and cost-effectiveness analysis. Cost-effectiveness analysis avoids placing a monetary value on health. Instead, the analysis compares the incremental cost of the intervention to the incremental health effect achieved. The quality-adjusted life year, or QALY, has emerged as a standard measure of effectiveness, and the cost per QALY saved has been estimated for a wide range of health interventions (Gold et al., 1996). The QALY approach not only incorporates the quantity of life or years of life extension from an intervention, but also the quality of life, based on individuals' preferences over different health states. For example, a year of life with a serious illness might be weighted as being as valuable as 0.7 of a year of life with perfect health. Placing a monetary value on a QALY allows the health effects to be monetized, converting any cost-effectiveness analysis into a cost-benefit analysis.

The use of the life year approach is illustrated in the FDA's (1999b) analysis of a proposed rule about food labeling related to trans fatty acids, nutrient content claims, and health claims. By encouraging more healthful dietary choices, changes in food labeling regulations have the potential to reduce mortality from coronary heart disease. In the FDA's analysis, the cost of a fatal event is the discounted years of life lost multiplied by the dollar value of a quality-adjusted life year. FDA estimates that the average victim of coronary heart disease loses 13 years of life, which discounted at 7 percent becomes 8.4 discounted years. Valuing each life year at $100,000, the average value per fatal case, i.e., the analogue to the VSL, is about $840,000.

**The Same Life-Saving Benefits Should Be Given the Same Value**

Although there is general agreement on the principle of valuing the life-saving benefits of regulations, the review of recent practice suggests that the EPA, the USDA, and the FDA rely on somewhat different VSL estimates. A hypothetical example provides an extreme case of the extent of disagreement. Suppose that each agency were considering the life-saving benefits of a regulation that reduced mortality risks for a group of 50-year-olds. The EPA's (1997) review of WTP estimates suggests the benefits should be based on a VSL of $4.8 million. The hybrid human capital/ WTP approach used by the USDA suggests a VSL of $721,418. The value of a life year approach used by the FDA implies that a VSL of $1.2 million should be used.[3] This range shows substantial disagreement; for example, both the USDA and FDA estimates fall outside the confidence interval around the EPA's estimate of the mean VSL.

If different regulatory agencies' efforts are guided by an inconsistent set of VSL's, the result will be an inefficient set of regulations. Consider a stylized regulatory decisionmaking process, where each agency uses cost-benefit analysis to decide whether to enact possible life-saving regulations. Given their different areas of regulatory responsibility and authority, assume each agency faces a schedule showing that it can save additional lives through more regulations, but only at an increasing marginal cost imposed on the economy. Each agency chooses to regulate until the marginal benefits of life saving, as measured by its preferred estimate of the VSL, just equal the marginal costs. When decisionmakers in the different agencies use inconsistent estimates of the VSL, the result is inefficient, in the sense that it is possible to re-allocate regulatory efforts to reach an outcome that all decisionmakers would agree is an unambiguous improvement.[4] Using the different VSL's from the hypothetical example, suppose the EPA marginally reduced its regulatory efforts and saved two fewer lives, while at the same time the USDA and the FDA marginally increased their regulatory efforts to save one more life each. The net result would be the same number of lives saved, but the regulatory costs would fall by $7.7 million.

Tengs and Graham (1996) provide a detailed analysis of the inefficiency that results from inconsistent, or in their perhaps more appropriate term, "haphazard," public investments in life-saving activities. They consider 185 life-saving interventions, which included but were not limited to regulatory efforts like those of the EPA, USDA, and FDA. In total, the interventions currently implemented are estimated to cost the economy approximately $21.4 billion and save approximately 56,700 lives. By choosing interventions to minimize costs, Tengs and Graham estimate that it is possible instead to save the same number of lives and save about $31.1 billion of costs. This surprising result is because Tengs and Graham identify many untapped interventions that save both lives and money. Implementing these interventions makes it possible not only to save the $21.4 billion currently being spent, but to save another $10 billion as well. Alternatively, holding the cost constant at the current level of $21.4 billion but choosing interventions to maximize lives saved, Tengs and Graham estimate that it would be possible to save about twice as many lives 117,000 annually than results from the current set of regulations.

The analysis of Tengs and Graham raises an important question: Are decisions about life-saving regulations based on inconsistent estimates of the VSL, or simply made haphazardly with little

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[3]Following the FDA (1999b), the value of a year of life is assumed to be $100,000, and a discount rate of 7 percent is applied. Assuming an individual at age 50 has a life expectancy of 29 years, discounting at 7 percent yields 12.3 years.

[4]This explanation draws on Sugden and Williams (1986, pp. 187-190) general discussion of the importance of consistency in decisionmakers' valuations of costs and benefits.

described above, where cost-benefit analysis drives every regulatory decision, is not a literal description of how decisions are made. Several reviews provide a mixed picture of the role of consideration of the benefits and costs? Clearly, the stylized regulatory decisionmaking process cost-benefit analysis in regulatory efforts. Based on a review of the record of the 1980's, Viscusi (1996) suggests that different agencies' reliance on cost-benefit analysis makes a systematic difference in their regulatory efforts. Using a VSL of $5 million as the cutoff for efficient regulations, Viscusi lists 13 regulations that pass a cost-benefit test per life saved, and 20 regulations that fail a cost-benefit test. Similarly, Hahn's (1996) review of 92 final and proposed rules for 1990 to mid-1995 finds that, using the agencies' estimates of benefits and costs, only 17 would pass a cost-benefit test. However, Viscusi (1996) notes an interesting pattern in the earlier record. He argues that the fact that all of the listed regulations that were issued by the U.S. Department of Transportation (DOT) pass a cost-benefit test is no accident: The DOT relies heavily on cost-benefit analysis, using $3 million for the VSL in its evaluations.

Aside from regulatory decisions of the DOT, it is hard to escape the conclusion that few decisions about life-saving regulations are being made primarily based on benefits and costs. These so-called "haphazard" decisions may reflect other systematic influences, such as political pressure. Whether these influences are a legitimate part of the regulatory decisionmaking process is a much broader question. For the narrower question considered here, using a consistent VSL estimate in evaluations of life-saving regulations by different agencies is clearly an important step toward the more limited goal of improving the economic efficiency of regulatory efforts.

**Different Life Saving Benefits Should Be Given Different Values**

The last section emphasized the desirability of different regulatory agencies using the same VSL when they are evaluating the same life-saving benefits. However, different regulations often result in fundamentally different types of life-saving benefits. The selected evaluations reviewed in section 1 address the life-saving benefits of reducing mortality from bladder cancer, cryptosporidium illnesses, viral illnesses, congenital toxoplasmosis, Guillain-Barré, syndrome, and coronary heart disease. This section discusses when it is desirable to use different estimates of the VSL for these different risk reductions. Two sources of heterogeneity in the VSL are discussed. First, there is heterogeneity in the willingness to pay across different health risks for the same individual. Second, there is heterogeneity across individuals in their willingness to pay for risk reductions.

Individual WTP for a given reduction in mortality risks probably differs depending upon the cause of death. The VSL typically estimated applies most directly to WTP to reduce the risks of unforeseen instant death, such as a workplace or traffic accident. However, people may be willing to pay substantially more to reduce risks where there is a lengthy period of morbidity preceding death, both because of the value of morbidity avoided and the psychic costs of imminent death. Empirical evidence on WTP for different types of mortality risks appears to be fairly limited. Jones-Lee, Hammerton, and Philips (1985) report that, given a choice between preventing 100 deaths from cancer, heart disease, or motor vehicle accidents, most respondents preferred to prevent deaths from cancer. The means of responses indicate that preventing 100 deaths from heart disease is worth almost twice as much preventing 100 deaths from motor vehicle accidents, while preventing 100 cancer deaths is valued at about three times the value of preventing accidental deaths. Based on this and other evidence, Tolley, Kenkel, and Fabian (1994) argue that the appropriate VSL for lung cancer mortality may be twice the size of the VSL appropriate for mortality due to unforeseen, instant death. Similarly, it may be appropriate to use a higher VSL to evaluate the benefits of reducing mortality from bladder cancer due to water pollution and a lower VSL to evaluate the benefits of reducing mortality from acute infection from foodborne illness.

While the same individual may have a different WTP to reduce the risks of different causes of death, different individuals may also have different WTP's to reduce the same risk. Just as for other commodities, people may value health and safety differently due to idiosyncratic differences in tastes and preferences, income levels, and so on. Just as for schooling human capital, people may value their health and safety capital differently at different points in the life cycle (Cropper, 1977). In addition to variation over the life cycle in WTP to reduce risks to adults, altruism in societal WTP means that there may be a special premium on reducing mortality risks for children.

The various sources of heterogeneity in WTP lead to the somewhat controversial conclusion that different VSL's should be used to evaluate the life-saving benefits of regulations that affect different groups of people. The EPA (1997, p. 77) notes that the population most affected by reductions in air pollution-related mortality risks is likely to be older than average, disproportionately drawn from those aged 65 and over. Improvements in drinking water filtration to prevent infection by cryptosporidium will reduce risks especially for sensitive populations, including children, especially the very young, the elderly, pregnant women, and the immunocompromised (EPA, 2000a). Regulations to prevent exposure to *Toxoplasma gondii* in food will reduce risks for infants (Roberts and Frenkel, 1990). Ideally, the benchmark VSL of $4.8 million suggested by the EPA (1997) should be adjusted to account for these differences. For example, because of the methods used the standard estimate of the VSL mainly reflects the preferences of workers with an average age around 40. The correct VSL to evaluate an air pollution regulation might be somewhat lower, while a higher VSL should be used when evaluating food-handling regulations that affect the risks to infants. The conceptual justification for the use of different VSL's is that, in private decisions, individuals display different WTP to reduce risks depending upon their age and other characteristics, so public decisions should reflect the same preferences.

Limited evidence suggests that WTP to reduce mortality risks varies systematically over the life cycle of working age adults. In a theoretical analysis, Shepard and Zeckhauser (1982) predict that the relationship between the VSL and age will show an inverted U-shape, with a peak around the age of 40 years, dropping to about 50 to 70 percent of the peak by the age of 60. This pattern is roughly consistent with the empirical results of Jones-Less et al. (1985), but the magnitude of the changes in VSL over the life cycle are estimated to be smaller than predicted by theory. For example, the VSL at age 65 is estimated to be still about 90 percent of the peak VSL from age 40. These patterns are also similar to the life cycle patterns in the VSL estimated by the hybrid human capital/WTP approach.

Moore and Viscusi (1988) extend the standard wage-risk study to explore if workers of different ages reveal different WTP for job risks. Using data from the 1977 Quality of Employment Survey, their results imply that the value of a life year averaged more than $170,000 (1986 dollars), and that the VSL is about $6 million. The results imply that different types of life-saving activities will have much different values depending upon the age of the affected individuals and the timing of the risk reduction. For example, to a worker who expects to live for 35 more years, a 1-year life extension is estimated to be worth only $11,000 now. But a one-year life extension is estimated to be worth about $400,000 for an older worker with a life expectancy of 5 years.

The wage-risk approach does not provide information on the value of life-saving activities that affect children, the elderly, and other groups who are not in the labor force. Studies that examine revealed preferences for risks in other market contexts are beginning to provide preliminary estimates of the appropriate VSL for these groups. Blomquist et al. (1996) analyze decisions about seat belt use for children, and estimate that WTP to reduce risks to children is equal to or larger than WTP to reduce risks to adults. Mount et al. (2000) use data on automobile purchases to estimate how much single-car families and families of different composition spend on safety. This approach allows them to estimate the VSL for children, adults, and the elderly. For example, one set of estimates suggests the VSL for adults is $6.34 million, while the VSL for children is $4.28 million and the VSL for the elderly is $4.59 million. This suggests the same inverted U-shape predicted by the theoretical analysis of Shepard and Zeckhauser (1982). However, the estimated VSL for children is sensitive to certain assumptions made in the analysis. Under some sets of assumptions, the VSL for children exceeds that of adults and the estimated VSL steadily declines over the life cycle.

Another approach to estimating WTP for life-saving activities that affect different age groups is to conduct surveys that directly ask about preferences for hypothetical life-saving programs. Cropper, Aydede, and Portney (1994) report the results of surveys of over 3,000 respondents given choices between various pairs of life-saving activities. For the median respondent, saving one 20-year-old is equivalent to saving seven 60-year-olds, while saving the lives of 20-year-olds and 40-year-olds are viewed similarly. This suggests a somewhat different pattern for the VSL over the life cycle, with the VSL being roughly constant until the age of 40 but sharply dropping at older ages. However, in these surveys respondents were put in the role of social decisionmaker. Asking people about how they think societal decisions should be made is different that asking them about their willingness to pay to reduce their own risks. Because of this difference, it could be argued that these survey responses are not that relevant to the empirical pattern of VSL over the life cycle.

In addition to the role of age, other individual characteristics may affect WTP for risk reductions. The role of income is another controversial example. If regulatory efforts are judged solely on the basis of economic efficiency, the principles of cost-benefit analysis imply that the VSL should also depend on the average income of the population experiencing the risk reduction. Many analysts object to this implication on the grounds of equity or social justice, and in fact it is often cited as a reason to prefer cost-effectiveness analysis over cost-benefit analysis when evaluating health interventions. As Pauly (1995) notes, this objection is often a red herring because many health and safety interventions do not have a wealth bias. Kenkel (1997) argues further that concern about the unequal distribution of benefits and costs is not new or unique to the analysis of health interventions. He points out that there are several methods, including the distributional weights approach and the basic needs approach, to bring distributional concerns into cost-benefit analysis in a systematic way. Taking this approach suggests the use of income-adjusted VSL's for strictly efficiency-based cost-benefit analysis of life-saving regulations, to be supplemented with additional analysis that account for the distribution of costs and life-saving benefits.

**Conclusions**

Another way to summarize the arguments made in the preceding sections is that the evaluations of the life-saving benefits of regulations should use consistent and specific estimates of the VSL. When different agencies reduce similar health risks for similar populations, they should use consistent estimates of the VSL; but each agency should use VSL estimates that are specific to the health risk and population affected by its regulations. This presents a challenge for both the research community that generates VSL estimates and the policymaking community that uses them.

One way to develop a catalogue of consistent and specific VSL estimates is the "monetized QALY approach" such as that used by the FDA (1999a, 1999b). Achieving consistency would be straightforward: different agencies could use consistent dollar value per QALY when evaluating all regulatory efforts. The monetized QALY approach would also yield specific VSL's that depend on age, pre-existing health state, and cause of death. Whether the monetized QALY approach yields specific VSL's that are good estimates of societal WTP is more problematic. For example, the monetized QALY approach might understate societal WTP for regulations that save the lives of children, because there is some evidence that people are willing to pay a special premium for such risk reductions. Empirical evidence also suggests that the VSL declines more slowly with age than that implied by the monetized QALY approach.

The conceptual foundation for monetizing QALY's needs to be examined closely and linked to the VSL literature. QALY weights are based on individual preferences over health states, as revealed in surveys or experiments. These methods deserve at least the same level of scrutiny as the contingent valuation method. A noted limitation is that many methods used to develop QALY weights rely on asking respondents about health states that they have not experienced. As a validity check, market behavior should be analyzed to see if it is consistent with QALY approach and weights. This might also provide a revealed-preference approach to monetizing QALY's. Until a number of important issues along these lines are resolved, it is premature to view the monetized QALY approach as meeting the need for a set of consistent and specific VSL estimates.

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