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Estimating the Values of Mortality Risk Reductions in Low- and Middle-Income Countries[1]

Abstract: The value of small changes in mortality risks, generally expressed as the value per statistical life, is an important parameter in benefit-cost analysis. However, little is known about the values held by populations in low- and middle-income countries. This article introduces a symposium that includes three additional articles which explore related theory and research.

Keywords: benefit transfer; income elasticity; value per statistical life.

JEL classifications: D6; H4; I1; Q51.

1 Introduction

It can be difficult to decide how to best allocate resources in any setting, but it is particularly challenging in low- and middle-income countries where needs are great and resources are very limited. Benefit-cost analysis provides a well-established and useful framework for supporting these decisions, investigating the harms and improvements likely to result from different investments. One major strength of such analysis is that it provides information on the preferences of those affected, which can be very useful regardless of whether the decision is ultimately made on other grounds.

Reduction of premature mortality is a major goal of many investments in low- and middle-income settings, and dominates the benefits estimates for numerous environmental, health, and safety policies. Unfortunately, we know relatively little about the preferences of these populations for spending money to reduce their own mortality risks rather than on other goods and services. The lack of such estimates presents important and significant challenges, requiring careful consideration of

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both how to fill this research gap over the long run and how to best estimate these benefits in the interim.[2]

This symposium brings together a series of articles that investigate the state of this research, suggest approaches for applying it in the near term, and identify opportunities for improvements. It includes discussion of the underlying theory and conceptual issues (Hammitt, 2017), review and application of the available research on individuals' willingness to trade off changes in earnings for changes in job-related mortality risks (Viscusi & Masterman, 2017), and results from survey research conducted in China and other countries (Hoffmann, Krupnick & Qin, 2017).

This introductory article provides an overview of key concepts and previous reviews of the literature. It then introduces the articles that follow, summarizes differences in the value per statistical life estimates that result from different approaches, and discusses research needs.

2 Basic concepts

In benefit-cost analysis, the starting point for valuing mortality risk reductions is typically an estimate of the change in the likelihood of death in a defined time period for individuals affected by the policy. This risk change can be aggregated over the affected population to calculate the number of statistical cases averted. The term "statistical" is used to emphasize the role of probability; most policies reduce the risk incurred by the affected population rather than preventing identifiable deaths with certainty. A statistical life thus involves aggregating small risk changes across individuals. For example, if 10,000 individuals each experience a risk reduction of 1 in 10,000 in a given year, then one statistical life is "saved" $(10{,}000 * 1/10{,}000 = 1)$.

Consistent with the benefit-cost analysis framework, the value of these risk reductions is generally based on individuals' willingness to trade off their spending on other goods and services for reductions in their own risks. For mortality risk reductions, individual willingness to pay (WTP) is typically expressed as the value per statistical life (VSL).[3] More specifically, VSL is an individual's marginal rate of substitution between wealth and the risk of dying in a defined time period (Hammitt, 2017). Presumably, individual WTP accounts for both the pecuniary effects of the risk change (including avoided out-of-pocket medical expenses and losses in

2 Value per statistical life estimates may also be used to derive thresholds for cost-effectiveness analysis, which is often utilized to prioritize spending on health-related policies.

3 Estimates of willingness to accept compensation are also consistent with the benefit-cost analysis framework; however, WTP is more commonly used to value improvements from the status quo.

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future earnings) and the nonpecuniary effects (including experiencing the joys of life itself and delaying pain and suffering).

For small changes in risk, VSL can be approximated by dividing WTP by the risk change. For example, if an individual is willing to pay $600 for a 1 in 10,000 reduction in his or her risk of dying in the current year, his or her VSL is $6,000,000 ($600 WTP ÷1/10,000 risk change). These estimates are often aggregated throughout the population. For example, if a population of 10,000 persons each experience a 1 in 10,000 risk reduction in a given year, and each individual is willing to pay $600 for this risk reduction, then one less death is expected in that year and the value of averting this death is $6,000,000 ($600 ∗ 10,000).

The VSL terminology is often misunderstood. The VSL is not the amount that the government, the analyst, or an individual places on saving a life with certainty. Rather, it represents the values we each place on small changes in our own risks. We demonstrate these values almost every day; for example, in deciding whether to buy protective equipment, to drive more safely, or to use less polluting fuels.

Estimates of individual WTP are generally derived using stated or revealed preference methods. Stated preference methods typically employ survey techniques to ask respondents about their WTP for an outcome under a hypothetical scenario (see Hoffmann et al., 2017). Such methods are attractive because researchers can tailor the approach to directly value the outcome(s) of concern; surveys can describe particular health risks from specific causes and also target respondents with particular characteristics (such as income or age). A key concern is that respondents may have little incentive to respond accurately, since the payment is hypothetical. Careful design and implementation is thus required to conduct a study that yields accurate and reliable results.

Revealed preference methods infer the value of nonmarket goods from observed behaviors and prices for related market goods. For example, hedonic wage studies examine the additional compensation associated with jobs that involve higher risks of fatal injuries, using statistical methods to separate the effects of these risks on wages from the effects of other job and personal characteristics (see Viscusi & Masterman, 2017). While this use of market data has the advantage of relying on behavior with real consequences, it may be difficult to find a market good that can be used to estimate the value of the outcome of concern, for which sufficient data of adequate quality are available.

Because substantial time and expense is required to conduct new primary research, typically analysts rely on existing valuation studies. This approach is referenced as "benefit transfer" to indicate that the populations and policies studied are not necessarily identical to the population and policy considered in the benefit-cost analysis. Such transfers involve carefully reviewing the literature to

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identify high-quality studies that are suitable for use in a particular context, and determining whether and how to combine and adjust the results prior to application. "Quality" is evaluated by considering the likely accuracy and reliability of the data and methods used; "suitability" involves exploring the similarity of the risks and the populations affected. There are no firm guidelines; benefit transfer relies heavily on the informed judgment of the analyst and requires clear disclosure and discussion of related uncertainties and their implications.

3 Previous reviews

Several recent reviews have addressed the global VSL literature. They generally find that the number of studies conducted in low- and middle-income countries is relatively small and that most address countries in the middle-income group. Counting the number of such VSL studies is complicated, however, by changes in the status of these countries over time. For example, countries that were classified as low or middle income at the time the data were collected may now be included in higher income categories. Currently, of the 218 countries identified by the World Bank, 31 are classified as low income and 108 are middle income.[4] The remaining 79 are high income.

Organisation for Economic Co-operation and Development (OECD, 2012), researchers conducted a comprehensive review and meta-analysis of VSL stated preference studies.[5] Narain and Sall (2016) then built on that work and identified additional VSL stated preference studies conducted in low- and middle-income countries. Consolidating information from these reviews with the results of other work, we found about 50 VSL stated preference studies that have been completed in countries that were classified as low or middle income at the time when the data were collected.[6] Most of these studies address middle-income countries. The number of VSL hedonic wage studies conducted in low- and middle-income countries is much smaller. Viscusi and Masterman (2017) identify six such studies that were conducted in countries classified as middle income at the time the data were collected; some are now in the high-income category. This means that very few studies address the preferences of populations residing in low-income countries, and

4 https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups, as viewed June 2017.

5 This database and related reports are available at: http://www.oecd.org/env/tools-evaluation/env-value-statistical-life.htm.

6 I thank Lucy O'Keeffe for identifying these studies based on previous reviews by the author, additional references provided via email by Maureen Cropper, Sandra Hoffmann, Alan Krupnick, and Christopher Sall (June 21, 2017), and additional searches.

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that the available studies address a relatively small fraction of all middle-income countries.

Low- and middle-income countries are diverse, and the population-average VSL may vary for several reasons. Given that the effects of many factors are poorly understood, analysts often focus on the relationship between VSL and income.[7] It seems unlikely that VSL would remain constant across populations with substantially different incomes. For example, as discussed in more detail below, the estimated U.S. population-average VSL is between $9 million and $10 million. A $9 million VSL implies that the average resident is willing to pay $900 for a 1 in 10,000 mortality risk change, or 1.6% of U.S. gross domestic product (GDP) per capita, which was $56,116 in 2015.[8] In a low-income country, where GDP per capita may average less than $2,000, it seems impossible that the average individual would be willing to spend $900 on the same risk reduction, given the necessity for spending on more basic needs. Overall, individual WTP per unit of risk reduction should decrease as income decreases, resulting in a smaller VSL.

Transfer of estimates from higher income countries by adjusting for population-average income requires three types of data: a base VSL, income estimates for both the base VSL and the target populations, and an estimate of the change in VSL associated with a change in income; i.e., VSL income elasticity. Assuming that the elasticity is constant across the income range addressed, the formula is

$$\mathrm{VSL}_{\mathrm{Target}} = \mathrm{VSL}_{\mathrm{Base}} \left(\frac{\mathrm{Income}_{\mathrm{Target}}}{\mathrm{Income}_{\mathrm{Base}}} \right)^{\varepsilon},$$

where ε is defined as income elasticity.

One challenge is to identify the appropriate VSL to use as a starting point. Current government guidance estimates the population-average VSL as between $9 million and $10 million in the United States as of 2015, based on review of the literature (U.S. Department of Health and Human Services, 2016; U.S. Department of Transportation, 2016; U.S. Environmental Protection Agency, 2016). These estimates are roughly 160–180 times U.S. GDP per capita. In contrast, meta-analyses of stated preference studies suggest that the population-average VSL across all OECD countries for the same year is about $4 million (OECD, 2012).[9] This

7 Some global health analyses also adjust for age and life expectancy, generally assuming that VSL declines with age (see, for example, Jamison et al., 2013, Chang, Robinson, Hammitt & Resch, 2017). Robinson and Hammitt (2016) discuss the available research on the relationship between VSL and age in high-income settings and note that the relationship is uncertain; more research is needed to understand the extent to which these relationships are likely to differ in lower income settings.

8 United States per capita GDP estimate in current 2015 dollars from the World Bank: http://data.worldbank.org/indicator/NY.GDP.PCAP.CD?name_desc=true.

9 OECD VSL updated to 2015 dollars provided via email by Nils Axel Braathen, March 6, 2017.

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estimate is about 105 times GDP per capita across all OECD countries.[10,11] A major difference between these estimates is the extent to which they rely on revealed or stated preference studies. The U.S. estimates are dominated by hedonic wage studies, while the OECD estimates only include stated preference studies. Thus, the differences in the estimates may reflect differences in the methods used as well as in the criteria applied to select studies for inclusion and the approaches used to combine estimates across studies, rather than solely variation in the values held by different populations.

A second challenge is to identify the appropriate income elasticity for transferring values across countries. Changes in the estimate can change the results by orders of magnitude. Hammitt and Robinson (2011) reported that the then existing studies found VSL income elasticities ranging from as low as 0.10 to greater than 2.0. The elasticity may vary depending on the income range considered. However, when extrapolating from high-income countries to much lower income settings, elasticities below 1.0 seem implausible. As income becomes increasingly constrained, the fraction of income individuals are willing to devote to achieving small mortality risk reductions is likely to decrease, given the difficulties of funding basic needs.

In more recent reviews, analysts have further investigated the appropriate elasticities, and coalesced on estimates of around 1.0. For example, OECD (2012) recommended a central estimate of 0.8 across OECD countries; a more recent OECD analysis (Roy, 2016) used a central income elasticity of 1.0 when transferring estimates to African countries. In work for the World Bank, Narain and Sall (2016) and World Bank and IHME (2016) used an elasticity of 0.8 for high-income countries and an elasticity of 1.2 to transfer estimates to low- and middle-income countries.

This method of extrapolation has important limitations, because it does not directly address other influencing factors. The VSL is expected to vary with individual characteristics (such as age and health status), with risk characteristics (such as whether it results from illness or injury, or from a cause viewed as voluntary or controllable), and with the characteristics of the society (such as access to health care and cultural norms). The effects of many of these characteristics on VSL are not well understood. For example, there are large differences in life expectancies across countries with differing income levels, and many interventions are targeted on particular age groups. However, the reviews cited above do not recommend adjusting for age or life expectancy due to deficiencies and gaps in the empirical research.

10 While VSL studies may use per household or per worker income in calculating income elasticities, GDP per capita or gross national income (GNI) per capita is often used in transferring VSL across countries.

11 OECD per capita GDP was $37,913 in current 2015 dollars, based on exchange rates using the World Bank Atlas methods: http://data.worldbank.org/region/oecd-members.

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4 Symposium articles

The first article in this symposium, "Extrapolating the Value per Statistical Life Between Populations: Theoretical Implications," by James K. Hammitt, explores the conceptual issues introduced above in more detail. The standard economic model suggests that VSL should decrease with wealth, that income elasticity should be at least as large as the coefficient of relative risk aversion with respect to wealth, and that the effects of other factors are either expected to be small or cannot be determined from theory. In applying this model, he notes that the appropriate measure of income is uncertain; the measure used may substantially affect the results of extrapolating VSL estimates from high-income countries to lower income settings.

The next article, "Income Elasticities and Global Values of a Statistical Life," by W. Kip Viscusi and Clayton J. Masterman, addresses the available hedonic wage research. The authors examine 68 studies conducted in 14 countries, only two of which (India and Pakistan) are not currently classified as high income. They note that many countries lack sufficiently detailed data on fatalities and employment to support these types of analyses. The authors explore issues related to identifying the appropriate income elasticity for transferring estimates in different contexts. They conclude that within the United States, on average, elasticities are likely to be between 0.5 and 0.7, increasing to slightly above 1.0 for other countries. They suggest that U.S. studies that rely on Census of Fatal Occupation Injuries data provide the best starting point for extrapolating VSL estimates across countries, because these studies do not appear to be subject to the publication bias found in other research. The authors use a base U.S. VSL of $9.6 million and an income elasticity of 1.0 as a default, and find that the resulting VSLs range from $45,000 to $18.3 million across countries.

The final article, "Building a Set of Internationally Comparable VSL Studies," by Sandra Hoffmann, Alan Krupnick, and Ping Qin, investigates the use of stated preference methods. It focuses on a study completed in three Chinese cities, and compares the results with those from seven other studies that rely on a similar survey. Of the eight countries addressed by these studies, two are not classified as high income (Mongolia and China). The authors explore issues related to tailoring the survey to the characteristics of the population, finding that payment screen elicitation may work better in some cultures than the dichotomous choice format frequently recommended for use in high-income countries. Across the Chinese cities studied, they find that VSL averages about $610,000, with income elasticities ranging from about 0.1 to 0.3 depending on the estimation approach. The authors compare these results with the findings of their other studies that use a similar survey, and find that the implied income elasticities vary over a wide range.

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Table 1 VSL Estimates Extrapolated Using Alternative Approaches.

Approach	GNI per Capita (2015 USD)[a]		
	$1,026	**$4,036**	**$12,476**
World Bank and IHME (2016)[b]	$0.053 million (51 ∗ GDPpc)	$0.272 million (67 ∗ GDPpc)	$1.650 million (132 ∗ GDPpc)
Viscusi and Masterman (2017)[c]	$0.171 million (167 ∗ GNIpc)	$0.676 million (167 ∗ GNIpc)	$2.088 million (167 ∗ GNIpc)

Notes:
[a]These income levels are currently used as the dividing lines between the World Bank income groups, which are defined based on GNI per capita calculated using the Atlas method for exchange rates (see footnote 12).
[b]These calculations assume that income levels are expressed as GDP per capita (GDPpc) rather than as GNI per capita (GNIpc). Based on OECD VSL = $4.032 million, OECD GDPpc = $38,128, income elasticity = 1.2 for low- and middle-income countries, = 0.8 for high-income countries. (Estimates provided by Christopher Sall and Urvashi Narain of the World Bank via email, March 14, 2017.)
[c]Based on U.S. VSL = $9.6 million, U.S. GNIpc = $55,980, income elasticity = 1.0. (See Viscusi & Masterman, 2017.)

5 Summary and conclusions

Table 1 illustrates the VSL estimates that result when using different approaches to extrapolate values across countries with relatively large differences in population-average incomes. In this example, we report VSL estimates for the three income levels that the World Bank currently uses to divide countries into low-, lower middle-, upper middle-, and high-income groups.[12,13] We include estimates from two sources. The first is based on the stated preference research from OECD's meta-analysis supplemented by additional data collected by the World Bank, and uses the income elasticities applied in recent World Bank analyses. The second relies on the approach discussed in Viscusi and Masterman (2017), based on the hedonic wage studies. As illustrated by the table, the World Bank approach results

12 As of 2017, the World Bank defines low-income economies as those with 2015 GNI per capita of $1,025 or less; lower middle-income economies are those with GNI per capita between $1,026 and $4,035; upper middle-income economies are those with GNI per capita between $4,036 and $12,475; high-income economies are those with GNI per capita of $12,476 or more, using the World Bank's Atlas method for exchange rates (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).
13 We do not intend to imply that these VSL estimates should be used for all countries within these groups. Rather, VSL should be calculated based on the income of the population affected by the policy of concern.

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in lower estimates, and the use of different elasticities means that ratio of the VSL to the income measure varies.

While different approaches can lead to substantially different estimates, the extent to which these differences are likely to affect the conclusions of benefit-cost analyses is unclear. In some cases, the benefits may exceed the costs by a large enough margin that the choice of a VSL estimate may not matter much. In other cases, the choice of a VSL estimate may have a substantial impact on the conclusions.

These findings raise two major issues in need of further exploration. The first is whether it is possible to harmonize the approaches used to extrapolate VSL estimates, at least in sensitivity analyses. It is not possible for any one benefit-cost analysis to address all of the potential investments in low- and middle-income countries, yet it is difficult to compare the results across studies when different approaches for estimating the VSL are used – especially since mortality risk reductions often dominate the benefits. Without more harmonization, differences in the consequences of alternative investments can be obscured by differences in methods, potentially leading to widely varying conclusions regarding the desirability of particular policies.

Second, perhaps it is time to start investing in a more ambitious primary research program, rather than continually tweaking the approach to benefit transfer. In the near term, this research program may need to focus on stated preference studies, given that the data needed to support hedonic wage studies may not be available in many countries. Although stated preference research poses many challenges, it also has the advantage of allowing researchers to investigate the values placed on risks of different types that affect different population groups. Such research will help us to better understand the preferences of those affected, which can aid in policy implementation as well as evaluation. It also moves us away from focusing largely on the effects of income differences, and encourages us to pay more attention to other sources of variation such as differences in cultural norms and other context-specific factors.

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