Wellbeing measures of mortality risks: life-cycle contradictions and ordinal index challenges

W. KIP VISCUSI*

University Distinguished Professor of Law, Economics, and Management, Vanderbilt Law School, Nashville, TN, USA

Abstract: The value of a statistical life (VSL) monetizes the expected loss in wellbeing associated with the risk of death. The utility loss resulting from a fatality is central to the empirical framework for estimating the VSL. The VSL trajectory over the life cycle exhibits an inverted-U shape, following a trajectory similar to that of lifetime patterns of consumption. The U-shaped pattern displayed by happiness measures over the life cycle is the opposite of the inverted-U shape pattern displayed by the VSL. It is consequently inappropriate to use happiness measures as ordinal ranking substitutes for the VSL for the purposes of estimating the benefits of mortality risk reduction. Compared to ordinal wellbeing scales, the VSL also offers a variety of additional capabilities by providing a cardinal index of the unit benefits for changes in mortality risks.

Introduction

The valuation of reduced mortality risks comprises the largest benefit component of US government regulations and has a prominent role in policies throughout the world (Sunstein, 2014; US Office of Management and Budget, 2015; Viscusi, 2018). While there are differences across countries in how to assess the benefits of mortality risk reductions, the most common economic framework is to monetize these benefits in order to make them comparable to policy costs. An alternative approach advocated by Frijters et al. is to use measures of life satisfaction to value the effects of policies on individual wellbeing. My article demonstrates that the conventional economic procedure

* Correspondence to: Vanderbilt Law School, 131 21st Ave. South, Nashville, TN 37203, USA. Email: kip.viscusi@vanderbilt.edu
to monetize changes in risk already embodies a fundamental concern with wellbeing and is a superior approach to quantifying benefits.

The most common approach to monetizing the changes in mortality risks uses estimates of the value of a statistical life (VSL), which is the trade-off rate between money and mortality risks. For example, the VSL corresponding to a willingness to pay of $900 to reduce a risk of 1/10,000 yields a value per unit risk, or a VSL, of $9 million (i.e., $900/(1/10,000)). Current estimates of the VSL for the USA by Viscusi (2018) indicate a VSL of $10 million, which is similar to the values used by US government agencies and higher than the VSL levels used in other countries. A person’s VSL is the willingness to pay for a small change in risk, which is consistent with established economic principles for benefit assessment. As I will show, the VSL also serves as a cardinal index for assessing the effect on wellbeing of changes in mortality risks and is a superior benefit assessment approach.

The VSL, wellbeing and the contradictory impacts of age

The VSL, which is the marginal rate of trade-off between money and fatality risks, has a common formulation across different domains of choice, whether the mortality risks pertain to jobs, products or activities (Viscusi, 2018). In particular, if \( y \) is the income level and we let \( u_1(y) \) equal the utility when healthy, \( u_2(y) \) equal the utility when deceased or the bequest function, and \( p \) be the probability of death, then:

\[
VSL = \frac{(u_1(y) - u_2(y))}{(1 - p)u_1'(y) + pu_2'(y)}
\]

Both \( u_1 \) and \( u_2 \) are functions of income, but both the utility and marginal utility of any given income level are less in the ill health state. The VSL is simply the difference in the utility levels between being healthy and dead, divided by the expected marginal utility of income. These von Neumann–Morgenstern utility functions are defined up to a positive linear transformation, so that the division by the expected marginal utility of income serves to normalize the units of the VSL. Individual wellbeing and the decline in wellbeing with death are pivotal concerns of the VSL, where this valuation of small changes in risk is in monetary terms. The formulation in the equation above generalizes to other adverse health effects such as the valuation of risks of nonfatal injuries and illnesses such as cancer.

The VSL is not a universal constant, but varies with factors such as age and income (Viscusi, 2018). Wellbeing measures such as life satisfaction scores, which are elicited using ordinal scales such as 0–10, also vary with personal characteristics. The role of age variations has been prominent in each of...
these literatures. Given that the VSL and life satisfaction measures each have wellbeing as central concerns, one would expect that these measures would exhibit similar kinds of heterogeneity with demographic factors. Numerous empirical analyses have examined the life-cycle variations of VSL and measures of wellbeing. If the age-related trajectories for VSL and life satisfaction measures are similar, then that parallel might suggest that the approaches are parallel economic approaches, but in different units using different scales.

The established pattern for VSL estimates based on estimated wage premiums for risk is that the VSL–age relationship has an inverted-U shape. The VSL rises over the life cycle, reaching a peak for workers in their mid-40s, after which it declines. This drop is not precipitous, however, as workers aged 62 have a higher VSL than workers aged 20. The age–VSL relationship closely tracks the life-cycle pattern of consumption, which is not surprising since the VSL corresponds to the willingness to pay for the reduced risk, which at any given age is related positively to a person’s financial resources.

The inverted-U pattern for VSL and age has additional implications for the valuations of each life-year. If each year of life were equally valued, the VSL would steadily decline with age because of the diminished life expectancy with age. Underlying the inverted-U-shaped trajectory for the VSL is a corresponding trajectory of the value of a statistical life-year (VSLY), which also displays an inverted-U relationship, but with a somewhat later peak in workers’ 50s. This pattern of VSLY estimates is inconsistent with assumptions of a constant valuation per year of life, as in some quality-adjusted life-year (QALY) approaches.

The age-related trajectories of various happiness and wellbeing measures are opposite to that of VSL. The qualitative wellbeing measures display a U shape, reaching a minimum in middle age. The recent review and extension of the literature by Graham and Pozuelo (2017) concluded that the U curve was borne out quite widely within 46 countries. Among the many other studies documenting the U shape for happiness and age, Steptoe et al. (2015) found a U shape in some but not all countries, and Blanchflower and Oswald (2008) found a U shape even after controlling for cohort effects. Great apes exhibit similar relationships for happiness as a function of age (Weiss et al., 2012). While not all studies have found a U shape in the happiness–age relationship for all countries, even studies generating different results emphasize alternative terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/bpp.2019.47
possibilities, such as a flattening of the U shape after controlling for fixed effects (Frijters & Beatton, 2012) rather than an inverted-U.

The life-cycle patterns for VSL and happiness follow opposite trajectories. The VSL rises and then falls over the life cycle, whereas happiness measures fall and then rise. Measures of negative wellbeing such as measures of depression more closely follow the life-cycle trajectory of the VSL. These empirical relationships suggest that the incorporation of individual welfare is quite different for the VSL and wellbeing measures.

The procedures for applying the VSL and wellbeing measures in order to assess benefits also are quite different. US government agencies use an average VSL for all ages, except that they monetize short remaining periods of life using the VSLY or QALYs. If policy-makers wished to make the VSL conditional on age, the appropriate approach would be to reflect the inverted-U-shaped pattern. Despite the decline in remaining life expectancy with age, the VSL would not have a consistent negative slope until after its peak in middle age. The wellbeing approach advocated by Frijters et al. assumes linearity, leading to a steady decline of mortality risk valuations after birth. Their proposed value of mortality risks is the number of years of remaining life multiplied by the average happiness level per year. To value lives, they advocate wellbeing-adjusted QALYs multiplied by the number of years of life, with a score of 0 after death. But is answering a life satisfaction question with a 0 for ‘not at all satisfied’ really equivalent to being dead, which is forever, and not a transitory happiness level? While this approach comports with a quantity-based conceptualization of equity, it is not derived from individuals’ willingness to pay for mortality risk reductions, which does not steadily decline with age. The VSL–age trajectory would be different if people could draw on their lifetime resources at birth in a world with perfect insurance and perfect capital markets and no moral hazard, but that is not the world in which we live. Public perceptions of equity also may differ internationally. Although the UK recognizes the quantity of remaining life in policy valuations of mortality risk reductions, attempts in the USA to use a lower VSL for those aged 65 and over led to a public outcry against the devaluation of the lives of seniors and subsequent abandonment of this policy practice (Viscusi, 2018).

The valuation of other health effects also differs when using the VSL and wellbeing approaches. It is possible to estimate money–risk trade-offs for health impacts other than death, including the estimation of the utility functions in the good health and ill health states (Viscusi, 2019), which serve as building blocks for economic analyses of wellbeing. Mild health impacts, such as temporary eye irritation, are tantamount to monetary losses but do not alter the marginal utility of income, whereas severe effects such as cancer
reduce both the level of utility and the marginal utility. These utility functions give rise to risk trade-off values that are the counterparts to the VSL. It is feasible to monetize the health impacts by ascertaining the policy endpoints (e.g., expected number of cancer cases prevented) and multiplying the policy endpoints by the valuations per expected health outcome.

The procedure described by Frijters et al. is more holistic and less concerned with the endpoints. Instead of assigning valuations to specific health impacts, their approach focuses on the underlying risk exposure and its effect on life satisfaction. For example, for air pollution, the wellbeing benefits effect is based on the overall life satisfaction impact of an increase of 10 µg/m³ in SO₂ or PM₁₀ exposures rather than the monetized value of each of the component health effects, as with conventional benefit–cost practices. Estimation of the happiness–air pollution trade-off is only a meaningful benefit measure if people are cognizant of the long-term health and happiness implications of exposures. It is a daunting task for current happiness measures to incorporate how such exposures will ultimately affect one’s health and in turn affect future life satisfaction.

Treatment of the role of discounting in my application of the VSL and in the wellbeing analysis of Frijters et al. has some parallels but is not identical. Suppose that the discount rate applied to government policies is \( r \). Then saving an expected life in \( n \) years would have a present value of \( \frac{\text{VSL}}{(1 + r)^n} \) if the VSL in the future is the same as the current value. However, the value of \( r \) also incorporates a rate of income growth that in turn will boost the VSL. The relation of the growth in VSL to income growth depends on the income elasticity of VSL, which averages 0.6 for the USA and 1.0 internationally. As a consequence, if the growth rate in the VSL is at a rate \( g \), the present value of reducing an expected death in \( n \) years is approximately \( \frac{\text{VSL}}{(1 + r - g)^n} \), where \( g \) is less than the VSL income growth rate in the USA. The discounting approach by Frijters et al. would subtract the discounting component due to income growth based on their belief that declining marginal utility of income does not affect happiness. The approaches consequently share a common purpose of damping the role of discounting because of the role of income growth, but the rationale and extent of the adjustment for income changes differ.

**Challenges of measuring wellbeing with an ordinal index**

Ordinal rankings of life satisfaction or happiness face considerable challenges in elicitation and application. The ordinal scales used to elicit such values are ranges such as 0–10, 1–7 or 1–3. These scales consequently are bounded from below and above, whereas monetary valuation scales are not. Based on a 0–10 scale, a person might think that a bad day with the flu merited a
score of 0, but being tortured by terrorists would surely be much worse. Similarly, a happy day might merit a 10, but inheriting the wealth of Jeff Bezos would nevertheless have a positive effect on wellbeing even if starting at a baseline value of 10. In contrast, a monetary scale is unbounded, permitting people to require compensation for enduring very adverse situations and allowing people to pay very large amounts for favorable policy outcomes.

By construction, the ordinal wellbeing scales also do not necessarily have cardinal significance. Just as the tallest basketball player on a team is not necessarily five times as tall as the shortest player, a person with a happiness score of 5 is not necessarily five times as happy as she would be with a score of 1. Interpersonal comparisons are also problematic. Moving Person A from 2 to 4 may have a different utility benefit than moving Person B from 7 to 9. The within-person and across-person comparisons of wellbeing are not necessarily meaningful, even if there are some situations in which the scale seems to function as a cardinal index. In contrast, the monetized willingness-to-pay amounts for policy outcomes and the extent of these differences across policies and across individuals are apparent and comparable.

The role of income is also quite different for the wellbeing approach and willingness-to-pay values. Wellbeing measures equate the value of moving a poor person from 2 to 4 to the value of moving a rich person from 7 to 9. But with a positive income elasticity of the benefit value, the conventional benefit value for the rich person may be much greater. Abolishing the linkage between benefit measures and willingness to pay has far-reaching efficiency and equity implications.

The wellbeing scales, by their very nature, are quite coarse. There are very few policy interventions that might lead to the movement of a point on a 10-point scale. Given the myriad of factors that might influence personal welfare, most of the effects are likely to be quite small. Using a life satisfaction scale will create particular problems for low-probability events. If the task is to assess the value of eliminating a 1/10,000 chance of a temporary injury or to assess the altruistic value of reducing poverty in some developing country, it is likely that the life satisfaction score will not be responsive to the policy shift. The scale is too coarse to address outcomes involving small shifts in welfare. The difficulties posed to life satisfaction scores by mortality risk valuations involving extremely small risks are likely to be more challenging than tasks for which wellbeing scores are better suited, such as assessing the change in wellbeing before and after being married.

How a respondent should conceptualize the life satisfaction or happiness scoring task is also not well defined. If a respondent is paraplegic, is the valuation task to assess the level of wellbeing, conditional on being a paraplegic, or is the appropriate reference point for thinking about this happiness rating the
level of wellbeing in perfect health? In the absence of a well-defined task, it is difficult to interpret the levels of the life satisfaction scores for an individual, but changes in that person’s score may be more informative.

Notwithstanding the many contrasts between life satisfaction and monetized risk approaches, there are some commonalities. Psychologists’ studies of happiness have found that the long-run effects on happiness of permanent disabilities are not as great as one might expect (Kahneman, 2011). While the apparent adaptation to disabilities could conceivably be the result of people rating their wellbeing conditional on being disabled, this pattern of happiness ratings echoes the results found using standard economic frameworks. In particular, the study by Sloan et al. (1998) asked individuals what risk of death they would be willing to incur in order to obtain a cure for multiple sclerosis (MS). The respondents who had MS were much less willing to undergo the treatment that posed a risk of death than were healthy individuals after being apprised of the implications of MS for their daily activities and health.

The cost-effectiveness criteria for wellbeing analyses also have a structure similar to those of benefit–cost tests. The Frijters et al. cost-effectiveness test can be written as:

\[
\frac{\text{Extra happiness}}{\text{Net cost}} > \lambda_1
\]

where \( \lambda_1 \) is the critical cost-effectiveness ratio. The extra happiness amount achieved per unit cost must exceed some cutoff value for it to be cost-effective. The standard benefit–cost test is:

\[
\frac{\text{Extra benefits}}{\text{Net cost}} > \lambda_2
\]

where \( \lambda_2 \) is the shadow price of capital that has a value of 1 if there is no binding budgetary constraint. In general, benefit–cost tests provide more definitive guidance than cost-effectiveness tests, especially in policy contexts in which the cutoff for desirable policies is based on the simple requirement that the extra benefits outweigh the net costs. Of course, this benefit–cost screening of policies does not guide the entire policy menu. More policies will have benefits exceeding costs than those that are adopted. But typically the influence of budgetary constraints is calculated more informally and not incorporated by setting an explicit requirement that the ratio of benefits to costs exceed some reference cutoff value above 1.0.

**Prospects for the application of wellbeing measures**

Wellbeing analyses and standard economic frameworks sometimes have parallel implications. However, measures of life satisfaction have fundamental
drawbacks relative to monetary benefits measures in that the scales are bounded, ordinal, not comparable across people or across time for any given person, not based on a well-defined wellbeing reference point and often insensitive to income effects. In addition to these intrinsic aspects of wellbeing scales, there are also challenges to applying the scales to mortality risks. Policies generating small changes in mortality risks are unlikely to register on a coarse wellbeing scale, and linear application of life satisfaction scores is inconsistent with revealed preferences.

The contrasting implications of life-cycle effects for the VSL and for happiness measures suggest that the different approaches are not interchangeable. Wellbeing measures and the VSL are measuring quite different things. If the application of VSL were divorced from individual wellbeing, then there might be some rationale for shifting to wellbeing measures. However, the monetary benefit measures incorporated in the VSL are not arbitrary accounting measures, but are intrinsically linked to individual utility levels and the decline in individual utility after death. The normalization of this utility difference through division by the expected marginal utility transforms this ordinal difference into a cardinal index of the monetary value of mortality reduction benefits. Measuring wellbeing is consequently central to the VSL model.

References


US Office of Management and Budget (2015), *2015 report to Congress on the benefits and costs of federal regulations and agency compliance with the Unfunded Mandates Reform Act*.  
